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Seed dormancy and seedling vigour as influenced by planting time environment and date of harvest in rice (*Oryza sativa* L.)

M. Arumugam[1]*, M. P. Rajanna[2] and R. Gowda[3]

1- Dept. of Microbiology and Cell Biology, Indian Institute of Science, Bangalore 560 012, India.
2- Rice Breeder Zonal Agricultural Research Station, V.C. farm, Mandya-571 405, India.
3- Dept. of Seed Science and Technology, UAS, GKVK, Bangalore- 560 065. India.
**Corresponding author's E-mail: arumugam@mcbl.iisc.ernet.in*

ABSTRACT
Seed dormancy is a genetically inherited trait whose intensity is modified by the environment during seed development and maturation. In order to study the effect of harvest time on the seed quality and optimum time of sowing to obtain good quality seeds, freshly threshed seeds of ten diverse rice genotypes harvested from six environments were evaluated for seed dormancy and seedling vigour index as a measure of seed quality. There were significant differences in germination in different genotypes in all the six environments as well as days after harvest. The germination percentage was initially low and gradually increased with increasing in days after harvest (0. 15, 30 and 45th day after harvest). Out of these six genotypes viz., IET 8116, KMP 101, IR 30864, KRH-1, IR-64 and MTU 1001 were found dormant, immediately after harvest. The studies indicated that sowing in the first (June 2nd fortnight) and second environment (July 1st fortnight) were resulted in production of non-dormant seeds. Whereas all the six environments were favorable to take up seed production of new promising rice genotype KMP 101.

Keywords: Environment, Seed Dormancy, Seedling vigour, Sowing Date, Rice.

INTRODUCTION
Rice (*Oryza sativa L.*) has been the major calorific and dietary protein source for many and outweighs any other crop due to its domestication for several thousand years. Although rice is grown across hundred countries, it is the major staple food crop for the people of the Asia pacific region, which accounts for 59 percent of world population. More than 90 percent of global rice is produced and consumed in this region. In India, the annual per capita consumption is 86 kg and constitutes about 30 percent of the total calorific sources (CRRI, 1996). Rice is India's provincial food crop contributing 40 percent of total food grain production and is grown in on 44.5 m.ha with the production of 85.5 m.t (Hindu, 2002). In Karnataka, rice is grown an area of 1.42 m.ha with an annual production of 3.6 m.t (UAS, 2000).

In India, rice is grown in two main seasons i.e wet season (kharif) and dry season (rabi). It has been observed that there are differences among genotypes for stability of different characters over seasons and locations and even different date of sowing with in the same season due to the influence of environment. It may cause the difference in relative ranking of varieties when they are compared over serious environments. Although stratification of environments has been used effectively to reduce the genotype-environment interaction, it may not be pragmatic since fluctuation across the environments will be of considerable magnitude (Allard & Bradshaw, 1964).

In Karnataka, India, under Cauvery command area, rice is cultivated in an area of nearly 0.1 million hectares during wet season and summer seasons. In wet season sowing starts in May-June and extends up to September- October. Though different varieties have been identified and recommended for sowing in different months , farmers are facing difficulties in adopting the same due to shift in rainfall pattern and scheduling of water in the canal.

As a result, many farmers are sowing long duration and medium duration varieties in June and July instead. The delay in sowing is known to reduce grain yield, seed quality because of poor seed setting and biotic stress due to high temp and high humidity at flowering. As a result of delay in sowing the harvest time also varies; therefore, it is imperative to know the effect of time of harvest on seed dormancy and seedling vigour.

The ability of seeds to delay their germination until the favorable time reaches in the right place is an important survival mechanism. Seed dormancy is an important physiological stage in the life cycle of many seed bearing plants. In an ever-changing environment, dormancy increases survival of species by distributing its germination over time and also by avoiding pre-harvest sprouting , which affects seed quality adversely in many cereals. In general seed dormancy is a qualitative and genetically inherited trait (Naylor, 1983) whose intensity is modified by the environment during seed development. Seed dormancy is very much influenced by season / environment (Sukumara Dev, 1982; Padmaja Rao, 1994) and crop duration. However , safe removal of seed dormancy is necessary; when ever fresh seed is required for planting immediately after harvest. Several studies (Agarwal, 1981: Biradar & Mahadevappa, 1993: Padma & Muralimohan reddy 2000) also reveal the effect of time of harvesting on seed dormancy and seedling vigour index in rice and many other crops. Considering this, an experiment was designed to study the influence of dates of planting on the occurrence and dissemination of seed dormancy and seedling vigour.

MATERIAL AND METHODS

The investigation was carried out during wet season 2002 using ten promising rice genotypes received from All India Coordinated Research Project on Rice, Zonal Agricultural Research Station, V.C. Farm, Mandya (12°32′N and 76°53′E with an annual rainfall of 765 mm). Ten genotypes constituting wide spectrum of variation in agro botanical traits (Table 1) were sown and transplanted in six different dates viz., E_1 (June 2nd fortnight), E_2 (July 1st fortnight), E_3 (July 2nd fortnight), E_4 (August 1st fortnight), E_5 (August 2nd fortnight) and E_6 (September 1st fortnight) by giving 15 days interval between each sowing. In order to study the effect of time of harvest on the seed dormancy, the freshly harvested seeds of each genotype from each environment was cleaned, dried to safe level of moisture (< 13%) and graded. The seeds were evaluated for their germination potential as well as seedling vigour.

Standard Germination Test

The germination test was conducted in laboratory using between paper methods (ISTA, 1996). One hundred seeds in each of two replications were placed on germination paper towels, which were then rolled. The rolled towels were incubated in a germination chamber maintained at 25 ± 1°C and 90 per cent relative humidity. The seedlings were evaluated on the 14th day, and the percent of germination was expressed based on normal seedlings to reveal the occurrence of dormancy due to sowing dates. Samples were stored in cloth bags at normal room condition to study the natural dissipation of seed dormancy. Seed samples were drawn at an interval of 15 days and tested for germination until the seed reached maximum germination percent.

Seedling Vigour Index (SVI)

Ten seedlings from each replication were selected at random on the 14th day after germination, and seedling length was measured. The same seedlings were dried at 80± 1°C for 24 hrs and weighed. The mean seedling length and dry weight were used for estimation of SVI in two different methods using the following formula (Abdul Baki and Anderson, 1973).

1. SVI Based on seedling length

SVI = Mean seedling length (cm) x Germination (%)

2. SVI Based on seedling dry weight

SVI = Mean seedling dry weight (mg) x Germination (%)

RESULTS AND DISCUSSION

The result of germination and seedling vigour studies conducted in twelve genotypes under six different sowing dates were presented in tables 2, 3 and 4. The results revealed that there were significant differences in germination in different genotypes in all six environments as well as days after harvest. The genotype Jaya, IET 8116, BPT 5204 and CTH 3 exhibited higher germination per cent of 71, 65, 60 and 68 respectively immediately after harvest (0th day) in the second environment (July 1st fortnight) and attained minimum certification standard (80%) at 15th day after harvest in most of the environment, indicating the dormancy period for these genotypes was hardly 15 days. The genotype BR 2655 recorded its minimum certification standard immediately after harvest in all the environments.

The genotypes IR 30864, CTH 1, IR 64 and MTU 1001 showed lower germination per cent immediately after harvest. IR 3086 attained minimum certification standard (80%) at 45th day after harvest in most of the environments except first (June 2nd fortnight) and third (July 2nd fortnight) environments, which suggested that the seeds of IR 30864, CTH 1 and IR 64 produced in these environments recorded a dormancy period of forty five days. However, these genotypes registered a maximum germination (> 96%) in fifth environment at the 45th day after harvest. Similar findings were reported by Rame Gowda *et al*., (2003) on some of the parental lines and hybrid rice KRH 2. Among the ten genotypes, MTU 1001 recorded the lowest germination percent immediately after harvest in almost all environments. However, maximum germination (>80%) was attained at 45th day after harvest in the second, fifth and sixth environments, it did not attain minimum certification standard even after 45 days after harvest in rest of the environments (Table 2). Angrish and Panwar (1995) have reported similar kind of results in the medium duration varieties of rice.

SVI based on mean seedling length

Among the twelve genotypes studied only eight genotypes *viz*., Jaya, IET 8116, BR 2655, BPT 5204, KMP 101, KRH 2, CTH 3 and Rasi had maximum seedling vigour in almost all environments (Table 3). However, the genotypes Jaya and BR 2655 had maximum vigour of 2896 and 2867 in the first environment, the first environment could produce good quality seeds. Similarly IET 8116 and CTH 3 attained maximum vigour in second environment (July 1st Fortnight). The higher vigour index indicated the suitable environments for the production of quality seeds. The genotype BPT 5204 performed well in third environment for higher vigour seeds. The popular hybrid KRH 2 had the maximum vigour (923) in the fourth environment. The drought tolerant short duration variety Rasi attained its maximum vigour (1222) in sixth environment.

The genotypes IR 30864, CTH 1, IR 64 and MTU 1001 showed lower seedling vigour in almost all the tested environments. However, in IR 30864 the fourth and sixth environments were favored for the production of higher vigour seeds. CTH 1 and IR 64 had maximum vigour of 1029 and 1537 respectively, in the second environment (July 1st Fortnight). The genotype MTU 1001 attained higher vigour of 107 in sixth environment (September 1st Fortnight) comparatively. Singh and Borikar (1985) also reported the influence of physiological maturity on seedling vigour of rice. Similar results were reported in soybean (Abdul Baki and Anderson, 1973).

SVI based on mean seedling dry weight

The results of SVI revealed that among the twelve genotypes only seven *viz.*, Jaya, BR 2655, BPT 5204, KMP 101, KRH 2, CTH 3 and Rasi had maximum vigour in all the six environments; however, the genotypes IET 8116 and BR 2655 had the maximum vigour immediately after harvest in first environment (June 2nd fortnight). The maximum vigour of 410 (0th days after harvest) was recorded for Jaya in sixth environment (September 1st fortnight). The maximum seedling vigour of 240, 253, 371, 371 and 397 (0th days after harvest) was recorded for BPT 5204, KMP 101, KRH 2, CTH 3 and Rasi in second, third, fifth and sixth environments respectively.

Table 1. Salient features of the rice genotypes used in the study.

Sl. No	Genotypes	Parents	Duration (days)	Grain type	Yield potential (t/ha)	Special character
1	Jaya	TN-1×TN-141	140-145	LB	7.5-8.0	Wide adaptability
2	IET 8116	Vikram × Andrewsali	140-145	LB	7.5-8.0	BPH and WBPH tolerant
3	BR 2655	Selection from BR 2655-9-3-1	140-145	MB	8.0-8.5	Tolerant to blast and non lodging
4	BPT 5204	(GEB 24 × TN 1) Mahsuri	145-150	MS	7.0-7.5	Good cooking quality
5	KMP 101	Mandya Vijaya × CTH 3	130-135	MS	7.0-7.5	Good cooking quality, tolerant to sheath rot.
6	IR 30864	(IR 17-38 × IR 7601-1-2-1) (IR 46 × Khoala)	130-135	LS	7.0-7.5	Tolerant to saline and alkaline condition
7	KRH 2(Hybrid)	IR 58025A × KMR-3R	130-135	LS	85-10.0	High yield and tolerant blast
8	CTH 1 (Mukthi)	Sirinda Meraha × IR 2153-159-1-4	125-130	MB	5.0-5.5	Cold tolerant, Red Kernel
9	CTH 3 (Bili Mukthi)	Reselection from CTH 1	120-125	MB	5.0-5.5	Cold tolerant, white Kernel
10	IR 64	IR 5657-3-2-1 × IR 2061-465-5-5	130-135	LS	7.0-7.5	Suitable for puffed rice industry
11	Rasi	TN1 × Co 29	120-125	MS	5.0-5.5	Drought tolerant
12	MTU 1001	Vajram × MTU 7014	130-135	LB	7.0-7.5	BPH tolerant

Note: LB = Long bold MB = Medium bold LS = Long slender MS = Medium slender.

Table 2. Germination per cent as influenced by environments and dates of harvest in rice.

Genotype	E1				E2				E3				E4				E5				E6			
	Days after harvest				Days after harvest				Days after harvest				Days after harvest				Days after harvest				Days after harvest			
	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45
JAYA	44	51	92	98	71	95	98	98	35	53	76	85	39	54	81	88	42	68	88	92	64	81	92	96
IET 8166	56	88	89	92	65	94	97	99	9	8	68	75	60	66	91	96	14	52	84	88	54	70	80	90
BR 2655	84	88	92	97	74	93	94	100	83	88	90	94	79	91	95	99	80	90	95	97	70	80	90	99
BPT 5204	44	85	86	94	60	87	93	97	32	51	85	87	50	75	85	87	40	69	87	94	41	69	78	88
KMP 101	23	80	89	92	29	97	97	99	46	80	92	97	60	79	97	98	49	78	94	95	58	84	88	96
IR 30864	5	34	53	57	7	39	82	98	7	17	30	60	35	55	78	85	14	50	89	90	22	48	72	86
KRH 2	40	89	90	98	51	97	98	98	51	82	90	98	59	78	94	95	57	83	92	98	40	51	64	87
CTH 1	4	26	51	62	61	90	90	97	12	22	60	80	14	38	66	80	24	40	82	94	3	6	44	78
CTH 3	58	73	95	99	68	92	92	95	57	90	95	97	56	79	98	99	52	80	92	99	36	67	64	86
IR 64	4	17	67	80	1	67	84	94	18	47	70	88	40	77	83	95	38	62	96	99	30	39	60	80
RASI	28	68	87	92	79	87	88	96	29	72	97	99	34	74	98	98	40	79	89	92	61	77	90	99
MTU 1001	1	20	41	56	1	59	59	86	0	1	49	63	2	8	55	77	6	20	71	91	26	44	66	92
Mean	33	60	78	85	47	83	89	96	32	51	75	85	44	65	85	91	38	64	88	94	42	60	74	90

Table 3. Seedling vigour index based on seedling length as influenced by environments and dates of harvest in rice.

Genotype	E1				E2				E3				E4				E5				E6			
	Days after harvest				Days after harvest				Days after harvest				Days after harvest				Days after harvest				Days after harvest			
	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45
JAYA	979	1075	1792	2896	1191	1870	2006	2020	724	1006	1504	1976	773	1009	1855	1955	709	926	2038	2157	1232	1906	2267	2444
IET 8166	909	1812	2254	2696	1034	1229	1340	1932	104	132	1821	1840	1044	1219	1916	2067	187	821	1859	1919	1234	1615	1927	2053
BR 2655	1946	2102	2217	2687	1545	2077	2129	2323	1892	1431	2011	2087	1573	1789	1848	2055	1489	1538	2617	2630	1637	1879	2166	2398
BPT 5204	1002	1739	2026	2061	1095	1902	1984	2206	688	1338	1776	1786	979	1570	1811	1971	645	657	1816	1891	919	1508	1772	2179
KMP 101	387	1599	1898	2008	500	1786	1827	2054	779	1759	1868	2167	1062	1473	2038	2188	938	1219	2026	2213	1007	1628	1946	2287
IR 30864	74	571	1078	1291	170	685	1546	1727	101	320	545	1466	625	1064	1815	1887	236	670	2005	2017	517	1083	1757	2143
KRH 2	488	2090	2167	2428	983	1210	2269	2514	590	1919	2264	2344	923	1282	1914	1916	742	1018	1036	2161	870	1147	1459	2132
CTH 1	46	104	550	1570	1029	1246	1841	1998	169	415	1134	2038	221	681	1344	1677	386	465	2105	235	88	137	983	1626
CTH 3	762	1595	2225	2632	1537	1563	1870	2425	905	1757	2128	2539	933	1389	2133	2144	846	1792	2473	2702	854	1520	1571	2153
IR 64	55	359	1584	2186	11	1101	1718	2247	305	987	1528	2214	622	1419	1712	2081	572	1301	2553	2701	693	956	1479	2045
RASI	486	1406	1605	2312	1517	1557	1756	1766	503	1433	1834	2529	535	1357	2045	2203	711	1623	2226	2355	1222	1719	1941	2211
MTU 1001	2	321	792	1411	7	855	1175	1745	0	9	932	1495	08	104	1003	1623	063	366	1750	2267	107	878	1864	2437
MEAN	595	1231	1682	2182	885	1423	1788	2080	563	1042	1612	2040	775	1196	1786	1981	627	1033	2042	2281	865	1331	1761	2176

Table 4. Seedling vigour index based on seedling dry weight as influenced by environments and dates of harvest in rice.

Genotype	E1				E2				E3				E4				E5				E6			
	Days after harvest				Days after harvest				Days after harvest				Days after harvest				Days after harvest				Days after harvest			
	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45
JAYA	242	306	552	637	355	570	637	735	193	318	494	553	215	324	477	660	210	375	748	736	416	608	690	720
IET 8166	364	572	690	757	293	423	423	423	40	50	306	375	300	336	501	672	79	286	629	660	297	455	560	675
BR 2655	572	588	598	728	444	512	517	700	544	540	572	517	435	501	570	743	440	495	713	726	385	440	540	545
BPT 5204	198	383	430	517	240	494	558	582	192	281	510	566	225	375	553	660	145	180	435	658	205	345	429	528
KMP 101	145	360	490	690	145	436	437	545	255	506	520	554	270	395	582	735	247	429	564	618	232	378	440	624
IR 30864	42	150	212	371	24	176	410	588	39	79	225	450	175	330	468	553	91	325	623	630	121	264	432	645
KRH 2	280	668	675	686	332	631	539	539	332	697	735	765	354	429	705	808	371	368	600	717	220	281	480	738
CTH 1	20	28	117	372	275	495	534	540	42	139	330	520	91	209	363	520	165	220	533	658	14	30	220	507
CTH 3	290	402	808	842	306	460	506	570	371	534	570	585	252	475	588	693	234	390	594	598	180	402	384	559
IR-64	32	71	402	480	1	369	504	564	106	259	410	484	180	402	581	760	215	403	816	743	180	254	450	560
RASI	126	340	653	736	356	479	528	624	131	468	534	545	153	481	735	784	240	514	668	690	397	499	585	674
MTU 1001	2	100	226	443	2	325	354	473	0	1	270	410	29	50	385	480	30	110	568	743	56	106	584	612
MEAN	193	331	488	605	231	448	496	574	187	323	456	527	223	359	542	672	206	341	624	681	225	339	483	616

Though IET 8116 producing higher vigour seed in almost all environments, it exhibited lower seedling vigour of 50 and 79 at 0th days after harvest in third and fifth environments due to persistency of dormancy. Similar studies on other crop species were reported in maize (Hussaini *et al.,* 1988); in carrot and beetroot (Karuna and Aswathaiah, 1989). The genotypes IR 30864, CTH 1, IR 64 and MTU 1001 had shown lower vigour of 42, 20, 71 and 100 (0th days after harvest) in first environment, and the same trend follows in almost all environments. Those genotypes which yielded higher vigour seeds in particular environment considered as suitable environment for cultivation of that particular genotype.

CONCLUSION

It is concluded from this study that seed dormancy and seedling vigour index of rice genotypes at different intervals after harvest varied significantly from environment to environment and among the genotypes of each environment, which is revealed the presence of genotypic variations for these characteristics. The germination percentage was initially low and gradually increased with increasing in days after harvest (0. 15, 30 and 45th day after harvest). Out of these six genotypes viz., IET 8116, KMP 101, IR 30864, KRH-1, IR-64 and MTU 1001 were found dormant, immediately after harvest. The studies indicated that sowing in the first (June 2nd fortnight) and second environment (July 1st fortnight) were resulted in production of non-dormant seeds. Whereas all the six environments were favorable to take up seed production of new promising rice genotype KMP 101. Seedling vigour index was estimated by means of seedling length and seedling dry weight methods to identify favorable environment for production of good quality seeds, indicated that sowing in the first environment (June 2nd Fortnight) is more favorable for the production of Jaya, IET 8116, BR 2655, Rasi and CTH 3. Similarly June 2nd fortnight was found favorable for IR 30864. Whereas , all the six environments were favorable to take-up seed production of new promising genotype KMP 101.

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