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Comparison of tests for the analysis of vigor and viability in paddy germplasm and their relationship to field emergence

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Abstract

We assessed the vigour and viability in selected land races grown in foot hills of Himalayan region (31.1048 °N; 77.1734 °E) mainly Himachal Pradesh. The objective of this study was to compare tests used to identify vigor in paddy seeds and to establish a model that relates the seeds' vigor, as determined in the laboratory, with field emergence. It was observed that all the genotypes were significantly different for all the tests and exhibited dormancy, as the germination percentage (%) in fresh seeds was very less but after 6 months storage and accelerated aging, it was above than minimum seed certification standards. Likewise, first count of seed germination test of rice could not prove to be good indicator of germination; however, such observation should only be recorded at final count stage. These results were confirmed by accelerated aging test, where fresh seeds were exposed to accelerated aging and their germination percentage was enhanced, which implies that during storage, the dormancy of rice seeds break down. The result on vigour index-I and vigour index-II also indicated less vigour in freshly harvested seeds. It was evident that with the increase in germination through various tests, the vigour index also increased proportionately. But all the germplasm was significantly differ from each other in respect to all the observed parameters. Assays for accelerated aging, controlled deterioration and tetrazolium showed the closest correlation to field emergence.

Keywords: Comparison of tests, vigor, viability, paddy germplasm, Himalayan regio

Introduction

Rice (*Oryza sativa* L.) is the basic food crop in the world particularly in India (Subbaiah *et al.*, 2011) ^[14] occupying a total of 23.3% of gross cropped area. Rice contributes 43% of total food grain production and 46% of total cereal production in India. Among the rice growing countries in the world, India has the largest area under rice (about 45 m.ha.) and ranks second in production next to China (Kaul *et al.*, 2006). Standard germination test is an indicator of seed quality, which can be used to predict the field emergence, if soil conditions are nearly ideal (Daurant and Gummerson, 1990) ^[9]. However, conditions in which the seed is found during examination are often in conflict with the conditions in the field. Field germination depends on seed viability. Seed viability or seed vigour are the set of characteristics that determine the activity and behavior of the seed lots of commercially acceptable seed germination in different environmental conditions. In addition to the above mentioned, longevity of the seed is determined by the seed vigour without adverse consequence (ISTA, 2009) ^[10]. To obtain more precise information about the quality of the seed lot different vigour tests are used (Milošević and Cirovic, 1994). Testing of seed viability using different seed vigour tests is very significant, since vigour tests give results, which are often better correlated with the results of field germination under unfavorable environmental conditions, than the results obtained by application of standard laboratory germination test (Johansen and Wax, 1978) ^[12]. McDonald (1975) grouped vigour tests into three groups: Physical tests determine seed characteristics such as size and mass. These tests are inexpensive, quick, can be applied to large number of samples, and are positively correlated with seed vigour. The main feature of seed development is accumulation of nutritive materials, which is also in direct correlation with vigour, i.e. with size and mass of seed. Physiological tests using germination and growth parameters. There are two types of these tests.

First type, when germination is done under favorable conditions (standard laboratory germination, and test of growth intensity). Second type, when seed is exposed to unfavorable environmental conditions (cold test, accelerated aging test, and Hiltner test). Biochemical tests are considered as indirect methods for estimation of seed value. These are Tetrazolijum test, conductometric measurements, enzyme activity and respiration.

Germination capacity is a crucial aspect of seed quality therefore germination tests are used worldwide to determine the maximum germination potential of a seed batch under optimum conditions. The seed industry uses the standard germination test or warm test (AOSA, 2002) for labeling.

Seed quality tests should relate to field emergence. According to Delouche & Baskin (1973) [2], vigour tests have proven to be more useful as predictors of field emergence than the warm test.

Materials and Methods

A total of 30 accessions of rice germplasm were used as experimental material out of which 10 were released varieties recommended for cultivation in Himachal Pradesh, 9 improved lines and 11 germplasm collected from different parts of Himachal Pradesh (Table 1). Germination test was carry out for fresh seed and also for the seed stored for six month.

Table 1: Rice cultivars and their source

S. No	Varieties	Source	Year of release	Source/Pedigree
1.	HPR-1068	CSKHPKV, Palampur	2005	IR 53455Nag- 11-1-12-1-3 IR 42015-83-3-22 × IR 9758-K2
2.	HPR-2720 (Palam Lal Dhan-1)	Do	2013	Pure line selection from IC455333
3.	HPR-2612(Palam Basmati-1)	Do	2013	Sarai/T23 × IR 66295-36-2
4.	KASTURI	Do	1994	Basmati 370 × CRR 88-17-1-5
5.	HPR-1156	Do		IR 32429122-3-1-2 × IR 31868-64-2-33-3
6.	HPR-2880(Him Palam Dhan-2)	Do	2016	HPU2216 × Tetap
7.	HPR-2656(Him Palam Dhan-1)	Do	2016	RP2421 × Tetap
8.	RP-2421	Do	1994	IR36 × Kanthawar
9.	VL-221	Do	1994	IR-2053-521-1-1-1 × CH-1039
10.	HPR-2143	Do	2005	HPR 9020-22-2-1-1-1 Phul Patas × HUP 741
11.	HPR-2682	Do	Improved lines	Him dhan-1 × IR-53915
12.	HPR-2687	Do	do	VL Dhan-221 × RP2421 × IR53925
13.	HPR-2697	Do	do	957 × RP-2421
14.	HPR-2699	Do	do	RP-2421 × VL dhan-221
15.	HPR-2707	Do	do	VL dhan-221 × JD-3
16.	HPR-2711	Do	do	TS-29 × HPV-2216
17.	HPR-2766	Do	do	HIM-1 × IR-53915
18.	HPR-2748	Do	do	Hessan Serai × T23 × IR66295
19.	HPR-2746	Do	do	Hessan Serai × T23 × IR66295-36-2
20.	Chinudhan	Jandrangal	Landraces	Villege-Jandrangal
21.	Jhinidhan	Timber	do	Pritam Chand. Dadh-Timber
22.	Saaldhan	Bir	do	Bachtan Singh Villege-Bir
23.	Sailadhan	Keor	do	Surjadevi. Villege-Keor
24.	Kaludhan	Pangal	do	Pratap Singh-Pangal
25.	Kalijhini-1	Jadrangal	do	Villege-Jadrangal
26.	Kalijhini-2	Indragal	do	Shyam Lal-Indragal
27.	Ramjawandhan	Nagarota	do	Bagawan -Nagarota
28.	Sukara	Bhatiyala	do	Bhatiyat- Chamba
29.	Chohartu	Rohru	do	Rohru, Shimla
30.	Karad	Dadryada	do	Chamba

Accelerated Aging Test

Un-imbibed seeds are subjected to conditions of high temperature (41 °C) and relative humidity (around 100%) for short period of 3-4 days. The seeds are then removed from the stress conditions and placed under optimum germination conditions. The Germination percentage and seedling Vigour index was recorded accordingly.

Germination Percentage

Germination test was conducted using 400 seeds in four

replications of 100 seeds each drawn at random from each treatment replication-wise by adopting blotter paper method as described by ISTA procedures. The temperature of 25±1 °C and RH of 90 per cent was maintained during the germination test.

First count (%) and final count (%) was taken for each treatment of every replication. The first count was taken on 7th day, while final count was taken on 14th day from the day when germination test was performed. The germination percentage was calculated as:

$$\text{Germination Percentage (First and final count)} = \frac{\text{Number of germinated seeds}}{\text{Number of seeds kept for germination}} \times 100$$

Seedling Length (cm)

Ten normal seedlings were randomly selected and length of the seedlings was measured from the tip of the primary leaf to

the root tip and mean seedling length was expressed in centimeters.

Seedling Dry Weight (g)

Ten normal seedlings used for seedling length measurements were put in butter paper pocket and kept in hot air oven at 80°C for 17 hours. The dry weight of the seedlings was recorded and expressed in grams.

Seedling Vigour Index

The seedling vigour index was calculated by adopting the method suggested by Abdul- Baki and Anderson (1973) and expressed in number by using following formulae.

Seedling vigour index - I = Germination (%) X Seedling length (cm)

Seedling vigour index - II = Germination (%) X Seedling dry weight (g)

Field Emergence (%)

Field emergence of stored one hundred rice seeds drawn at random from each treatment in three replications was recorded. The seeds were sown in well prepared soil at 2 to 3 cm depth and covered with soil. Field emergence count was taken on the 7th day and 14th day after sowing and the emergence percentage was calculated taking into account the number of seedlings emerged above the soil surface.

$$\text{Field emergence (\%)} = \frac{\text{Number of seedling emerged on 7th day}}{\text{Total number of seeds sown}} \times 100$$

Result and Discussion

Result clearly indicates that there is a wide difference in germination percentage among the germplasm. The germination of freshly harvested seeds after accelerated aging test, after six months storage and field emergence are presented in Table 2. It has fast count germplasm HPR-2656 (58.33%) has the highest germination % followed by Sukara (57%) and minimum germination % was observed in HPR-2682 (1.33%). Surprisingly germplasm HPR-2697 (87.00%) has a maximum number of germination percent though it has only 28.66% of germination in fast count. However HPR-2656 (58.33%) has second highest germination percentage

and HPR-2682 (27.33%) counted minimum germination %. On the other has germination test result of 6 month stored seeds clearly indicated that the different germplasm exhibit different label of dormancy pride. Germplasm HPR-2656 (98.66%) counted highest germination % in fast count and also in second count (100.00%) where as in fresh seed it counted only (87.00%) of germination in final count which clearly represent the dormancy. HPR-2656 also has 100% field emergence but minimum field emergence was recorded in Karad (64.33%).

Fresh seed of Kalijhini-2 (2244.33) exhibited maximum Vigour index-I followed by HPR-2697(2211.07) where as HPR-2682(490.95) has a minimum Vigour index-I (Table 2.). On the other hand maximum Vigour index-II was recorded in HPR-2421(6.49) and a minimum on HPR-2720(0.37)

However there were significant differences among germplasm (6 month stored seeds among) for Vigour index-I and Vigour index-II in both for germination test and Field emergence test (Table 2)

In case of accelerated aging test different germplasm behaved differently, highest seed germination was recorded in VL-221 (94.66%) followed by HPR-2612 (86.33%) and minimum germination was recorded HPR-2766 in (20.66%) (Table. 1)

In case of Vigour index I VL-221 (3483.17) expressed maximum followed by HPR-2711 (3244.33). KASTURI (655.71) with a minimum Vigour index I. highest Vigour index-II was recorded in Chinudhan (8.22) and lowest in HPR-2766 (1.49) (Table 2.)

The result on vigour index-I and vigour index-II (Table 2) also indicated less vigour in freshly harvested seeds. It was evident that with the increase in germination through various tests, the vigour index also increased proportionately.

Similar results were reported by Copeland and McDonald (2001) ^[1], Delouche and Baskin (1973) ^[2], Venter van de *et al.* (1993) ^[8], Noli *et al.* (2008) ^[4] and Patin and Gutormson (2009) ^[7]. All variation in the different character must be due to the variation in genetic constitution among the different germplasm.

Table 2: Germination percentage-first and final count

Varieties	Fresh seeds				6 month stored seeds			
	Germination test		Accelerated aging test		Germination test		Field emergence test	
	First count	Final count	First count	Final count	First count	Final count	First count	Final count
HPR-1068	43.66 (41.34)	81.00 (64.13)	13.66 (21.68)	83.66 (66.13)	98.66 (84.54)	99.66 (88.05)	53.33 (46.89)	99.66 (88.05)
HPR-2720	15.33 (23.04)	58.66 (49.97)	21.66 (27.72)	61.33 (51.53)	95.33 (77.50)	98.33 (82.63)	48.33 (44.02)	98.33 (82.63)
HPR-2612	50.66 (45.36)	76.33 (60.87)	17.33 (24.59)	86.33 (68.27)	98.3 (82.63)	99.66 (88.05)	41.66 (40.18)	99.66 (88.05)
KASTURI	2.66 (9.35)	59.33 (50.36)	6.66 (14.94)	52.66 (46.51)	93.00 (74.65)	98.66 (83.43)	51.33 (45.74)	98.66 (83.43)
HPR-1156	48.33 (44.02)	78.00 (62.00)	21.33 (27.49)	63.66 (52.91)	97.00 (80.08)	99.66 (88.05)	40.66 (39.60)	99.66 (88.05)
HPR-2880	21.66 (27.72)	64.00 (53.10)	33.33 (35.24)	84.66 (66.92)	97.00 (80.08)	98.66 (83.43)	54.00 (47.27)	98.66 (83.43)
HPR-2656	58.33 (49.77)	86.33 (68.27)	8.33 (16.76)	56.33 (48.61)	98.66 (84.54)	100.00 (89.96)	51.00 (45.55)	100.00 (89.96)
HPR-2421	41.00 (39.79)	84.66 (66.92)	14.66 (22.50)	75.66 (60.41)	95.33 (77.50)	97.66 (81.22)	49.00 (44.40)	97.66 (81.22)
VL-221	31.33 (34.02)	67.66 (55.32)	21.33 (27.49)	94.66 (76.62)	96.66 (79.47)	98.66 (83.43)	44.00 (41.53)	98.66 (83.43)
HPR-2143	16.33 (23.82)	54.33 (47.46)	8.66 (17.10)	53.33 (46.89)	90.00 (71.55)	96.33 (78.95)	22.00 (27.95)	96.33 (78.95)
HPR-2682	1.33 (5.41)	27.33 (31.49)	2.00 (8.12)	29.33 (32.77)	97.33 (80.60)	99.66 (88.05)	42.66 (40.76)	99.66 (88.05)
HPR-2687	36.66 (37.25)	81.33 (64.37)	29.33 (32.14)	66.33 (54.51)	97.33 (80.60)	98.66 (83.43)	57.66 (49.39)	98.66 (83.43)
HPR-2697	28.66 (32.35)	87.00 (68.84)	19.66 (26.31)	86.33 (68.27)	98.66 (84.72)	99.33 (87.25)	39.00 (38.62)	99.33 (87.25)
HPR-2699	30.33 (33.40)	67.33 (55.12)	19.00 (25.83)	78.33 (62.23)	97.66 (81.22)	99.00 (85.34)	51.66 (45.95)	99.00 (85.34)
HPR-2707	32.66 (34.84)	78.00 (62.01)	29.66 (32.98)	55.66 (48.23)	97.66 (81.22)	98.33 (82.63)	61.33 (51.53)	98.33 (82.63)
HPR-2711	14.33 (22.23)	57.00 (49.00)	18.33 (25.33)	80.66 (63.89)	97.66 (81.22)	99.00 (85.34)	49.33 (44.60)	99.00 (85.34)
HPR-2766	8.33 (16.76)	50.00 (44.98)	0.66 (3.84)	20.66 (27.02)	97.66 (81.22)	98.66 (84.72)	53.66 (47.08)	98.66 (84.72)
HPR-2748	25.66 (30.42)	69.00 (56.14)	18.33 (25.33)	80.66 (63.89)	97.33 (80.60)	97.66 (81.22)	41.33 (39.99)	97.66 (81.22)
HPR-2746	33.33 (35.24)	82.33 (65.13)	20.66 (27.02)	57.66 (49.39)	95.66 (77.97)	99.00 (85.34)	39.33 (38.82)	99.00 (85.34)
Chinudhan	17.00 (24.33)	62.00 (51.92)	28.33 (32.14)	81.66 (64.62)	97.00 (80.08)	97.33 (80.60)	38.66 (38.43)	97.33 (80.60)
Jhinidhan	15.00 (22.77)	58.00 (49.58)	23.66 (29.069)	84.66 (66.92)	93.00 (74.65)	98.00 (82.01)	31.66 (34.25)	98.00 (82.01)
Saaldhan	28.33 (32.14)	61.33 (51.53)	14.66 (22.50)	62.66 (52.31)	96.00 (78.49)	87.66 (69.41)	34.33 (35.85)	87.66 (69.41)

Sailadhan	20.66 (27.02)	56.00 (48.42)	23.66 (29.09)	72.33 (58.24)	84.00 (66.40)	98.33 (82.63)	43.00 (40.95)	98.33 (82.63)
Kaludhan	34.33 (35.85)	72.33 (58.25)	14.66 (22.50)	67.33 (55.12)	99.00 (85.342)	99.66 (86.13)	47.00 (43.26)	99.66 (86.13)
Kalijhini-1	40.33 (39.41)	76.33 (60.87)	6.66 (14.94)	67.66 (55.32)	98.00 (82.0)	99.66 (88.05)	38.33 (38.23)	99.66 (88.05)
Kalijhini-2	40.66 (39.60)	86.33 (68.29)	13.66 (21.68)	68.66 (55.93)	98.66 (84.54)	99.33 (86.13)	41.00 (39.79)	99.33 (86.13)
Ramjawandhan	28.33 (32.14)	73.60 (59.10)	8.33 (16.76)	73.66 (59.10)	99.00 (85.34)	99.33 (86.13)	39.00 (38.62)	99.33 (86.13)
Sukara	57.00 (49.00)	85.00 (67.19)	21.33 (27.49)	72.33 (58.24)	96.66 (79.47)	99.33 (86.13)	57.00 (49.00)	99.33 (86.13)
Chohartu	29.00 (32.56)	62.33 (52.12)	10.66 (19.05)	59.66 (50.55)	94.66 (76.62)	97.66 (81.22)	37.66 (37.84)	97.66 (81.22)
Karad	7.33 (15.69)	42.00 (40.37)	11.00 (19.34)	42.33 (40.57)	30.33 (33.40)	64.33 (53.30)	37.66 (37.84)	64.33 (53.30)
Mean	31.23	56.05	23.26	55.73	78.28	83.14	41.80	83.14
SE(m±)	108.8	9.061	7.18	10.76	9.44	6.86	50.56	6.86
CD (5%)	1.60	56.10	1.24	0.64	3.763	4.43	41.80	4.43

Table 3: Germination test- Vigour index-I and vigour index –II

Varieties	Fresh seeds				6 month stored seeds			
	Germination test		Accelerated aging test		Germination test		Field emergence test	
	Vigour index-I	Vigour index-II	Vigour index-I	Vigour index-II	Vigour index-I	Vigour index-II	Vigour index-I	Vigour index-II
HPR-1068	1665.32	4.92	2265.16	5.49	2114.60	11.70	1483.40	6.99
HPR-2720	1585.83	0.37	2305.95	3.80	1784.50	6.88	1732.23	5.16
HPR-2612	1166.40	3.74	1661.91	4.22	1411.13	8.70	1396.87	5.12
KASTURI	610.63	2.72	655.71	2.21	1991.30	8.18	1094.60	3.95
HPR-1156	1612.03	3.15	1803.92	4.69	2113.27	8.64	1047.63	5.13
HPR-2880	1378.78	3.87	2585.01	5.33	1966.20	7.60	2130.63	7.20
HPR-2656	2005.69	5.26	1724.10	4.30	1952.10	9.02	1745.37	5.45
HPR-2421	2138.80	6.49	2426.50	6.27	1872.67	9.06	968.67	6.39
VL-221	1784.22	5.61	3483.17	8.07	2207.70	8.79	1369.03	5.24
HPR-2143	819.18	4.65	780.54	2.76	2063.43	8.85	1187.60	3.49
HPR-2682	490.95	1.41	703.27	1.89	1730.87	6.61	370.53	3.19
HPR-2687	2088.31	5.22	2344.85	4.78	2023.63	8.74	2112.10	6.71
HPR-2697	2211.07	6.16	3133.15	6.92	1969.00	9.12	1285.97	5.32
HPR-2699	1377.55	5.42	1884.47	5.16	1883.30	8.71	1105.07	3.75
HPR-2707	1563.86	4.61	1493.86	3.81	1688.87	10.18	987.13	6.25
HPR-2711	1706.29	3.92	3244.33	6.87	1775.43	9.12	1720.30	5.99
HPR-2766	1369.09	4.18	741.32	1.49	1906.43	7.89	1932.40	5.82
HPR-2748	1687.53	4.73	2594.80	6.20	1967.43	7.22	588.13	4.46
HPR-2746	1418.61	6.25	2233.30	4.13	1822.00	6.72	1446.27	3.66
Chinudhan	1415.00	5.36	2752.66	8.22	2352.23	9.65	853.33	3.74
Jhinidhan	1362.82	5.68	2667.06	4.90	1955.20	7.34	1462.43	5.22
Saaldhan	1633.44	3.57	2305.50	6.61	2324.87	11.08	2056.33	8.49
Sailadhan	1612.53	6.02	2802.84	6.00	2472.47	9.57	1749.60	5.13
Kaludhan	1837.19	6.31	2318.41	6.21	2821.23	12.18	2196.70	7.44
Kalijhini-1	1095.79	6.43	687.38	1.72	2217.80	7.81	1005.90	5.16
Kalijhini-2	2244.30	2.09	2612.80	4.15	1985.17	7.93	1515.43	3.91
Ramjawandhan	1764.23	4.26	2194.08	5.33	2033.83	8.60	1543.20	5.39
Sukara	1895.27	5.65	2324.77	7.52	2606.20	10.88	1794.77	6.72
Chohartu	1065.39	6.46	1669.80	4.05	1676.23	8.78	1394.93	5.67
Karad	710.78	2.95	1092.14	2.54	1427.07	5.96	1070.90	3.84
Mean	1750.32	0.7188	2049.00	0.223	2003.87	0.928158	1411.02	0.1357
SE(m±)	458.06	4.58	793.44	4.85	307.41	8.72	144.37	5.33
CD (5%)	6.85	1.5733	4.917	1.85	6.7461	1.47	5.198	1.315

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