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Studies on seed longevity of rice genotypes

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Abstract
The laboratory study was carried out to find the storability of the seventeen rice genotypes at Department of Seed science and Technology, University of Agricultural Sciences Raichur, Karnataka. The seeds raised under direct seeded rice (DSR) method at farmer's field in Raichur district, Karnataka. The seeds were harvested, procured and stored in cloth bag under ambient condition for twelve months. Significantly, lowest moisture content was observed in MAS-26 (11.00 %) at the end of storage period followed by the genotype MT-4541 (11.20 %), MTU-1010 (11.3 %). Among the genotypes, MAS-26 recorded higher seed germination percentage (83.60 %), higher test weight (22.97 g), highest seedling length (26.20 cm), seedling dry weight (9.99 mg seedling^{-1}), seedling vigour index (SVI) II (836), highest speed of germination (22.91), electrical conductivity (0.191 dSm^{-1}), higher total dehydrogenase (TDH) activity (0.491 OD value), minimum loss of α- amylase activity (12.66 mm) and the least fungal infection (7.53 %) was noticed at the end of storage time. Rice genotypes under natural ageing showed significant difference for quality parameters that varies from one genotype to other. This investigation helps in understanding the storage potential of the genotypes which can be helpful in crop improvement programme.

Keywords: Genotype MAS-26, moisture content, seed germination, SVI, electrical conductivity, alpha amylase, dehydrogenase activity

Introduction
The population projections from the United Nations and income projections from the Food and Agricultural Policy Research Institute (FAPRI) around the world demand for rice which is estimated to be 496 million tonnes in 2020 and further increase to 555 million tonnes in 2035. The increasing population rate challenges the world's food requirements and an area expansion under rice likely to decline nowadays because of urbanization, climate change and high value agriculture. In this context, rice yields must be enhanced at least 8-10 million tonnes more each year with an annual increase of 1.2 to 1.5 per cent over the coming decade, so the extra rice required to feed the accelerating population ought to be met only by improving the productivity of rice, it is more so in India.

During seed production, it is very important to produce high yield with good productivity under different climate changing patterns and also during storage. Seeds deteriorate very fast over a period of storage time. Damage in seed quality during storage can be prevented if seeds obtained from parent plants are genetically pure, free from disease and insect pests. The loss of viability during storage due to atmospheric factors at the time of maturity is a common phenomenon in all crop seeds (Roberts, 1972). Seed quality may also differ between cultivars, among and within the seed lots. The two important factors *i.e.*, temperature and relative humidity affect seed longevity during storage as well studied and quantified for rice (Ellis *et al*., 1992) [13] and influenced by genetic factors of the varieties involved (Agarwal, 1974) [3] and also regulated by initial seed quality, physical and chemical composition of seed (Doijoide, 1988) [12]. As different cultivars possess different physical structure and chemical composition which determines the longevity of seed in storage.

Thus, maintenance of high seed quality during storage is of great significance. Therefore, an understanding of how best the seeds can be stored under temperature and relative humidity at relatively low cost, with minimum deterioration of seed quality for periods extending over one or more seasons will be of immense use for seed industry and for farming community. Hence, there is a need to identify the genotypes with good seed longevity for use in hybridization programme as well as bringing them in seed production chain which are highly suitable for direct seeded rice (DSR) cultivation. The literature pertaining to the storability of the seeds obtained from respective genotype rose under direct seeded rice (DSR) method were scanty. Keeping this in view, the present study was undertaken to screen the available rice genotypes for their longevity.

Materials and methods

The study on longevity of rice genotypes was investigated at Department of Seed Science and Technology, University of Agricultural Sciences, Raichur (India). The freshly harvested seeds were procured from direct seeded rice (DSR) research plot and kept for storage in cloth bag up to 12 months under ambient conditions. The experiment was designed in Completely Randomized Block Design (CRD) with seventeen rice genotypes *viz*., (G_1:RYC-230, G_2:GNV-1405, G_3:GNV-1089, G_4:GNV-1301, G_5:GNV-05-01, G_6:GNV-1109, G_7:MT-4253, G_8:IET-22066, G_9:MT-4021, G_{10}:BPT-5204, G_{11}:IET-18299, G_{12}:MT-4420, G_{13}:MTU-1010, G_{14}:MT-4541, G_{15}:IET-19251, G_{16}:MAS-26 and G_{17}:MAS-946-1) and three replication (Fig. 1). Observations were noted at bimonthly intervals and subjected to test the proposed physiological, biochemical and seed health parameters.

Physiological parameters

The observations for seed quality parameters *viz*., moisture content of seed was determined as per ISTA rules (ISTA, 1985) [22]. Germination test was conducted on pure seed fraction using 100 seeds in three replicates following between paper (BP) method at 25^0C temperature and 93±2% relative humidity as per ISTA (1985) [22]. The numbers of normal seedlings were counted on 5th day (first count) and 14th day (final count) of germination from all the replications. The average of three replications was expressed as germination percentage. From the germination test, five normal seedlings were taken in butter paper and dried in hot air oven maintained at 70 ± 2^0 C temperature for 24 hours. Then, the seedlings were removed and allowed to cool in a desiccator for 30 minutes before weighing in an electronic balance. The average weight was calculated and expressed as seedling dry weight in milligram. Seedling vigour index (SVI) II was calculated on germination and seedling dry weight basis as per the following formula (Abdul-Baki and Anderson, 1973) [1] *i.e*., SVI II = Seed germination (%) × seedling dry weight (mg), where in seedling length = shoot length (cm) + root length (cm). Ten normal seedlings were taken randomly from each replication at final count of germination test for measuring the shoot length and root length in centimeters. Eight replication of thousand seeds were counted manually from a sample drawn randomly from each treatment and weighed as per the procedure given by ISTA. The mean weight of the sample was recorded as thousand seed weight and expressed in grams. Seeds were germinated on paper medium with four replications of 100 seeds each. The speed of germination was calculated by using the formula as suggested by Maguire (1962) [29] as below

$$\text{Speed of germination} = \frac{G_1}{D_1} + \frac{G_2}{D_2} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + \frac{G_n}{D_n}$$

Where, G_1, G_2, - - - G_n are the number of seeds germinated on D_1, D_2, - - - D_n day

Biochemical parameters

Electrical conductivity

Five grams of seeds in two replications were soaked in acetone for half a minute and thoroughly washed in distilled water three times. Then, the seeds were soaked in 25 ml distilled water and kept in an incubator maintained at 25 °C ± 1 °C for twelve hours. The seed leachate was collected and the volume was made up to 25 ml by adding distilled water. The electrical conductivity of the seed leachate was measured in the digital conductivity bridge (ELICO) with a cell constant 1.0 and the mean values were expressed in deci Simons per centimeter (dSm^{-1}) (ISTA, 1999) [21].

Dehydrogenase activity

Twenty five representative seeds from each treatment in two replications were taken and preconditioned by soaking in water overnight at room temperature. The dehusked seeds were steeped in 0.25 per cent solution of 2, 3, 5-triphenyl tetrazolium chloride and kept in dark for two hours at 40ºC for staining. The stained seeds were thoroughly washed with water and then soaked in 10 ml of 2 methoxy ethanol (methyl cellosolve) and kept overnight for extracting the red colour formazan. The intensity of red colour was measured using ELICO UV-VIS spectrophotometer (model SC-159) using blue filter at 470 nm wave length and methyl cellosolve was used as a blank. The optical density (OD) value obtained was reported as dehydrogenase activity (Kittock and Law, 1968) [28].

Alpha amylase activity

The α-amylase activity was analyzed as per the method suggested by Simpson and Naylor (1962). Two gram of agar shreds and one gram of potato starch was mixed together in water to form paste and the volume was made up to 100 ml with distilled water. The homogenous solution of agar-starch mixture after boiling was poured into sterilized petri-dishes and allowed to settle in the form of gel after cooling. The pre-soaked (for 8 hour) and half cut seeds (with their half endosperm and embryo portion intact) were placed in the petri-dishes in such a way that the endospermic part remained in contact with agar-starch gel. The petri-dishes were closed and kept in dark at 30 º C. After 48 hour, the petri-dishes were uniformly smeared with potassium iodide solution (0.44 g of iodine crystal + 20.008 g potassium iodide in 500 ml distilled water) and excess solution was drained off after few minutes. The diameter of halo (clear) zone formed around the seed was measured in mm and reported as α – amylase activity.

Seed health test

Seed health testing of stored seeds for fungal infection was carried out using blotter technique. Twenty five seeds taken at random were placed at equidistance without surface sterilization on three layered sterile moisture blotters in petri plates. Each treatment was replicated four times. The plates were incubated at alternating cycle of UV light and dark for 12 h. at 20 ± 2° C for seven days. The seeds were examined under a stereomicroscope on 8th day after incubation. The number of infected seeds were counted and expressed in percentage (ISTA, 1999) [21].

Statistical analysis

The data collected from the experiments were analyzed statistically by the procedure prescribed by Sundararaj *et al*. (1972). Critical differences were calculated at 1 per cent level wherever 'F' test was significant. Control treatment was compared with rest of the treatment by following ANOVA statistical analysis.

Results and Discussion

The moisture content of seeds recorded at bimonthly interval showed variations up to 10th month and decreased at 12th

month of storage irrespective of the genotypes. Significantly, lowest moisture content was observed in MAS - 26 (11.00 %) at the end of storage period followed by MT-4541 (11.20 %), MTU-1010 (11.3 %) (Table 1). Results are in agreement with the findings of Agarwal (1976) [2], Dharam Singh (1999) [10], Ramandane and Ponnuswamy (2004) in rice, Pham Long Giang and Rame Gowda (2007) in hybrid rice, Rettinassababady and Ramanadane (2012) in rice and Sawant *et al*. (2012) in wheat. The increase in moisture could be due to increase in relative humidity of the storage environment and also the differential behaviour of the genotypes in absorbing the moisture during natural ageing. The container used in the present study was cloth bag which is moisture pervious. The other probable means of seed moisture increase are metabolic release of water, insect infestation and fungal infection as reported by Raja (2003). The increased moisture content also leads to biochemical events take place such as increased hydrolytic enzyme activity and increased free fatty acid (Gomathi, 2009) [15].

Among the genotypes, MAS-26 recorded higher seed germination initially (95.53 %) and maintained the same up to 12 months of storage (83.60 %), while genotype GNV-1301 recorded lower germination (91.57%) initially and maintained the same throughout the storage period (78.20 %) (Table 1). There was a significant progressive reduction in germination per cent with increase in duration of ageing in rice was also reported by Anil Sebastian and Selvaraju (2017) [4] and Pedireddi *et al*. (2018). In the present study, mean test weight also decreased among the genotypes from 18.07 g at initial stage to 17.45 g at the end of storage (Table 1). Even after 12 months of storage, out of seventeen genotypes, thirteen genotypes maintained seed germination above the minimum seed certification standard (80.00%). These results are in accordance with the findings of (Ramanadane and Ponnuswamy, 2004) in rice, Biradar Patil *et al*. (2007) [7] in hybrid rice, Pham Long and Rame Gowda (2007) in hybrid rice, Choudhury *et al*. (2011) [8] in rice and Anil Sebastian and Selvaraju (2017) [4] in rice. This variation in storability among the genotypes was obviously due to the genetic control to resist deterioration during storage (Yogalakshmi *et al*., 1996). The decrease in germination percentage during storage might be attributed to ageing effect, leading to depletion of food reserves and decline in synthetic activity of embryo apart from death of seed because of fungal invasion, insect damage and storage conditions (Vijaykumar Kunkur *et al*., 2007 in cotton) and (Manjunath *et al*., 2008 [30] in chilli).

The relative length of seedling and dry matter production in germinating seedling would predict their subsequent growth and performance (Woodstock and Combs, 1964). Seedling length and dry matter production of the seedlings are the manifestation of the physiological efficiency of the germinating seeds, which depends on the seedling vigour (Heydecker, 1973) [19] and seedling growth has been regarded as a good index to measure the vigour of seeds (Abdul-Baki and Anderson, 1973) [1]. Deterioration in seed quality associated with decrease in seedling length, dry matter production and vigour index with the passage of time in storage has been confirmed by Singh *et al*. (2004). In the present study, MAS-26 genotype proved best at the end of storage as it recorded highest seedling length (26.20 cm), seedling dry weight (9.99 mg seedling^{-1}) and seedling vigour index II (836) (Table 2). These parameters gradually decrease among the genotypes over storage time. This variation may be due to the inherent genotypic difference and the amount of stored food reserve mobilized as reflected in test weight which ultimately contributed to longer seedling length, higher seedling dry weight as well as vigour. The decrease in the seedling vigour index was related to the decreased seed germination and mean seedling length over a storage period as reported by Rame Gowda (1992), Biradar patil *et al*. (2007) [7] in hybrid rice, Anil Sebastian and Selvaraju (2017) [4] and Pedireddi *et al*. (2018) in rice. Our findings are also in accordance with the results of Sundaralingam (2005) and Kavitha (2011) [24] in rice and Javid *et al*. (2013) [23] in sorghum, rice, maize and pigeonpea.

Speed of germination declined with the advancement of storage in all the genotypes but extent was varied with genotypes. The genotype MAS-26 recorded highest speed of germination in all the months of storage (23.60 at initial and 22.91 at the end of storage) over rest of the genotypes, whereas lowest was observed in GNV-1301 (20.07 at initial and 19.24) at the end of storage (Table 2). Similar results were found by Maruthi (2016) [31] and Anil Sebastian and Selvaraju (2017) [4] in rice. Highest speed of germination might be due to higher seed index hence, seed with higher initial capital food reserve always showed rapid and fast germination (Kavitha, 2002) [25].

Deterioration alters the semi-permeable property of the membrane and the membrane integrity**.** The conductivity of the seed leachate was found to be good index of seed viability (Mathews and Bradnock, 1968) [32], vigour (Grabe, 1967) and deterioration (Hibbard and Miller, 1928) [20]. Membrane integrity of the seed has greater influence on seed performance (Tappel, 1965 and Berjack, 1968) [5]. Electrical conductivity (EC) of seed leachate, leaching of sugars and amino acids are negatively associated with membrane integrity and so with germination and vigour (Delouche and Baskin, 1973; Bhaskaran, 1995; and Sabirahamed, 2003) [9, 6]. In the present study, electrical conductivity of the seed leachate increased with increase in period of storage. Among the genotypes, MAS-26 released lower electrolytes to seed leachate (0.141 dSm^{-1} at initial to 0.191 dSm^{-1} at the end of storage) and genotype GNV-1301 recorded more EC (0.186 dSm^{-1} to 0.236 dSm^{-1} respectively) (Table 3). The significant variation in EC may be due to increase of moisture content that might have promoted the metabolic process resulting in leaching of free sugars and free amino acids. The probable reason for low electrical conductivity in the seeds presumed to be the quenching of free radicals, which consequentially restore the membrane integrity. These results are in conformity with the findings of Sundaralingam (2005), Nagarajaiah (2014) [34], Khidrapure (2015) [27], Anil Sebastian and Selvaraju (2017) [4] and Pedireddi *et al*. (2018) in rice. The dehydrogenase enzyme activity is a good stable metabolic marker to estimate the degree of vigour in seeds (Saxena *et al*., 1987) and have positive association with vigour and viability of seeds (Halder and Gupta, 1982; Rudrapal and Basu, 1982) [17]. The dehydrogenase enzyme activity decreased with the advancement in storage period due to the inability of the seed tissues to reduce tetrazolium chloride to insoluble formazan as revealed by Raja (2003) in paddy. In the present study, the total dehydrogenase activity (TDH) decreased with increase in storage period. At the end of storage, MAS-26 recorded higher TDH activity (0.491 OD value), whereas, GNV-1301 recorded lower (0.372 OD value) (Table 3). Decrease in dehydrogenase enzyme activity may be related to age induced deterioration which is a common phenomenon in any living entity and difference in genotypic response may be due to variation in inherent genotypic composition to withstand the impact of ageing. The changes in electrical conductivity and dehydrogenase activity can be

correlated with the loss of germination and seedling vigour of the seeds during storage. Alpha-amylase actually represents the predominant contribution of the carbohydrate metabolism in endosperm of rice seeds and represents the variable spectrum of germination potential (seed vigour) of sindh rice cultivars (Galani *et al.,* 2011) [14]. Rame Gowda (1992) reported a decrease in the activity of enzymes *viz.,* a-amylase, catalyze and peroxides, coupled with progressive ageing of rice seeds. Alpha-amylase plays an important role in hydrolyzing the endosperm starch into soluble sugars in the aleurone layer that provide the energy for the growth of roots and shoots (Rao *et al.,* 1996). The early vigour in rice is measured through root and shoot length of seedlings. The information on α-amylase isozymes and their association with early vigour-related traits have been reported earlier. Svetlana *et al*. (2013) reported that radicle extension was closely correlated with α- amylase activity and suggested that this might be a limiting step in germination. In the present findings, although alpha-amylase activity declined in all the genotypes during storage period but, minimum loss of alpha - amylase activity (21.24 mm at initial to 12.66 mm at the end of storage) was noticed in the genotype MAS-26 and highest in the genotype GNV-1301 (10.90 mm at initial to 7.72 mm at the end of storage) (Table 3) (Fig. 2). Similar results were observed by Rame Gouda (1992), Nagarajaiah (2014) [34], Khidrapure (2015) [27], Anil Sebastian and Selvaraju (2017) [4] and Peddireddi *et al*. (2018) in rice. Diwan and Shenoy (2001) [11] observed the association between high mobility type amylase isozymes and higher vigour in paddy genotypes and reported that it could be due to the presence of genes controlling both the traits on a single chromosome. This is supported by the observations that the genes governing α-amylase isozymes are located on rice chromosome 1 and a positively contributing QTL for shoot length is also on chromosome1 (Hemamalini *et al*., 1996) [18].

Fungal infection is also one of the factors of seed deterioration. Murthy *et al.* (1987) [33] reported infection of various fungi in paddy seeds during storage. Evaluation of seed health status in the study revealed progressive increase in infection as the storage period increased (Fig.15). The least fungal infection was observed in the genotypes MAS-26 (1.12 %), MT-4541 (1.17 %) and genotype MTU-1010 (1.33 %) at initial stage. Whereas, maximum incidence was noticed in genotype GNV-1301 (3.67 %) followed by GNV-1405 (3.56 %) and BPT-5204 (3.37 %) (Table 3). Similar results of genotypic variations in fungal infection have been reported by Varughese and Pillai (1990), Khashem *et al.* (1996) [26], Vijayan (2005), Naher *et al*. (2016) [35], Naveeen Kumar *et al*. (2017) and Pedireddi *et al*. (2018) in rice.

Table 1: Seed moisture content (%) and test weight (g) and seed germination (%) as influenced by rice genotypes during storage

Genotypes	Moisture content				Test weight				Seed germination			
	Months of storage											
	0	4	8	12	0	4	8	12	0	4	8	12
G_1: RYC-230	11.59	11.12	11.33	11.73	18.17	17.55	17.43	17.51	93.92	90.23	86.00	81.23
G_2: GNV-1405	12.03	11.04	11.36	12.23	12.65	12.17	12.21	12.03	91.83	87.10	82.19	78.67
G_3: GNV-1089	11.57	11.38	11.68	11.67	15.78	15.20	15.06	15.12	94.30	90.60	87.00	81.67
G_4: GNV-1301	12.47	11.00	11.72	12.51	13.94	13.45	13.39	13.46	91.57	86.88	82.00	78.20
G_5: GNV-05-01	11.77	10.87	11.20	12.20	13.06	12.59	12.49	12.51	93.00	89.13	83.00	79.70
G_6: GNV-1109	11.52	11.63	11.97	11.53	21.41	20.85	20.75	20.87	94.80	92.07	88.03	82.43
G_7: MT-4253	11.49	12.17	12.47	11.47	21.21	20.73	20.62	20.75	94.87	92.10	88.37	82.60
G_8: IET-22066	11.66	10.83	10.97	12.10	19.00	18.36	18.24	18.34	93.10	89.50	83.07	80.10
G_9: MT-4021	11.42	11.63	11.73	11.33	23.07	22.30	22.15	22.25	94.93	92.67	88.50	82.73
G_{10}: BPT-5204	11.90	11.22	11.47	12.29	14.25	13.68	13.54	13.59	92.67	88.97	82.19	78.80
G_{11}: IET-18299	11.60	11.10	11.60	11.90	12.90	12.45	12.31	12.34	93.47	90.20	85.97	81.00
G_{12}: MT-4420	11.67	11.04	11.58	12.08	20.83	20.16	20.10	20.22	93.30	89.83	85.63	80.63
G_{13}: MTU-1010	11.43	11.87	12.00	11.30	22.97	22.26	22.17	22.31	95.10	92.73	88.97	83.47
G_{14}: MT-4541	11.37	11.83	12.15	11.20	19.90	19.25	19.14	19.24	95.20	93.33	90.20	83.57
G_{15}: IET-19251	11.54	11.47	12.21	11.55	17.86	17.24	17.122	17.20	94.70	91.35	87.87	82.30
G_{16}: MAS-26	11.48	11.99	12.20	11.00	22.80	22.25	22.13	22.27	95.53	93.43	92.03	83.60
G_{17}: MAS-946-1	11.53	11.43	12.30	11.63	17.33	16.72	16.59	16.67	94.37	90.72	87.17	82.03
Mean	11.59	11.39	11.76	11.76	18.07	17.48	17.38	17.45	93.92	90.64	86.36	81.34
Sem±	0.15	0.26	0.17	0.19	0.32	0.17	0.14	0.07	1.96	0.41	0.43	0.48
CD @ 1 %	0.59	1.01	0.64	0.74	1.23	0.66	0.55	0.26	0.51	1.59	1.66	1.84

Table 2: Seedling lengths (cm), Seedling dry weight (mg seedling $^{-1}$), speed of germination and seedling vigour index (SVI) II as influenced by rice genotypes during storage

Genotypes	Seedling length (cm)				Seedling dry weight				Speed of germination				Seedling Vigour Index (SVI) II			
	Months of storage															
	0	4	8	12	0	4	8	12	0	4	8	12	0	4	8	12
G_1: RYC-230	24.80	22.80	20.80	18.60	8.44	8.26	8.22	7.96	21.98	21.70	21.50	21.23	793	746	707	646
G_2: GNV-1405	21.18	19.20	17.23	15.60	8.02	7.36	7.37	7.22	20.29	20.03	19.78	19.39	736	642	606	568
G_3: GNV-1089	25.19	23.00	21.90	19.90	8.62	8.43	8.36	8.17	22.25	22.04	21.80	21.48	812	763	727	668
G_4: GNV-1301	20.60	18.70	17.20	15.40	7.95	7.47	7.41	7.19	20.07	19.90	19.66	19.24	727	649	608	562
G_5: GNV-05-01	22.26	20.80	18.80	16.85	8.12	7.91	7.88	7.68	21.19	21.01	20.83	20.61	755	705	654	612
G_6: GNV-1109	27.70	25.80	23.90	21.80	9.54	9.39	9.34	9.11	22.91	22.73	22.56	22.45	904	865	822	751
G_7: MT-4253	28.20	26.80	24.00	22.20	9.77	9.50	9.41	9.17	22.96	22.75	22.59	22.37	927	875	831	757
G_8: IET-22066	24.22	21.34	19.50	17.65	8.25	8.05	7.90	7.77	21.25	21.03	20.86	20.63	768	720	656	622
G_9: MT-4021	29.61	26.90	24.20	22.45	9.98	9.76	9.71	9.47	23.10	22.92	22.70	22.38	948	905	859	783
G_{10}: BPT-5204	21.95	19.80	17.50	15.99	8.06	7.52	7.46	7.26	20.35	20.18	19.86	19.64	747	669	613	572

G_{11}: IET-18299	24.68	22.20	20.40	18.56	8.37	8.21	8.14	7.85	21.80	21.59	21.35	21.09	782	741	699	636
G_{12}: MT-4420	24.60	21.40	19.70	17.89	8.30	8.07	7.91	7.80	21.64	21.41	21.24	20.90	774	725	678	629
G_{13}: MTU-1010	29.72	27.20	26.30	23.40	10.23	9.96	9.91	9.56	23.23	22.95	22.74	22.36	973	923	881	798
G_{14}: MT-4541	29.90	28.10	25.50	24.70	10.26	9.99	9.94	9.68	23.32	23.15	22.90	22.45	976	933	897	809
G_{15}: IET-19251	26.65	25.20	23.40	21.50	9.27	8.97	8.83	8.65	22.84	22.70	22.51	22.34	878	819	776	712
G_{16}: MAS-26	32.12	30.20	28.10	26.20	11.01	10.37	10.24	9.99	23.60	23.40	23.18	22.91	1051	969	943	836
G_{17}: MAS-946-1	26.06	24.80	22.00	20.50	9.07	8.95	8.78	8.63	22.58	22.42	22.26	22.06	856	812	766	708
Mean	25.85	23.78	21.79	19.95	9.01	8.72	8.64	8.42	22.08	21.88	21.67	21.38	847.57	791.78	748.38	686.32
Sem±	0.57	0.94	0.77	0.89	1.67	0.61	0.14	0.09	0.30	0.25	0.21	0.16	15.93	13.93	13.14	5.78
CD @ 1 %	2.20	3.61	2.96	3.44	0.64	2.35	0.55	0.37	1.14	0.96	0.79	0.63	61.37	53.66	50.61	22.27

Table 3: Electrical conductivity (dSm-¹), Dehydrogenase activity (OD value), alpha-amylase activity (mm) and fungal incidence (%) in rice genotypes during storage

Genotypes	Electrical conductivity				Dehydrogenase activity (OD value)				alpha-amylase activity				fungal incidence			
	Months of storage															
	0	4	8	12	0	4	8	12	0	4	8	12	0	4	8	12
G_1: RYC-230	0.169	0.175	0.191	0.219	0.617	0.590	0.460	0.429	15.30	13.80	9.70	8.61	2.07	5.67	7.48	9.20
G_2: GNV-1405	0.184	0.190	0.206	0.234	0.515	0.538	0.417	0.380	11.16	10.10	8.72	7.82	3.56	5.91	7.73	9.80
G_3: GNV-1089	0.166	0.172	0.188	0.216	0.619	0.594	0.469	0.436	15.50	13.92	9.82	8.66	1.99	5.64	7.37	9.17
G_4: GNV-1301	0.186	0.192	0.208	0.236	0.494	0.534	0.412	0.372	10.90	10.09	8.20	7.72	3.67	6.01	7.83	9.93
G_5: GNV-05-01	0.179	0.185	0.201	0.229	0.535	0.554	0.436	0.387	13.73	12.17	9.36	7.93	3.13	5.83	7.67	9.63
G_6: GNV-1109	0.161	0.167	0.183	0.211	0.709	0.631	0.488	0.459	16.49	15.05	10.94	8.85	1.80	5.25	7.07	8.70
G_7: MT-4253	0.158	0.164	0.181	0.209	0.728	0.639	0.498	0.462	17.92	16.28	12.59	10.31	1.60	4.88	6.90	8.63
G_8: IET-22066	0.175	0.181	0.197	0.225	0.559	0.575	0.439	0.401	14.79	13.23	9.23	8.00	2.56	5.79	7.63	9.50
G_9: MT-4021	0.155	0.161	0.177	0.205	0.763	0.642	0.512	0.465	18.16	16.63	12.80	10.51	1.40	4.87	6.50	8.33
G_{10}: BPT-5204	0.181	0.186	0.202	0.230	0.523	0.550	0.428	0.384	11.21	10.55	9.26	7.84	3.37	5.87	7.67	9.73
G_{11}: IET-18299	0.172	0.178	0.194	0.222	0.601	0.586	0.454	0.418	15.07	13.48	9.39	8.15	2.13	5.77	7.48	9.37
G_{12}: MT-4420	0.173	0.179	0.195	0.223	0.576	0.582	0.449	0.407	14.91	13.32	9.23	8.09	2.31	5.78	7.60	9.40
G_{13}: MTU-1010	0.151	0.157	0.174	0.202	0.806	0.660	0.560	0.470	19.14	17.80	13.25	11.25	1.33	4.81	6.47	8.17
G_{14}: MT-4541	0.148	0.154	0.170	0.198	0.812	0.678	0.575	0.487	20.35	18.21	14.87	11.68	1.17	4.52	6.43	8.00
G_{15}: IET-19251	0.163	0.169	0.185	0.213	0.693	0.624	0.481	0.446	15.99	14.53	10.43	8.80	1.83	5.57	7.23	8.80
G_{16}: MAS-26	0.141	0.147	0.163	0.191	0.832	0.682	0.580	0.491	21.24	19.86	15.71	12.66	1.12	4.17	5.68	7.53
G_{17}: MAS-946-1	0.165	0.171	0.185	0.213	0.657	0.614	0.472	0.440	15.83	14.19	10.07	8.78	1.84	5.63	7.33	8.93
Mean	0.166	0.172	0.188	0.216	0.649	0.604	0.478	0.431	15.75	14.31	10.80	9.16	2.17	5.41	7.18	8.99
Sem±	0.001	0.002	0.005	0.008	0.009	0.001	0.002	0.005	0.09	0.24	0.19	0.19	0.29	0.24	0.08	0.16
CD @ 1 %	0.002	0.007	0.018	0.030	0.035	0.004	0.009	0.021	0.36	0.92	0.75	0.74	1.12	0.92	0.32	0.62

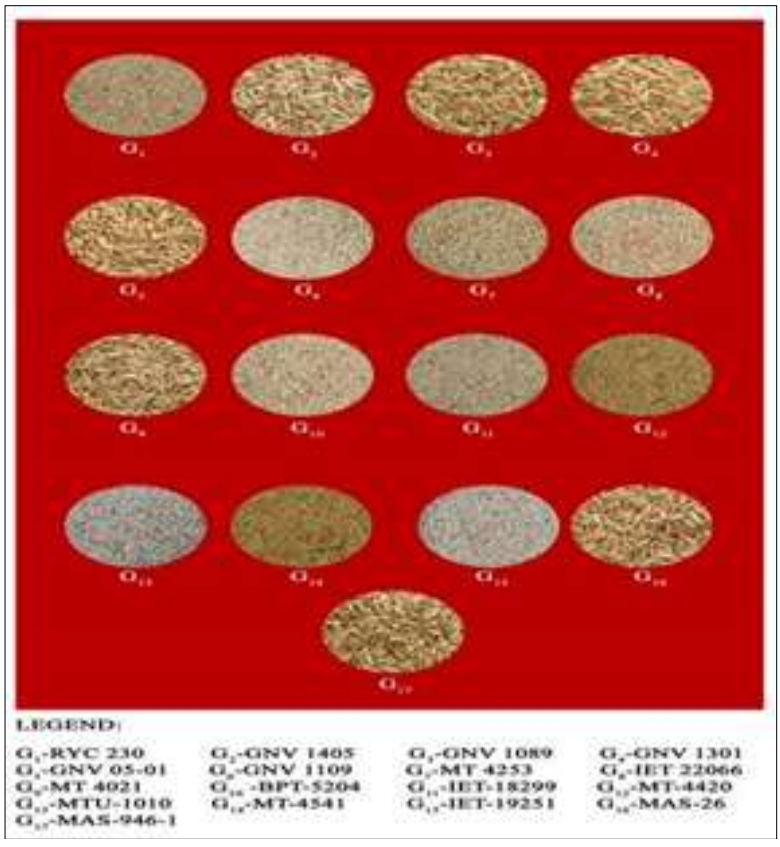

Fig 1: Rice genotypes used for longevity studies

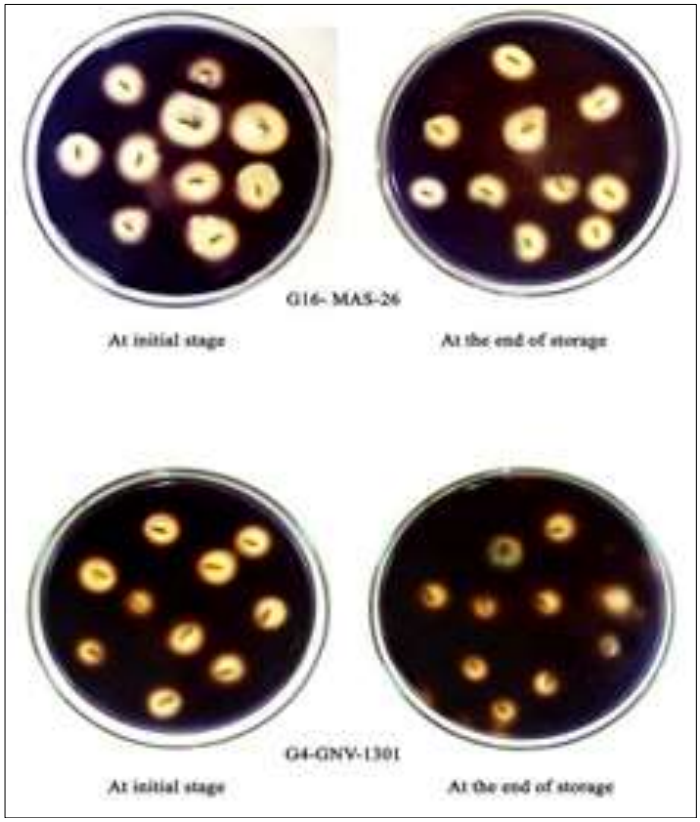

Fig 2: Alpha anylase activity of rice genotypes during storage

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