Direct RESEARCH JOURNALS

Direct Research Journal of Agriculture and Food Science Vol.1 (5), pp. 59-66, November 2013
Available online at http://directresearchpublisher.org/drjafs

Original Research Paper

Traditional Wisdom to safe guard the quality of organic Rice as a salvation to chemical residues of fertilizers

Arumugam* K., Senthivel .T. and Radhamani .T

Faculty of Agriculture and Animal Husbandry Gandhigram Rural Institute (DU), Gandhigram, Dindugul- 624 302, India.

ABSTRACT

Studies were undertaken to elicit information to standardize the optimum dose and soaking period of bio growth regulators in rice seeds, to evaluate the effect of sources and method of application of bio-growth regulators (panchakavya and brassinolide) on organic rice seed during 2003 and 2004 and to assess the quality of rice seeds cv. ADT(R) 45). The results illustrated that, the combined use of panchakavya 3 % and brassinolide 0.5 ppm (M_3) recorded the minimum seed moisture content in the initial period of storage which gradually increased with increasing storage period. Combination of panchakavya 3 % and brassinolide 0.5 ppm (M_3) registered the highest germination % (93) compared to untreated control (inorganic alone) (74%), showed lower values of Electrical conductivity, highest dehydrogenase enzyme activity while, this treatment recorded the maximum root and shoot length, dry matter production and vigor index after 10 months of storage. Among different of treatments, seed treatment + seedling root dip + foliar spray (S_7) recorded the minimum seed moisture content, higher germination potential and higher dehydrogenase enzyme activity which also declined with continuation of storage periods.

Key word: Quality of organic rice, Seed treatment, Brassinolide, Panchakavya..

*Corresponding Author E-mail: radha.agri@gmail.com

Accepted 17 July 2013

INTRODUCTION

Rice (*Oryza sativa* L.) accounts for the dietary energy requirements of almost half the world population. Over 90 percent of the world's rice is produced and consumed in Asia. Rice is the staple food for nearly 65 percent of the population in India (Sharma, 2004). The projected global rice demand for 2025 would be700 million tonnes, but current production was only 593 million tonnes. It is estimated that India's population by 2010 will increase to 1.2 billion from today's one billion mark and the country would need 143.0 million tonnes of rice to balance the food budget (Singh, 2002).

Chemical fertilizers is one of the major factors for increasing the food production from 50 million tonnes to 200 million tonnes .The chemical residues of fertilizers and pesticides accumulated in the soil year after year have rendered soil lifeless with its structure hardening. Now, the agricultural research is focused on evolving ecologically sound, biologically sustainable and socio economically viable technologies. The organic production system was imperfect and continued to be incomplete for want of an input to replace foliar fertilization, growth promoting hormones and immunity boosters to maximize the efficiency of cultivated crops and coordinate the process leading to sustained higher productivity.

As a salvation, Indian knowledge system is a treasure trove of information on panchakavya, one of the traditional wisdom meant to safe guard plants and soil micro organisms (Natarajan, 2002).With this background, an investigation was carried out to study the physiological, biochemical action of panchakavya and brassinolide on quality of organic rice variety ADT(R)45.

Seed is a living hygroscopic material with a very complex and heterogeneous composition. It should be maintained well from harvest to next sowing season without appreciable loss in vigor and viability. Storage of seed starts even before the harvest in the standing crop. Quality of seed in terms of storage potential is influenced by pre harvest factors viz., cultural and edaphic factors (Roberts, 1972), storage conditions (Harrington and Douglas, 1970) and incidence of storage insects and

Table 1. Standardization of panchakavya as seed treatment for rice.

Treatments	Germination (%)	Shoot length (cm)	Root length (cm)	Dry matter production (mg per 10 seedlings)	Vigor index
Concentration					
T_1 Control (water soaked)	85 (67)	12.4	14.7	112	2274
T_2 PK 2%	87 (70)	13.0	18.1	120	2706
T_3 PK 3%	95 (77)	14.9	21.4	138	3449
T_4 PK 4%	91 (73)	13.8	19.3	128	3012
T_5 PK 5%	88 (69)	13.2	18.6	122	2779
SEd	0.8	0.3	0.3	3	75
CD (0.05)	2.0	0.6	0.5	5	151
Soaking duration					
S_1 12 hrs.	87 (70)	12.5	16.9	119	2619
S_2 16 hrs.	91 (72)	14.1	19.1	127	3015
S_3 20 hrs.	90 (71)	13.8	18.7	125	2899
SEd	0.6	0.2	0.2	2	58
CD (0.05)	1.0	0.4	0.4	4	117

fungi (Sinha*et al*., 1979). Seed lots of the same kind, cultivars, chronological age and even germinability do not store equally well under identical conditions (Justice and Bass, 1978).

MATERIALS AND METHODS

A standardization study was carried out in the laboratory of Faculty of Agriculture and Animal Husbandry, Gandhigram Rural University, Dindigul during 2003 and 2004 to find out the suitable concentration and soaking period of bio-growth regulators. With a view to realize the objectives, the field experiment was conducted in the farmer's field at Jumbuliampatti village, Dindigul district, Tamil Nadu during 2003 and 2004 to study the effect of bio growth regulators on quality of rice cultivar ADT(45). The resultant seeds were examined under laboratory condition in the Faculty of Agriculture and Animal Husbandry, Gandhigram Rural University, Dindigul and Agriculture College and Research Institute, TNAU, Madurai during 2004 to assess the quality.

RESULTS AND DISCUSSION

Standardization test

The rice cultivar ADT(R) 45 soaked with different concentration of panchakavya (2, 3, 4 and 5 percent) and different concentration of brassinolide (0.25, 0.50, 1.00 and 2.00 ppm) for 12, 16 and 20 hours soaking duration to standardize the optimum dose showed that panchakavya and brassinolide treatments in general improved the germination percentage, seedling growth characteristics, vigor index and dry matter production over untreated treatment.However, the optimum dose and soaking period were found to be 3 percent panchakavya for 16 hours and 0.50 ppm brassinolide for 16 hours. (Table1 and 2). The similar result was conformed by Vijayan and Sundralingam (2005) who reported that 3 percent panchakavya was the ideal concentration for foliar spray in rice and Venkatesan (2004) in rice seeds treated with brassinolide.

Main field experiment

Effect of bio-growth regulators on quality characters

Seed storage studies was carried out with resultant rice seeds of ADT(R) 45 and it was also stored along with untreated control (inorganic alone) in cloth bag upto 10 months under ambient condition. This study revealed significant results. The initial storage study (P_0) was carried out at one week after harvest and subsequent evaluation was done at bi-monthly interval.

Seed moisture content (%)

The moisture content of seed plays a major role in determination of storability (Copeland and Mc Donald, 1995). In the present study, the combined use of panchakavya 3 % and brassinolide 0.5 ppm (M_3) registered the minimum seed moisture content in the initial period of storage which gradually increased with increasing storage period (Table 3). The bio-growth regulators could have lost their effect over storage period, which might have allowed seeds to become hygroscopic.

Among the method of application, seed treatment + seedling root dip + foliar spray (S_7) showed the minimum

Table 2. Standardization of brassinolide as seed treatment for rice.

Treatments	Germination (%)	Shoot length (cm)	Root length (cm)	Dry matter production (mg per 10 seedlings)	Vigour index
Concentration					
T_1 Control (water soaked)	85 (67)	12.4	15.0	111	2329
T_2 BL 0.25 ppm	90 (71)	13.8	19.0	129	2907
T_3 BL 0.5 ppm	95 (77)	14.8	20.8	140	3382
T_4 BL 1 ppm	91 (73)	14.1	19.4	131	3049
T_5 BL 2 ppm	87 (69)	13.5	18.7	125	2801
SEd	0.6	0.3	0.3	3	48
CD (0.05)	1.3	0.6	0.7	6	97
Soaking duration					
S_1 12 hrs.	88 (70)	13.1	17.8	121	2719
S_2 16 hrs.	91 (72)	14.1	19.2	132	3030
S_3 20 hrs.	90 (72)	13.9	18.7	129	2934
SEd	0.5	0.2	0.3	2	37
CD (0.05)	1.0	0.5	0.5	5	75

Table 3. Moisture content (per cent) of organic rice seeds during storage as influenced by bio-growth regulators.

	Storage periods (months)					
Treatments	**P_0**	**P_2**	**P_4**	**P_6**	**P_8**	**P_{10}**
Bio growth regulators						
M_1 – Panchakavya	10.2	10.5	11.1	12.4	13.3	13.8
M_2 –Brassinolides	10.2	10.6	11.0	12.3	13.2	13.9
M_3 - Panchakavya + Brassinolides	10.2	10.5	10.8	11.9	13.0	13.5
Sed	0.01	0.05	0.03	0.04	0.02	0.02
CD (P=0.05)	0.08	0.20	0.19	0.20	0.09	0.07
Method of application						
S_1 -Seed treatment	10.3	10.5	11.0	12.2	13.2	13.7
S_2 -Seedling root dip	10.3	10.7	11.1	12.6	13.6	14.1
S_3 –Foliar spray	10.3	10.6	11.1	12.4	13.5	14.0
S_4 –Seed treatment + Seedling root dip	10.2	10.5	10.9	12.1	13.1	13.7
S_5 – Seed treatment + foliar spray	10.2	10.5	10.9	12.0	12.9	13.4
S_6 - Seedling root dip + foliar spray	10.3	10.6	11.1	12.3	13.3	13.7
S_7 -Seed treatment + Seedling root dip+ folia spray	10.1	10.3	10.6	11.6	12.7	13.1
Sed	0.04	0.06	0.08	0.10	0.03	0.07
CD (P=0.05)	0.09	0.11	0.20	0.21	0.06	0.21
Untreated control (inorganic alone)	10.3	10.7	11.2	12.6	13.7	14.2

Po – one week after harvest; P_2 – two months; P_4 – four months; P_6 – six months; P_8 – eight months; P_{10} – ten months
Interaction not significant.

seed moisture content in the initial period of storage which also increased with increasing the storage period over all other treatments (Table 3). The increase in seed moisture content could be due to hygroscopic nature of the seed enabling moisture absorption from the surrounding atmosphere. The used container was cloth bag which is moisture pervious (Prasad, 1983; Jeyaraj*et al*., 1986).

Germination (%)

Irrespective of treatments germination potential of the seeds decreased with increasing in periods of storage. This result was in conformity with Raja (2003) and Vijayan (2005). In the present study, the combination treatments of panchakavya 3 % and brassinolide 0.5 ppm (M_3) recorded the highest germination percentage (93 %)

Table 4. Germination (per cent) of organic rice seeds during storage as influenced by bio-growth regulators.

Treatments	Storage periods (months)					
	P_0	P_2	P_4	P_6	P_8	P_{10}
Bio growth regulators						
M_1 – Panchakavya	92	90	89	87	87	86
	(74.16)	(72.02)	(70.43)	(69.25)	(69.11)	(67.90)
M_2 –Brassinolides	93	91	89	88	88	87
	(74.51)	(72.34)	(71.31)	(69.95)	(69.62)	(68.67)
M_3 - Panchakavya + Brassinolides	93	92	91	90	89	87
	(74.96)	(74.50)	(73.51)	(72.38)	(70.98)	(69.14)
SEd	0.06	0.51	0.46	0.56	0.30	0.03
CD (P=0.05)	0.26	2.16	1.98	2.40	1.30	0.14
Method of application						
S_1 -Seed treatment	92	91	89	88	88	86
	(73.0)	(73.01)	(71.05)	(70.13)	(69.76)	(68.32)
S_2 -Seedling root dip	89	87	86	85	84	81
	(72.26)	(69.16)	(67.83)	(67.44)	(67.50)	(64.44)
S_3 –Foliar spray	91	88	87	85	85	84
	(71.00)	(69.75)	(68.94)	(66.21)	(65.63)	(66.41)
S_4 –Seed treatment + seedling root dip	94	92	91	90	89	88
	(74.90)	(74.01)	(72.62)	(71.44)	(71.07)	(69.76)
S_5 – Seed treatment + foliar spray	96	94	92	91	91	89
	(77.82)	(75.51)	(74.01)	(73.09)	(72.59)	(70.98)
S_6 - Seedling root dip + foliar spray	91	90	88	87	87	85
	(72.59)	(71.29)	(70.07)	(69.26)	(68.62)	(67.51)
S_7 - Seed treatment + seedling root dip + foliar spray	96	95	95	93	92	91
	(79.89)	(77.94)	(77.71)	(76.19)	(74.17)	(72.59)
SEd	0.95	1.22	1.45	1.48	0.74	0.51
CD (P=0.05)	2.00	2.55	3.04	3.10	1.55	1.07
Untreated control (inorganic alone)	88	85	84	80	77	74

P_o – one week after harvest; P_2 – two months; P_4 – four months; P_6 – six months; P_8 – eight months; P_{10} – ten months interaction not significant.

as compared to control (inorganic alone) (74 %) after 10 months of storage (Table 4).Among the method of application, seed treatment + seedling root dip + foliar spray (S_7) recorded higher germination % which also declined gradually with increasing in storage periods. On the practical point of view, the results brought out beneficial effects of bio-growth regulators either in individual or combination of treatments by maintaining more than 80 percent germination (the minimum seed certification standard) upto 10 months in cloth bag. The retention of higher germination potential might be due to initial vigor potential of resultant seeds. In general, decline in germination potential of the stored seeds might be due to natural ageing and increase in membrane leakage as reported by Abdul- Baki and Anderson (1973).

Growth parameters

Data presented in Tables 7,8 and 9 illustrated that the use of panchakavya 3 % and brassinolide 0.5 ppm (M_3) recorded maximum root length and shoot length, dry matter production and vigor index which gradually decreased with increase in storage period. Irrespective of the treatments, the vigor was maximum in the initial periods of storage while it was minimum at the 10^{th} month of storage (Table 7, 8 and 9).

Seed deterioration as evident from loss of viability is associated with decreased root length, shoot length, dry matter production and vigor index with the passage of time in storage. This had already been confirmed by earlier workers (Jerlin, 1990; Manonmani, 1990; Pandian, 1997).

Among different treatments, seed treatment + seedling root dip + foliar spray (S7) showed higher root and shoot length, dry matter production and vigor index over all other treatments which also showed decreased trend with increase in storage period. Upon storage the decline of root and shoot length was steeper in the case of untreated control (inorganic alone) while it was slow in the seeds treated with bio-growth regulators. These findings confirm the results reported by Vijayan (2005) in rice. The dry matter production of the seedling is the

Table 7. Root length (cm) of organic rice seeds during storage as influenced by bio-growth regulators.

Treatments	Storage periods (months)					
	P_0	P_2	P_4	P_6	P_8	P_{10}
Bio growth regulators						
M_1 – Panchakavya	18.6	18.2	17.8	17.1	17.0	16.0
M_2 –Brassinolides	18.9	18.4	18.0	17.6	17.1	16.4
M_3 - Panchakavya + Brassinolides	20.5	20.1	19.7	18.8	18.5	17.2
SEd	0.1	0.1	0.1	0.1	0.2	0.1
CD (P=0.05)	0.3	0.5	0.4	0.6	1.0	0.4
Method of application						
S_1 -Seed treatment	18.9	18.3	18.0	17.5	17.0	16.4
S_2 -Seedling root dip	17.5	17.0	16.7	16.2	15.9	15.3
S_3 –Foliar spray	17.8	17.4	17.0	16.6	16.4	15.7
S_4 –Seed treatment + seedling root dip	19.4	18.9	18.9	18.2	17.6	16.6
S_5 – Seed treatment + foliar spray	20.9	20.6	20.0	19.3	18.7	17.4
S_6 - Seedling root dip + foliar spray	18.2	17.8	17.5	17.0	16.6	15.9
S_7 - Seed treatment + seedling root dip + foliar spray	22.6	22.2	21.7	21.0	20.5	18.5
SEd	0.5	0.4	0.3	0.4	0.4	0.4
CD (P=0.05)	1.1	0.8	0.7	0.9	0.8	0.7
Untreated control (inorganic alone)	17.4	16.8	16.5	16.0	15.9	15.0

Po – one week after harvest; P_2 – two months; P_4 – four months; P_6 – six months; P_8 – eight months; P_{10} – ten months Interaction not significant.

Table 8. Shoot length (cm) of organic rice seeds during storage as influenced by bio-growth regulators.

Treatments	Storage periods (months)					
	P_0	P_2	P_4	P_6	P_8	P_{10}
Bio growth regulators						
M_1 – Panchakavya	14.8	14.1	13.7	13.4	13.1	12.8
M_2 –Brassinolides	14.9	14.0	13.8	13.6	13.3	13.0
M_3 - Panchakavya + Brassinolides	15.2	14.5	14.4	14.1	13.7	13.4
SEd	0.04	0.04	0.06	0.05	0.05	0.03
CD (P=0.05)	0.20	0.21	0.31	0.20	0.22	0.20
Method of application						
S_1 –Seed treatment	15.0	13.9	14.0	13.7	13.3	13.2
S_2 -Seedling root dip	13.4	12.9	12.7	12.7	12.5	12.3
S_3 -Foliar spray	14.0	13.6	13.4	13.1	12.9	12.5
S_4 –Seed treatment + seedling root dip	15.4	14.3	14.2	13.9	13.5	13.4
S_5 – Seed treatment + foliar spray	15.8	15.2	14.7	14.4	13.9	13.7
S_6 - Seedling root dip + foliar spray	14.7	13.8	13.7	13.4	13.1	12.8
S_7 - Seed treatment + seedling root dip + foliar spray	16.2	15.8	15.3	14.7	14.3	13.9
SEd	0.08	0.20	0.06	0.06	0.05	0.07
CD (P=0.05)	0.16	0.40	0.13	0.14	0.10	0.14
Untreated control (inorganic alone)	13.4	12.8	12.7	12.6	12.5	12.2

Po – one week after harvest; P_2 – two months; P_4 – four months; P_6 – six months; P_8 – eight months; P_{10} – ten months , Interaction not significant.

Table 9. Dry matter production (mg per 10 seedlings) of organic rice seeds during storage as influenced by bio-growth regulators

	Storage periods (months)					
Treatments	**P_0**	**P_2**	**P_4**	**P_6**	**P_8**	**P_{10}**
Bio growth regulators						
M_1 – Panchakavya	119	112	109	104	100	97
M_2 –Brassinolides	120	115	111	106	101	98
M_3 - Panchakavya + Brassinolides	127	121	117	111	108	103
SEd	0.5	1.0	0.4	1.0	1.0	0.4
CD (P=0.05)	2	5	2	4	5	2
Method of application						
S_1 -Seed treatment	119	116	111	106	102	97
S_2 -Seedling root dip	110	104	101	97	92	89
S_3 –Foliar spray	113	108	104	101	96	91
S_4 –Seed treatment + seedling root dip	123	118	113	107	103	100
S_5 – Seed treatment + foliar spray	131	125	120	114	110	106
S_6 - Seedling root dip + foliar spray	117	112	108	103	100	95
S_7 - Seed treatment + seedling root dip + foliar spray	142	131	128	122	117	114
SEd	3	2	3	4	2	3
CD (P=0.05)	6	5	6	7	5	5
Untreated control (inorganic alone)	109	104	100	96	90	88

Po – one week after harvest; P_2 – two months; P_4 – four months; P_6 – six months; P_8 – eight months; P_{10} – ten months
Interaction not significant.

Table 5. Electrical conductivity (dSm^{-1}) of organic rice seeds during storage as influenced by bio-growth regulators.

	Storage periods (months)					
Treatments	**P_0**	**P_2**	**P_4**	**P_6**	**P_8**	**P_{10}**
Bio growth regulators						
M_1 – Panchakavya	0.127	0.133	0.137	0.148	0.158	0.168
M_2 –Brassinolides	0.126	0.128	0.135	0.147	0.156	0.166
M_3 - Panchakavya + Brassinolides	0.117	0.117	0.131	0.140	0.152	0.163
SEd	0.002	0.002	0.003	0.001	0.001	0.001
CD (P=0.05)	0.007	0.01	0.01	0.006	0.002	0.002
Method of application						
S_1 -Seed treatment	0.127	0.129	0.136	0.147	0.157	0.169
S_2 -Seedling root dip	0.134	0.137	0.143	0.155	0.166	0.177
S_3 -Foliar spray	0.132	0.135	0.141	0.153	0.163	0.175
S_4 –Seed treatment + seedling root dip	0.122	0.125	0.135	0.142	0.154	0.165
S_5 – Seed treatment + foliar spray	0.113	0.118	0.127	0.138	0.147	0.158
S_6 - Seedling root dip + foliar spray	0.129	0.131	0.139	0.151	0.160	0.171
S_7 - Seed treatment + seedling root dip + foliar spray	0.106	0.109	0.118	0.129	0.140	0.148
SEd	0.004	0.004	0.004	0.004	0.002	0.003
CD (P=0.05)	0.008	0.007	0.009	0.008	0.006	0.006
Untreated control (inorganic alone)	0.134	0.137	0.144	0.156	0.167	0.179

Po – one week after harvest; P_2 – two months; P_4 – four months; P_6 – six months; P_8 – eight months; P_{10} – ten months;Interaction not significant.

ultimate manifestation of physiological vigor (Heydecker, 1973). Seedling vigor is usually characterized by the weight of seedlings after a period of growth and this essentially a physiological phenomenon influenced by the reserve metabolites, enzyme activities and the growth regulators. (Das Gupta and Austenson,1973).

Electrical conductivity

The electrical conductivity values showed negative association with germination percentage of seeds. In the present study, use of panchakavya 3 % and brassinolide 0.5 ppm (M_3) showed lower values of electrical

Table 6. Dehydrogenation enzyme activity (OD value) of organic rice seeds during storage as influenced by bio-growth regulators.

Treatments	Storage periods (months)					
	P_0	P_2	P_4	P_6	P_8	P_{10}
Bio growth regulators						
M_1 – Panchakavya	0.134	0.127	0.124	0.121	0.115	0.108
M_2 –Brassinolides	0.138	0.129	0.127	0.124	0.119	0.111
M_3 - Panchakavya + Brassinolides	0.149	0.140	0.137	0.130	0.125	0.120
SEd	0.002	0.001	0.020	0.001	0.001	0.002
CD (P=0.05)	0.008	0.003	0.006	0.003	0.004	0.007
Method of application						
S_1 -Seed treatment	0.139	0.130	0.127	0.124	0.120	0.113
S_2 -Seedling root dip	0.130	0.127	0.123	0.118	0.114	0.107
S_3 –Foliar spray	0.135	0.125	0.121	0.115	0.108	0.102
S_4 –Seed treatment + seedling root dip	0.141	0.133	0.131	0.127	0.122	0.117
S_5 – Seed treatment + foliar spray	0.146	0.136	0.135	0.131	0.125	0.120
S_6 - Seedling root dip + foliar spray	0.137	0.128	0.125	0.121	0.117	0.110
S_7 - Seed treatment + seedling root dip + foliar spray	0.154	0.144	0.141	0.138	0.133	0.127
SEd	0.003	0.004	0.003	0.003	0.003	0.003
CD (P=0.05)	0.007	0.007	0.005	0.006	0.007	0.006
Untreated control (inorganic alone)	0.130	0.127	0.123	0.117	0.113	0.105

Po – one week after harvest; P_2 – two months; P_4 – four months; P_6 – six months; P_8 – eight months; P_{10} – ten months
Interaction not significant.

conductivity which gradually increased with advancement of storage periods (Table 5). Irrespective of treatments, the electrolytes in the seed leachate was more especially at the later period of storage. Among the different of treatments, seed treatment + seedling root dip + foliar spray (S_7) showed lower values of electrical conductivity over all other treatments which also gradually increased with advancement of storage periods. This might be due to increase of moisture content which have promoted the metabolites and electrolytes through the semi permeable membranes into the imbibing medium due to loss of membrane integrity (Paul and Ramasamy, 1979; Mullet, 1979).

Dehydrogenase activity

The dehydrogenase enzyme activity in the embryo is a good indication of degree of activeness in viable seeds (Moore, 1972) and has positive association with vigor and viability of seeds (Rudrapal and Basu, 1979; Haldar and Gupta, 1982; Kharduki, 1983). In the present investigation, the combined treatments of panchakavya 3 % and brassinolide 0.5 ppm (M_3) showed highest dehydrogenase enzyme activity in the initial storage periods which gradually reduced with continuation in storage period (Table 6).

The treatment, seed treatment + seedling root dip + foliar spray (S_7) registered higher dehydrogenase enzyme activity which also declined with continuation of storage periods. This might be due to dehydrogenase enzyme activity which reduced with the continuation of storage periods due to the inability of the seed tissues to reduce tetrazolium chloride to insoluble formation. This was revealed in black gram by Eevera (2000).

References

Abdul-Baki AA, Anderson JD (1973). Vigour determination in soybean seed by multiple criteria. Crop Sci., 13: 630-633.

Copeland LO, Mc Donald MB (1995). Principles of seed science and technology, Mac Millan Publishing Company, New York.

Das-gupta PR, Austenson HM (1973). Analysis of interrelationship among seedling vigour, field emergence and yield in wheat. Agron. J., 35: 417-422.

Eevera T (2000).Seed storage studies in black gram (Vigna munga (L.) Hopper) cv. ADT3.M.Sc (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore.

Haldar S, Gupta K (1982).On the mechanism of sunflower seed deterioration under low and high relative humidity. Seed Sci. and Technol., 10: 267-270.

Harrington JF, Douglas JE (1970).Seed storage and packing application for India. Published by National Seeds Corporation Ltd., New Delhi.

HeydeckerW(1973).Vigour. In: Viability of seeds (Ed. E.H. Roberts), Chapman and Hall, London, pp. 209-252.

Jerlin R(1990).Studies on seed yield and quality of rice (Oryza sativa L.) and Echinochloa crus-galli as influenced by crop weed interference. M.Sc. (Ag.), Thesis submitted to Tamil Nadu Agricultural University, Coimbatore –3.

Jeyaraj T, Vanangamudi K, Palaniswamy V, Karivaratharaju TV(1986).Production and storage of sorghum seed. Seeds and Farms, 12: 15-18.

Justice OL, Bass L

(1978).Principles and practices of seed storage. Agricultural Hand Book, Number 50B, USDA, Washington, D.C. pp.289.

Kharduki L (1983).Physiological and biochemical changes in seeds during storage under controlled condition. Ph.D Thesis, IARI, New Delhi.

Manonmani V (1990).Certain aspects of seed production and storage of (Oryza sativa L.) Seeds. M.Sc. (Ag.) Thesis submitted to Tamil Nadu Agricultural University, Coimbatore.

Mullet HJ (1979).The relationship between seed size, total seed electrolytes leakage and embryo growth of Phaseolus vulgaris. Aust. Seed Sci. Newsl., 5: 60-64.

Natarajan K (2002).Panchakavya. A manual. Other India Press, Mapusa, Goa, India. p.33.

Pandian P (1997).Influence of mother crop nutrient, pre-harvest sanitation spray and provenance on seed quality in the scented rice cv. ADT 41. M.Sc.(Ag.) Thesis submitted to Tamil Nadu Agricultural University, Coimbatore-3.

Paul SR,Ramasamy KR (1979).Relationship between seed size and seed quality attributes in cowpea. Seed Res., 7: 63-70.

Prasad B, Mehta AK, Sinha MK(1983).Relative efficiency of zinc amendment organic waste in zinc nutrition of crops in calcareous soil. In: Proc. National Seminar on Utilization of organic wastes. pp.82-88.

Roberts EH (1972).Cytological, genetic and metabolic changes associated with loss of viability. In: Viability of seeds (Ed. Roberts, E.H.), Chapman and Hill Ltd., London.

Rudrapal AB Basu RN (1979).Lipid peroxidation and membrane damage in deterioration of wheat and mustard seed. Indian J. Expt. Biol., 20: 465-470.

Sharma D (2004).Rice is now oryza syngenta. Farmers Forum, March, 19-20.

Singh BN (2002).Rice in India and Global rice scenario. In: Training manual of summer school, on genetic evaluation and utilization (GEU) in rice improvement held between 6th May to 4th June, 2002. Central Rice Research Institute, Cuttack. pp. 1-12.

Venkatesan K (2004).Studies on physiological, biochemical and molecular action of brassinolide in maize (Zea mays) and its effect on yield in selected Agriculture and Horticulture crops Ph.D Thesis submitted to Tamil Nadu Agriculture University, Coimbatore-3.

Vijayan R and Sundralingam (2005).Organic seed production in rice cv ADT 43 Ph.D Thesis submitted to Tamil Nadu Agriculture University, Coimbatore-3.