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Evaluation of soybean (*Glycine max*) genotypes for seed longevity

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ABSTRACT

Variability in seed quality traits associated with seed longevity was studied during 2005 for 15 soybean *(Glycine max* (L.) Merrill) cultivars of 3 different seed sizes, small (‘ADT1’, ‘Co1’, ‘Indira Soya 9’, ‘MAUS 32’ and ‘JS 90-41’), medium (‘JS 335’, ‘JS 71-05’, ‘MAUS 47’, ‘NRC 37’ and ‘Bragg’) and bold type (‘JS 9305’, ‘NRC 7’, ‘PS 1024’, ‘PS 1029’ and ‘MAUS 61-2’) under accelerated ageing condition at 90% relative humidity and 42°C temperature. Soil emergence, seed coat rupture force, water imbibition kinetics, reduction in germination due to stress were observed because these are directly or indirectly related with seed longevity characteristics. Faster decline in seed germination after aging at high temperature and humidity was observed in ‘Co 1’, which absorbed more moisture and required less rupture force to break the seed coat. Significantly high positive correlation coefficient, (r=0.766**) was found between soil emergence and germination after 8 days of accelerated ageing.

Key words: Seed coat rupture force, Seed longevity, Soybean

Soybean (*Glycine max* (L.) Merrill) is one of the most important oilseed crops in the world. It is a cheaper source of quality protein and edible oil. Although most of soybean is grown in temperate region, there is tremendous potential to expand its production in the tropics. However, one of the major problems encountered in soybean production in tropical and sub tropical region is rapid deterioration of seed quality during storage, leading to poor germination and sub optimal plant stand. Accelerated ageing is a quick test based on increased seed deterioration under hot and humid condition of storage. Use of seed vigour test in addition to viability test for estimating seed deterioration during long-term seed storage has also been made by Hampton and Tekrony (1995). The Accelerated ageing tests were useful for identifying lines with inferior field emergence but were not reliable enough to replace field tests for identifying the best emerging lines (Francisco *et al*. 2001). The seed coat is one of the main determinants of seed germination, vigour and longevity potentials. Seed coat thickness and its mechanical strength is another most commonly considered parameter for longevity (Fraczek *et al*. 2005). An intact seed coat is capable of regulating the speed of water absorption protecting the embryo from injuries, which might otherwise result from rapid imbibition, but this condition does not always suffice. However, the legume cultivars with seed coat capable of delaying imbibition, instead of impeding it, were suggested as better alternatives (Chachalis and Smith 2000). Seed coat resistance for mechanical damage is a genetic character that varies among soybean cultivars. The soybean breeders are always in search of lines having good longevity for developing improved cultivars. The present investigation was aimed to study seed longevity as the function of variety, seed size, soil emergence, rupture force of seed coat and water imbibition kinetics.

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MATERIALS AND METHODS

Seeds samples of 15 soybean cultivars were grown under isoclimatic conditions at National Research Centre for Soybean, Indore, during (*rainy/kharif*) 2005. Seeds were shade dried after harvesting to about 9.0% moisture content. The 100 seed weight was taken by using electronic balance and on the basis of seed weight (g), the different cultivars were classified into 3 categories small (<10 g) – ‘ADT 1’, ‘Co1’, ‘Indira Soya 9’ (IS 9), ‘MAU S32’ and ‘JS 90–41’; medium (10–13 g) ‘JS 335’, ‘JS 71–05’, ‘MAUS 47’, ‘NRC 37’ and ‘Bragg’; and bold (>13 g) **–** ‘JS 9305’, ‘NRC 7’, ‘PS 1024’, ‘PS 1029’ and ‘MAUS 61-2’. The accelerated ageing test was conducted as per the method described by (Delouche and Baskin 1973). About 30 g of soybean seed samples of each cultivar packed in nylon net bags were stored at 90% relative humidity in a sealed desiccator maintained at 42°C using an incubator (Vertucci and Ross 1993). The samples were drawn on fourth and eighth day of storage and subjected to analysis for various parameters. Germination test was conducted on 100 seeds in triplicate using standard germination paper. The percentage of normal germinated seedlings was assessed after fourth and seventh days, according to the ASAO (2008) guidelines. For the determination of moisture percentage, method suggested by Basil (1992) was used. Moisture percentage of seeds was taken before and after exposure to the accelerated ageing. The loss in weight was calculated and converted into percentage on fresh weight basis. The rupture force of the seed coat was measured as the first break point on the graph of seed cracking using the texture analyzer (Stable Micro System) TA.XT plus. The seed was placed on the stationary metallic plate of the instrument using load cell of 500 kg. Test speed 0.5 mm/sec and post test speed was 2.0 mm/sec. The force was applied with moving the piston downward. The moment the moving piston comes in contact of the seed surface, pressure is created on the surface of the seed. The increase of force is plotted along the Y-axis and the duration of force applied, until the seed is crushed into pieces, is plotted along the X-axis. There is a gradual increase in the graph with the increase of force and after a certain time (fraction of a second), there is a sudden drop on the graph indicating the first break in the seed and that is for the seed coat rupture force. The water uptake pattern was measured as per the procedure given by Halis and Smith (1997). Five grams seeds with isomoisture content in three replications were soaked in 25 ml of distilled water at 25±2°C and their weight was recorded at every hour interval up to 8 h. The last observation, being overnight observation was recorded after 15 h of soaking. The rate of water uptake was calculated as percentage increase over the initial weight of seeds with time. To observe the soil emergence of the genotypes under study four replicates of 50 treated seeds (Carbendazim + Thiram @ 250 g/100 kg of seeds) were sown in a conventionally prepared area in 1.5 m long row spaced 0.25 m apart and at a depth of 2.5 to 3.5 cm. Emerged seedlings were counted once at the vegetative stage on the 14th day after sowing (Fehr and Caviness 1977).

RESULTS AND DISCUSSION

Seeds of various soybean cultivars undergone stress conditions due to accelerated ageing, showed variation in their potential to absorb moisture, germinate and produce normal seedlings with ageing period.

Moisture content

Initial seed moisture content varied from 9.0–9.1% among different cultivars. Seed moisture content increased significantly after 4 days of exposure to accelerated ageing condition (42°C and 90% relative humidity), and the range varied from 13.9 to 23.1%, highest for small seeded cultivar ‘Indira Soya 9’, and lowest for bold cultivar ‘MAUS 61-2’ (Table 1). It showed that there were differences in cultivars to tolerate the stress condition; the moisture absorption may

Table 1 Moisture content and germination percent of soybean cultivars after 4th and 8th day of accelerated ageing test

Cultivar	Moisture content (%)				Germination (%)			
	0 day ageing	After 4 days of ageing	After 8 days of ageing	Mean	0 day ageing	After 4 days of ageing	After 8 days of ageing	Mean (G)
‘ADT 1’	9.0	17.4	20.5	15.63	76 (60.69)	71 (57.47)	54 (47.30)	67 (55.15)
‘CO 1’	9.1	17.4	29.7	18.75	70 (57.07)	69 (56.23)	42 (40.36)	60 (51.22)
‘IS 9’	9.1	23.1	25.2	19.12	75 (60.00)	50 (45.00)	36 (36.85)	49 (44.41)
‘MAUS 32’	9.1	15.2	19.8	14.70	76 (60.74)	71 (57.52)	59 (50.22)	69 (56.16)
‘JS 90-41’	9.0	17.5	24.2	16.90	75 (60.07)	72 (58.13)	45 (42.12)	64 (53.44)
‘JS 335’	9.1	17.1	18.2	14.81	86 (68.10)	82 (64.94)	64 (53.17)	77 (62.07)
‘JS 71-05’	9.1	17.1	19.5	15.23	84 (66.53)	76 (60.78)	60 (50.78)	73 (59.36)
‘MAUS 47’	9.0	15.5	20.2	14.90	83 (65.80	77 (61.47)	63 (52.59)	74 (59.95)
‘NRC37’	9.0	15.5	17.4	13.96	84 (66.67)	74 (59.41)	62 (51.98)	73 (59.35)
‘BRAGG’	9.0	15.2	16.4	13.55	98 (82.05)	94 (76.42)	84 (66.53)	92 (75.00)
‘JS 93-05’	9.0	15.2	22.5	15.58	98 (82.05)	84 (66.53)	72 (58.09)	85 (68.89)
‘NRC 7’	9.1	16.2	21.3	15.55	85 67.33)	73 (58.70)	60 (50.81)	73 (58.95)
‘PS 1024’	9.0	16.0	17.1	14.05	98 (82.05)	94 (76.42)	83 (65.80)	92 (74.76)
‘PS 1029’	9.1	16.2	21.1	15.46	81 (64.23)	79 (62.76)	58 (49.61)	73 (58.87)
‘MAUS 61-2’	9.1	13.9	15.9	12.96	97 (80.64)	94 (76.42)	90 (71.80)	94 (76.29)
Mean (V)	9.05	16.57	20.61		84 (68.29)	77 (62.55)	62 (52.53)	
	SEd (±)	CD (*P*=0.05)	CD (*P*=0.01)		SEd (±)	CD (*P*=0.05)	CD (*P*=0.01)	
V	0.069	0.13797	0.182		1.59264	3.16408	3.16408	
D	0.031	0.061	0.081		.71225	1.41502	1.87435	
V×D	0.120	0.238	0.316		2.75853	5.48035	NS	

Value in brackets are angular transformed be influenced by seed coat thickness. Seed coat thickness is also considered to contribute towards better storability by restricting the entry of moisture into the seed. There was a significant gradual increase in the moisture content over control after 8 days of ageing too. After 8 days of aging the moisture content varied from 15.9 to 29.76%, the maximum was observed in a small seeded variety 'Co1' and minimum for the same variety 'MAUS 61-2' that had shown after 4 days of ageing (Table 1). 'Co1' became more vulnerable after 4 days ageing and lost its membrane integrity thus absorbed highest moisture content after 8 days of ageing. There was a negative correlation between seed moisture content and germination of seed (r = –0.342) and between seed coat rupture force and moisture absorption under ageing conditions. It was evident that, the cultivar which absorbs high moisture content under artificial ageing condition, showed significantly higher reduction in germination.

Germination

The initial seed germination varied from 70–98% in different cultivars, maximum in 'Bragg', 'JS 9305' and 'PS 1024' and minimum in 'Co 1'. Significant fall of germination was recorded after four days ageing and germination range was 50–94%. Maximum germination after 4 days of accelerated ageing was found in 3 cultivars namely 'Bragg', 'JS 9305' and 'PS 1024' and minimum in 'IS 9' (Table1). There was a significant decline in the germination of all the cultivars with the advancement of ageing period (8 days) causing failure to maintain seed certification standard of 70% germination in all the cultivars except 'Bragg', 'JS 9305', 'PS 1024' and 'MAUS 61-2' (Table1). Highest reduction was found with small seeded cultivar and the lowest reduction in bold seeded cultivar. Cultivar differences in seed hygroscopicity may have influenced germination reduction because there was a tendency of higher seed moisture content after accelerated ageing to be associated with higher germination reduction as it is evident in cultivar 'Co 1' which absorbed maximum moisture and deteriorated greater after 8 days of ageing. Interestingly 'PS 1024' and 'MAUS 61–2' showed maximum rupture force applied on them as well as maintained highest germination (Table 1 and 2) after 8 days of ageing, which indicates that seed coat strength of cultivars also influence seed longevity. Thus, it was evident that there is genotypic variability with respect to longevity among different soybean cultivars, this is in general conformation of observations made by Zanakis *et al.* (1993).

Table 2 Seed index, seed coat rupture force and soil emergence of different soybean cultivars

Category	Cultivar	100 seed weight (g)	Mechanical strength of seed coat (N)	Soil emergence (%)
Small	'ADT 1'	8.53	94.02	54 (47.29)
	'CO 1'	8.83	99.03233	48 (43.84)
	'I S 9'	9.70	138.20	56 (48.46)
	'MAUS 32'	8.60	102.29	45 (42.10)
	'JS 90-41'	8.40	128.64	44 (41.53)
Medium	'JS 335'	12.14	140.61	42 (37.71)
	'JS 71-05'	10.11	129.62	81 (64.26)
	'MAUS 47'	12.11	134.99	69 (56.20)
	'NRC 37'	11.22	113.49	54 (47.49)
	'BRAGG'	12.84	148.09	93 (75.35)
Bold	'JS 9305'	13.33	138.43	88 (69.95)
	'NRC 7'	14.17	98.02	61 (51.30)
	'PS 1024'	14.38	155.94	90 (72.01)
	'PS 1029'	15.54	105.042	79 (62.87)
	'MAUS 61-2'	13.68	151.043	96 (79.26)
	'Mean	10.61	125.160	67
	SEd(±)	0.2684	3.1872	3.1346
	CD (*P*=0.05%)	0.5482	6.5289	6.4212
	CD (*P*=0.01%)	0.7381	8.8084	8.6631

*Value in brackets is angular transformed

Rupture force of seed coat

The rupture force of seed coat was measured to know the mechanical strength of seed coat of different soybean cultivars. Among cultivars the rupture force varied from 94.02 to 155.94 Newton, the maximum was observed for

Table 3 Coefficient of correlation between soil emergence and seed quality traits of soybean cultivars

Germination			Moisture content			100-seed weight	Rupture force of seed coat	Soil emergence
0 days	4 days	8 days	0 days	4 days	8 days			
1.000	0.942	0.947**	–0.342	–0.751	–0.696	0.695**	0.550*	0.758**
1.000	0.931**	–0.295	–0.785	–0.684	0.629*	0.521*	0.698**	
	1.000	–0.248	–0.739	0.813	0.651**	–0.579*	0.766**	
		1.000	0.242	0.218	0.011	–0.243	–0.181	
			1.000	0.557	–0.427	–0.050	–0.423	
				1.000	–0.470	–0.439	–0.480	
					1.000	0.353	0.682**	
						1.000	0.566*	
							1.000	

*indicate significant at (CD= *P*=0.05); **indicate significant at 1%

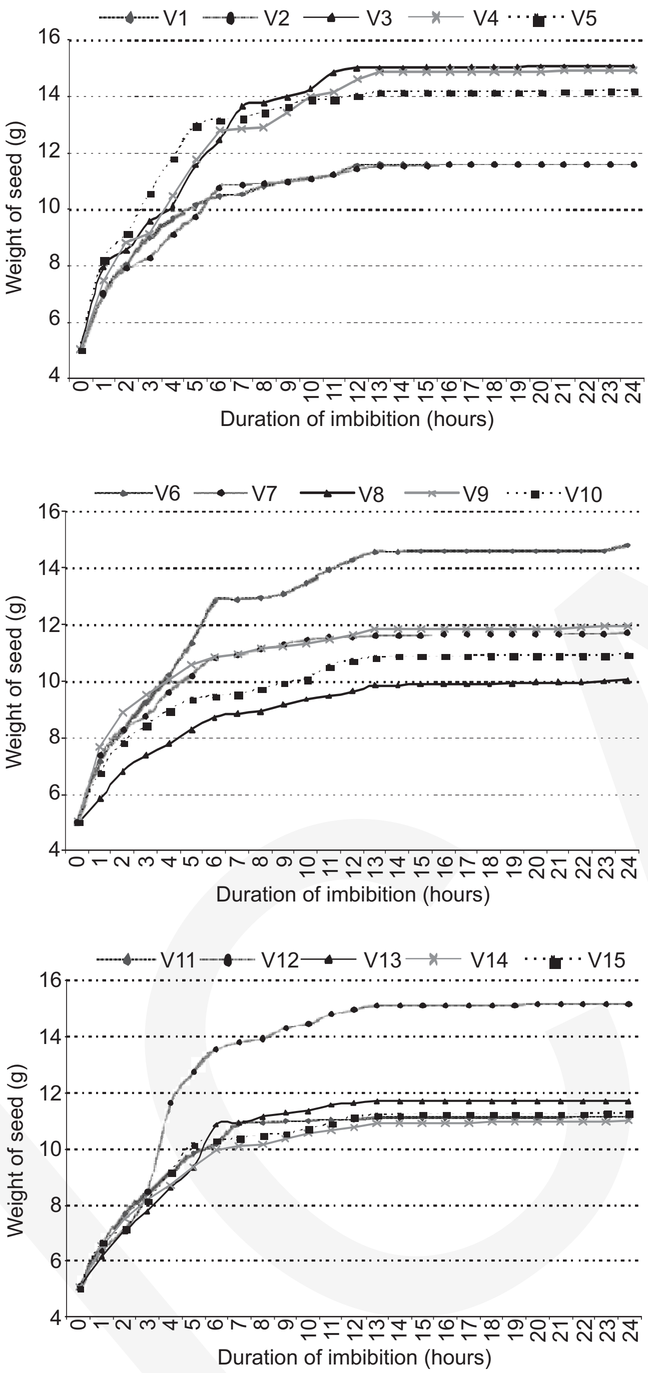

Fig 1 Water imbibition kinetics of different soybean cultivars

bold seeded 'PS 1024' and minimum for small seed type 'ADT 1' (Table 2). Rupture force of seed coat had significant positive correlation with soil emergence and laboratory germination. Soil emergence was positively associated with seed coat rupture force (r = 0.566) (Table 3). In the present study, yellow bold seeded varieties showed good stability as compared to small to medium seeded varieties except 'NRC 7'. Thus from the present study it is inferred that strength of the seed coat to bear high rupture force contributes towards longevity of seeds both under accelerated ageing conditions as well as in the field for seedling emergence. Strong seed coat prevented initial mechanical damage of the seed and augmented the potential to survive long. One of the bold yellow seeded cultivars 'PK 1024' remarkably showed the highest resistance to mechanical damage though small seededness is reported to be associated with lesser mechanical damage, same in case of cumin seed, recently reported that maximum rupture force requires for small seed than larger seed (Saiedirad *et al.* 2008).

Imbibition pattern

Imbibition pattern of seeds is primarily governed by the seed coat permeability. The water uptake was very rapid in the first few hours of imbibition followed by a lag phase of slow uptake, in all varieties. This lag phase started after 6–7 hr of initial rapid imbibition in different varieties (Fig 2). The rate of water absorption, the amount of water absorbed per hour varied considerably among different varieties. This variation was more pronounced at the early hours of imbibition, though after 24 h, by the end of imbibition period the difference in extent of water absorption tapered considerably. 'MAUS 47' and 'Bragg' had the slowest rate of water imbibition, whereas cultivars 'JS 90-41' and 'NRC 7' which deteriorated faster absorbed water at fastest rate (Fig 2). In general, the slowest imbibition was found in the medium seeded cultivar 'MAUS 47' and 'Bragg', which is good for seed longevity. The kinetics of imbibition is governed by the interaction of hygroscopicity of seed constituents and the permeability of seed to water, which is influenced by morphology, structure and composition of seed coat (Bewley and Black 1994). An intact seed coat is capable of regulating the speed of water absorption protecting the embryo from injuries which might otherwise result from rapid imbibition, but this condition does not always suffice. Water may reach the embryo in a variety of ways, while some authors concluded that in soybean water reaches the embryo mainly through the testa (Chachalis and Smith 2000).

Soil emergence

Soil emergence varied from 42 to 96%. Significant difference was found between standard seed germination and soil emergence among different cultivars. Maximum emergence was observed in a bold seeded cultivar 'MAUS 61–2' (96) followed by 'Bragg' (93) and 'PS 1024' (90). Except 'Indira Soya 9', all small seeded cultivars performed poorly in the field. Among bold seeded cultivar except 'NRC 7', all the cultivars emerged satisfactorily more than 70%. Bragg performed significantly higher among medium cultivars. Soil emergence was positively correlated with initial seed germination (r=0.758), 4 days aged seed germination (r=0.698), 8 days aged seed germination (r=0.766), 100 seed weight (r= 0.682) and rupture force of seed coat (r= 0.566) (Table 3). Rupture force of the seed

Table 3 Coefficient of correlation between soil emergence and seed quality traits of soybean cultivars

1	2	3	4	5	6	7	8	9
1.000	0.942	0.947**	–0.342	–0.751	–0.696	0.695**	0.550*	0.758**
	1.000	0.931**	–0.295	–0.785	–0.684	0.629*	0.521*	0.698**
		1.000	–0.248	–0.739	0.813	0.651**	–0.579*	0.766**
			1.000	0.242	0.218	0.011	–0.243	–0.181
				1.000	0.557	–0.427	–0.050	–0.423
					1.000	–0.470	–0.439	–0.480
						1.000	0.353	0.682**
							1.000	0.566*
								1.000

* indicate significant at (CD= *P*=0.05)
** indicate significant at 1%
Characters 1. 0days Germination; 2. 4days aging germination; 3.8 days aging germination; 4.0 days Moisture content; 5. 4days aged seed moisture content; 6. 8days seed moisture content; 7.100 seed weight; 8. Rupture force of seed coat; 9. Soil emergence

coat had significant positive correlation with soil emergence and laboratory germination. It can be concluded that seed traits like initial germination, rupture force of seed coat, seed coat permeability and soil emergence, which influence seed longevity are all interrelated. On an average ‘Bragg’, ‘JS 9305’, ‘PK 1024’ and ‘MAUS 61–2’ performed best (more than 80% germination) after ageing as well as in the soil emergence and also having high level of seed coat rupture force thus these varieties can be utilized in the breeding programme to improve the lines or cultivars which is having low seed longevity.

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