

Assessment and Classification of Indian Soybean [*Glycine max* L.) Merr] Varieties for their Response to Field Weathering

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ABSTRACT Assessment of sixty-two Indian soybean [*Glycine max* (L.) Merr.] varieties were done for their response to field weathering and further classified on the basis of seedling vigour index as affected by field weathering. The assessment was made after exposing the standing crop to ambient weather conditions by delaying the harvesting for three weeks. For field weathering treatment, soybean pods were manually harvested three weeks after physiological maturity, while control (unweathered) pods were harvested at physiological maturity. Field weathering adversely affects the standard germination, normal seedling growth and finally seedling vigour index. In the present study the average reduction in the SG and SVI value was 20 and 33.2%, and ranged from 1 to 63% and 2.7 to 76%, respectively among these varieties, when the harvesting was delayed by 3 weeks as compared to their corresponding unweathered seeds. The classification of field weathering tolerant/susceptible varieties would be beneficial for selection of a variety for cultivation in tropical climate, where the adverse weather conditions for soybean are prevalent at the time of harvesting. The tolerant varieties can be used for breeding programme for improvement of the varieties.

Keywords: Field weathering, seed deterioration, seedling vigour index, soybean.

Soybean seed quality is extremely unpredictable across locations and years indicating that environmental conditions during seed production have a significant influence on seed quality. The deterioration of seeds from physiological maturity till harvesting generally termed, as 'field weathering' and is most crucial factor limiting the productivity of soybean crop under tropical and subtropical conditions. Field weathering essentially takes place in the field itself when the seed is attached to mother plant and leads to reduction in germination and storage potential of the soybean seeds [1-3]. Adverse weather conditions such as high temperature, humidity and frequent rains at the time of maturity and harvest of the crop are mainly responsible for the field deterioration of soybean seeds [4-6]. At physiological maturity soybean seed reaches its maximum potential for germination and vigour [7, 8]. This potential is short lived as compared to other grain crops and reduces rapidly [9]. Harvesting the crop at physiological maturity can lower the deterioration of seed but due to some

other limitations such as drying of seeds for storage up to 15% moisture content at optimum temperature and relative humidity is not feasible at large scale production, particularly when weather conditions are not favorable at the time of harvest, availability of labour and other harvesting machinery is also a limiting factor for timely harvesting of crop. So it is imperative to screen the soybean varieties for their response to field weathering in tropical and subtropical weather conditions (hot, humid with intermittent rainfall). Dassou and Kueneman [1] have observed a wide genotypic variability for field weathering among American genotypes. Bhatia [2] have also reported the genotypic variability in seed longevity of some Indian soybean varieties and found that seed longevity is adversely affected by field weathering. A minimum of 80-90% germination of seed is required for certification and obtaining optimum productivity for soybean crop in U.S.A.[10].

Therefore, it was considered important to evaluate and classify all the released varieties for

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their response to delayed harvesting as well as field weathering. In the present study we have studied the germination potential and initial growth of seedlings of 62 soybean varieties harvested at physiological maturity and after three weeks of delayed harvesting. The varieties were further classified according to their seedling vigour index as affected by delayed harvesting along with field weathering in different groups viz. highly tolerant, tolerant, susceptible and highly susceptible.

MATERIALS AND METHODS

Seeds of 62 soybean varieties released for cultivation in India till the year 2000 were collected from the Plant Breeding Section of National Research Centre for Soybean, Indore. The varieties were planted during *Kharif* (Rainy season) 2000 and 2001 at the research farm of National Research Centre for Soybean, Indore, India, in randomized block design (RBD) with three replications. Each plot consisted of 5 m row length and row-to-row and plant-to-plant distance was maintained at 60 and 5 cm respectively. At the time of planting, seeds were treated with recommended fungicides viz. Bavistin and Diathane M @ 2 g/kg seeds and also with Rhizobium culture. A basal dose of N: P: K @ 20, 60 and 20 kg/ha was applied. The plants were kept free of weeds and insects by hand weeding and application of recommended insecticides respectively. At maturity, unweathered and field weathered seeds of each variety were collected as per the method described by Dassou and Kueneman [1] with some modifications. In order to assure the same stage of pods, at seed initiation (R5 stage [11]), about 500 pods were tagged in each plot. For unweathered seeds 250 tagged pods of each variety and replications were randomly picked at physiological maturity (R7 stage) and kept in the laboratory at 25°C for two to three weeks till the seed moisture reached to about 14-16% and then hand threshed. The R7 stage was identified when maximum dry matter was reached in the seeds; green color was lost both in pods and seed, and seed moisture content was about 50% [11]. Three weeks after physiological maturity another 250 pods were picked from each plot and also hand threshed to obtain field weathered seeds.

Standard germination (SG) and seedling vigour index (SVI): The test was performed on 50 seeds each per three replicate of each genotype and weathering treatments in rolled paper towels [12]. The paper towels were kept at 30°C in a seed germinator (Reico seed germinator, India) at 90% RH. Seedlings were

counted after five days. The seedling vigour index (SVI) was calculated according to Abdul Baki and Anderson [13] by using the following formula:

$$SVI = \text{Germination (percent)} \times [\text{Root length (cm.)} + \text{Shoot length (cm.)}]$$

RESULTS AND DISCUSSION

Field weathering defined as the deterioration of seeds from physiological maturity till harvesting, is by far the most crucial factor limiting the productivity of soybean crop under tropical and subtropical conditions [1]. Field weathering essentially takes place in the field itself when the seed is attached to mother plant and leads to reduction in germination and storage potential of the soybean seeds. The severity of problem of field weathering is evident in the present study. For two successive years (2000 and 2001), 62 soybean varieties released till date were evaluated for their response to field weathering. Unweathered (harvested at physiological maturity or R7-stage) and field weathered (harvested three weeks after physiological maturity) seeds of these varieties were subjected to germination and vigour test. All the data collected for two years was pooled for statistical analysis and is presented in Tables (1, 2 and 3). The data on weather conditions (temperature, RH and rainfall) for the maturity period to harvesting of these varieties (September 15 to October 30) are presented in figures 1A, B and C. Between the years, the mean standard germination, seedling length and dry weight, and SVI were significantly low (85.4%, 12 cm, 0.819 g and 1134, respectively) in the seeds harvested during first year (2000) of screening as compared to the seeds harvested in the second year (2001) of screening (89.2%, 13.1 cm, 1.01 g and 1169.2, respectively). However, a significant interaction between the year and weathering treatments indicated a differential response of these varieties to field weathering during two years of screening. Compared to unweathered seeds, there was 22, 21.5, 17.4 and 36% reduction in standard germination, seedling length, seedling dry weight and seedling vigour index in the field-weathered seeds during year 2000. As against this, the reduction in above parameters was 18.7, 14.2, 16 and 29%; respectively in the field weathered seeds harvested during year 2001. Hence, the adverse impact of field weathering on seed quality was of higher degree during 2000 as compared 2001. This could mainly be due to weather conditions i.e. higher temperature, humidity and frequency and amount of rainfall during the maturity and post maturity period observed during first year which was much severe than the second year.

Table 1. Effect of field weathering on germination and vigour index of 62 Indian soybean varieties.

Year	Standard Germination (%)		Seedling length (cms)		Seedling dry wt. (g/10seedlings)		Seedling vigour index (SVI)										
	UW	FW	UW	FW	UW	FW	UW	FW									
2000	96.0	74.9	85.4	22.0	14.4	11.3	12.9	21.5	0.90	0.74	0.82	17.39	1385.1	882.5	1133.8	36.3	
2001	98.4	80.0	89.2	18.7	14.1	12.1	13.1	14.2	1.10	0.92	1.01	16.04	1391.3	987.0	1189.2	29.1	
Mean	97.2	77.4	87.3	20.3	14.2	11.7	13.0	17.6	1.00	0.83	0.91	17.00	1388.2	934.8	1161.5	32.6	
Range	91.0-100.0	33.5-99.0	62.3-99.5	1.0-63.2	8.0-19.4	4.8-16.6	6.4-18.0	0.0-40.0	0.72-1.46	0.62-1.19	0.66-1.33	0.0-32.79	755.3-1937.5	229.8-1599.2	492.5-1712.7	2.7-76.7	
LSD (P=0.050)																	
Year(Y)			1.249				0.201				0.013					22.2	
Weathering (W)			1.49				0.010				0.013					22.2	
Variety (V)			6.956				1.123				0.073					123.7	
WxV			9.838				1.588				0.0104					175.0	
YxW			1.767				0.285				0.019					31.4	
YxV			9.838				1.588				0.104					175.0	
YxWxV			13.913				2.247				0.147					247.5	

UW=unweathered (Control) and FW=field weathered.

Table 2. Days to physiological maturity and 100 seed weight of 62 Indian Soybean varieties

Year	100 Seed Weight(g)	Days to Physiological Maturity
2000	10.51	91.63
2001	14.18	95.20
Mean	12.35	93.41
Range	8.2- 19.7	72- 114
LSD (0.05 P)		
Year (Y)	0.232	2.002
Variety (V)	0.826	2.369
YxV	1.168	3.351

Over the years, the average standard germination of unweathered seeds was 97.2%, which was significantly reduced to 77.4% in the field-weathered (delayed harvested) seeds (Table 1). The varieties also differed significantly for their standard seed germination, and the mean value ranged from 99.5 (Kalitur) to 62.25% (Hara Soya). The variety x weathering interaction was found to be significant indicating a differential response of these varieties for seed germination due to field weathering. The per cent seed germination in the unweathered seeds ranged from 100 to 91% as compared to 99 to 33.5% observed in the field weathered seeds of these varieties. The per cent decline in the germination in the field weathered as compared to unweathered seeds differed significantly among the assessed soybean varieties. This decline ranged from 1% (Kalitur) to 63.2% (Hara Soya) among the varieties. The genetic variability among cultivars would be very helpful in their selection for cultivation as according to the weather conditions of particular location. However, the standard germination of field weathered seeds after harvest itself was less than 70% in many of these soybean varieties, indicating non-suitability of their seeds for storage and planting in next season. The problem of seed quality in field-weathered seeds is further accentuated due to poor storage potential of these seeds [2,14].

Besides germination, other parameters associated with vigour of the seeds such as seedling length and seedling dry weight were also significantly affected by field weathering (Table 1). The average seedling length and dry weight of unweathered seeds of 62 soybean varieties was 14.17 cm and 0.997 g which declined to 11.59 cm and 0.921 g in field

weathered seeds, respectively. Varieties also differed significantly for these parameters, which ranged from 6.40 to 17.28 cm and 0.658 to 1.329 g, respectively. The variety x environment interaction was significant which indicated that the reduction in seedling length and dry weight due to field weathering differed significantly among the varieties.

As vigour declines much before viability (standard germination), germination alone may not indicate the extent of deterioration in seeds due to field weathering. Therefore, multiple criteria using germination and seedling length have been used to work out the seedling vigour index (SVI) [13]. The average SVI value in the unweathered seeds of 62 soybean varieties was 1388.2, which was significantly reduced to 955.8 in field-weathered seeds (Table 1). Hence, on an average, there was a decline of 31.15% in SVI due to field weathering in these varieties. Genotypes also differed significantly for their SVI values, which ranged from 492.5 to 1712.7. The interaction of varieties x weathering treatment was significant indicating a differential decline in SVI value in field weathered seeds as compared to unweathered seeds. The maximum decline was observed in varieties Hara Soya, JS 71-05, JS-2, PK-262, MACS 330 and NRC 7 while in varieties Kalitur, JS 80-21, Punjab-1, NRC 37, MACS 450, and Lee the decline was less.

This differential response of varieties for field weathering in soybean is dependent on several varietal characters such as seed size, days to maturity, per cent hard seeds, seed coat thickness, hull percentage, oil content etc. as reported earlier [1, 2 & 15]. The early maturing and bold seeded varieties are more susceptible to loss of seed quality due to field weathering as compared to late maturing and small seeded varieties [2]. It is also evidenced in the present study, the average days to physiological maturity and 100 seed weight of these varieties was 95 and 14.18 g and ranged from 72 days to 114 days and 8.20 g to 21.0 g, respectively (Table 2). There was no association for seedling vigour index of unweathered seeds with days to maturity or seed size. However, the seedling vigour index of field weathered seeds showed a strong negative association with 100 seed weight (correlation coefficient $r' = -0.426^{**}$) and a positive association with days to physiological maturity ($r = 0.297^{**}$). Hence, bold seeded and early maturing varieties tended to loose viability much faster than small seeded and late maturing varieties when subjected to field weathering.

Based on degree of reduction in seedling vigour index (SVI) value in field weathered seeds over unweathered seeds, soybean varieties were categorized in different groups which indicated their

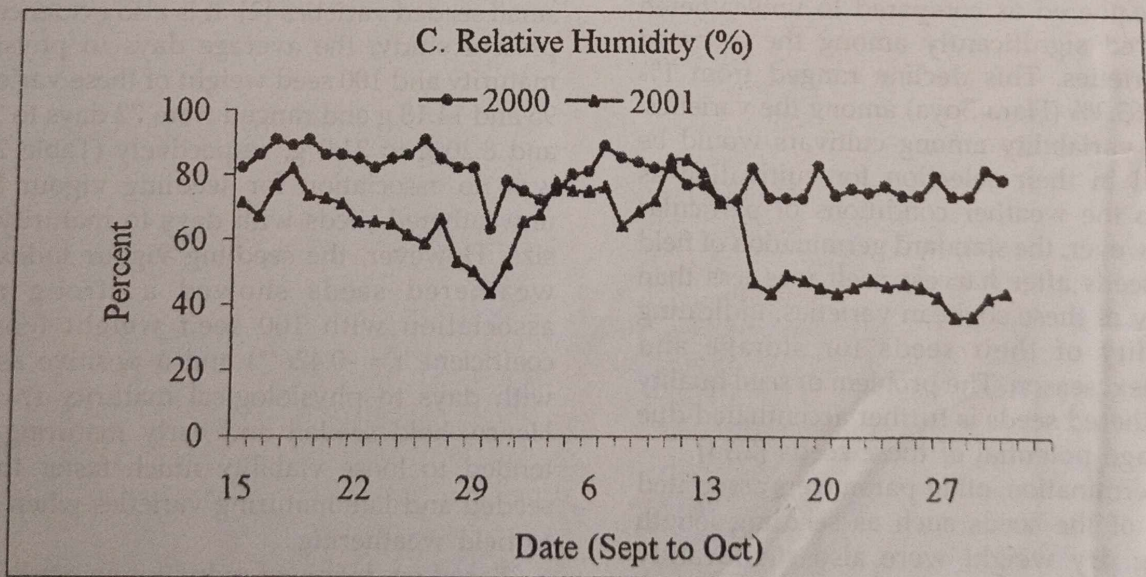
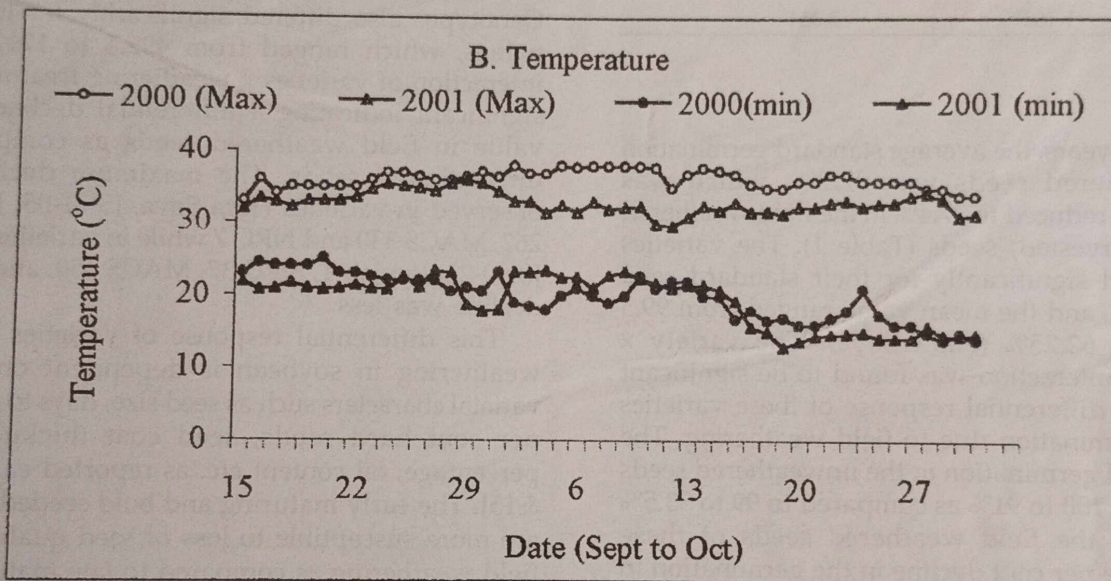
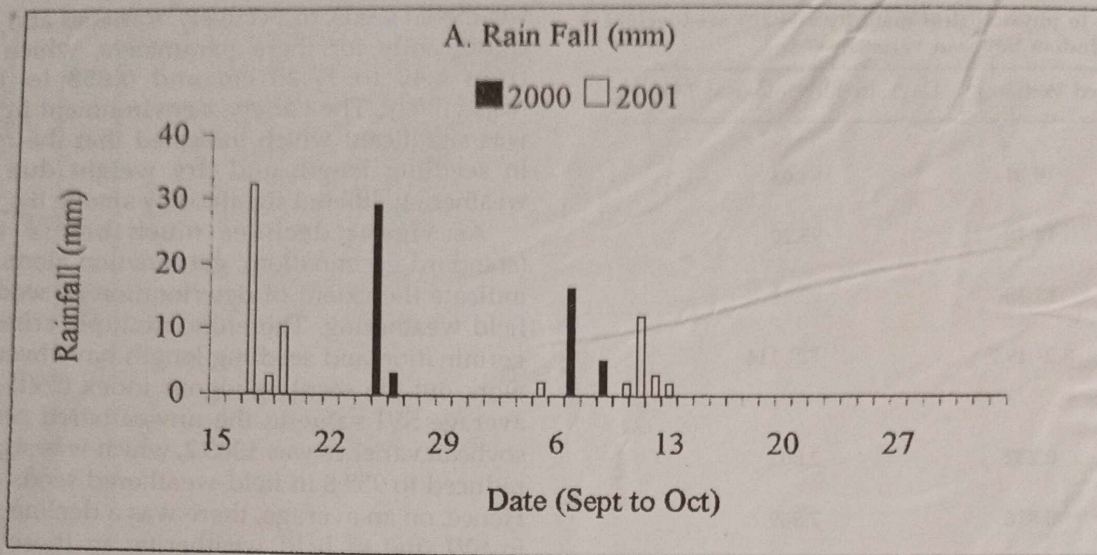


Fig.1: A. Intermittent rainfall, B. Temperature and C. Relative Humidity during the period of physiological maturity and field weathering (from 15 September to 31 October in the year 2000 and 2001 at Indore, India).

Table 3. Classification of 62 Indian soybean varieties for their response to field weathering.

Group	Category†	Range*	No. of Varieties	Varieties
I	Highly Tolerant	0-15%	8	Punjab-1 (2.65), Kalitur (5.07), JS 80-21 (6.13), NRC 37 (6.37), JS 72-280 (7.57), Lee (8.04), PK 472 (10.29), MACS 450 (13.87).
II	Tolerant	16-30%	21	JS 90-41 (18.31), Bragg (18.69), KHSb- 2 (19.25), PK 471 (19.27), GS-1 (22.51), MACS-124 (24.12), JS 79-81 (24.77), PK-308 (25.37), NRC -12 (25.66), MACS-58 (25.70), MAUS-32 (25.76), Pusa 20 (25.91), BS-1 (26.80), Alankar (26.84), PK-327 (27.27), JS 76-205 (27.98), PK 1024 (28.02), Indira Soya (28.34), T-49 (29.51) PK 564 (29.54), Co-1(29.85).
III	Susceptible	31-45%	21	VLS-47 (31.15), JS 75-46 (31.6), Co-2 (32.34), MAUS-47 (32.41), MACS-57 (33.26), Ankur (34.31), MACS 754 (34.47), Imp. Pellicon (35.10), Hardee (35.34), Pusa 40 (36.56), JS 335 (36.68), Pusa-37 (36.58), Shilajeet (38.54), JS 72-44 (39.07), MAUS-2 (39.81), PK-1029 (39.02) PK- 4 1 6 (39.24), Pusa 24 (39.01), Pusa 16 (39.51) Shivalik (42.77), Pusa 22 (43.68).
IV	Highly Susceptible	>45%	12	Monetta (47.84), KB-79 (48.03), MACS 13 (48.5), Samrat (51.97), SL-295 (56.38), NRC-7 (56.81), NRC-2 (64.37), JS 71-05 (65.18), PK-262 (65.54), MACS-330 (69.58), JS-2 (69.80), Hara Soya (76.72)

† Categories are made according to per cent reduction in seedling vigour index of varieties.

* Range indicates the per cent reduction in seedling vigour index (SVI).

Value in parenthesis shows the per cent reduction in seedling vigour index (SVI).

response to field weathering or tolerance to delayed harvesting (Table 3). All the varieties showed reduction in SVI value and hence none of the screened soybean varieties were completely resistant to field weathering. Varieties showing less than 15% reduction in SVI were grouped as highly tolerant. Out of 62 varieties only 8 (13%) were found to be highly tolerant. Varieties showing high levels of tolerance to field weathering included Punjab 1, Kalitur, JS 80-21, NRC 37, JS 72-280, Lee, PK 471 and MACS 450. Soybean varieties in which reduction in SVI was between 16 to 30% were grouped as moderately tolerant to field weathering. About 34% of varieties screened were found to be moderately tolerant and some of the prominent varieties falling in this group were JS 90-41, PK 472, MACS 124, and PK 1024. Varieties, which showed reduction in SVI between 31 to 45% and in which reduction was more than 45%, were grouped into susceptible and highly susceptible categories, respectively. Among the varieties evaluated, 34% were found to be susceptible and 19% were highly susceptible. Some of the prominent varieties found to be highly susceptible were JS 71-05, PK 262, NRC 7 and MACS 330.

In the present study, the quality of unweathered seeds harvested at physiological maturity did not significantly differ over years but the reduction in quality parameters of field-weathered seeds over unweathered seeds was of higher degree in 2000 than in 2001. Relatively higher temperatures, humidity and frequency and time of intermittent rainfall during the maturity and post maturity period were observed during year 2000 as compared to 2001 (Fig 1A, B, and C). Among the several environmental factors, high temperature, humidity and their fluctuations have been reported to exert the greatest influence on seed life [4, 6, 16]. Hence, relatively high temperatures and humidity and also the frequency and amount of rainfall were responsible for higher degree of deterioration in field weathered seeds in first year. Besides this the response of some soybean varieties do not change over the years as well as in different weather conditions and their germinability and vigour remain almost constant, so these varieties along with some highly susceptible varieties can be used for understanding of the physiology of seed deterioration in response to environmental interaction.

Under tropical conditions like in India, extensive care for timely harvesting and threshing of soybean crop is needed for maintaining the seed quality and productivity in subsequent seasons. The data presented here substantiate the severity of field deterioration in soybean under tropical weather condition. Though, large genotypic variability for seed quality in response to field weathering was observed, none of the screened soybean variety showed an absolute resistance. Therefore, based on their response, these varieties were classified as I) highly tolerant, II) tolerant, III) susceptible and IV) highly susceptible to field weathering (Table 3). This classification of varieties will be helpful for the farmers to produce better quality of soybean seeds through the selection of appropriate variety/ varieties and adoption of management strategy such as timely harvesting and threshing of the crop. The cultivation of field weathering tolerant varieties will be beneficial for the regions where post monsoon rains generally occur and the temperature and relative humidity are also very high at the time of harvest. The assessment and classification of varieties will also be helpful in molecular breeding programme for understanding the QTLs (quantitative trait loci) or gene responsible for susceptibility/tolerance of varieties for field weathering.

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