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Relation of Harvest Time to Quality Soybean Seed Produced in the Humid Tropics

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ABSTRACT. Five soybean (Glycine max L. Merr.) cultivars planted in wet and dry seasons were harvested at physiological maturity, harvest maturity, two weeks after harvest maturity and at four weeks after harvest maturity. The seeds were evaluated for viability and vigour through germination tests conducted under near optimal and sub-optimal conditions. Germination was higher in sand at 30 C as compared to germination in the field. Dry season seeds showed better germination than wet season seeds. Seeds of three soybean cultivars harvested at physiological maturity, followed by drying in open-sided shed, were found superior in viability and vigour to the seeds of harvest maturity in wet season but the viability and vigour of dry season seed from these two harvests did not differ significantly. A harvest delay by two weeks beyond harvest maturity during wet season significantly reduced the viability and vigour of seed in some cultivars and such a reduction was not observable in the dry season. A delay of four weeks after harvest maturity in the dry season significantly lowered the viability and vigour of seed in two soybean cultivars. The interaction between cultivar and harvest time was significant. Harvest time, depending on cultivars and weather conditions at and around maturity, is crucial for quality seed production in soybean in the humid tropics.

INTRODUCTION

One of the major obstacles to expansion of soybean cultivation in the tropics is the difficulty of producing high quality seed. High temperature and relative humidity that prevail in the tropics are not conductive to the production of quality seed, necessary to establish a required plant stand in the field. Therefore, timely harvest of matured soybean seed, in accordance to field conditions, is important in protecting and maintaining seed quality in the humid tropics.

Deterioration could be slowed down either by protecting the matured seeds from ambient field environment or remove them completely from

the field (Gregg, 1982). Harvest delays beyond optimum maturity extend field exposure and intensify field deterioration in soybean. Seed quality was shown to decline with subsequent reduction in germination and emergence when harvest was delayed beyond two weeks of harvest maturity (Paschal and Ellis, 1978; Arulnandhy, 1984) and also when the seeds were harvested 30 days after harvest maturity in hot humid conditions (Tekrony *et al.*, 1979).

It is essential that increased emphasis be devoted to the production of quality seed of acceptable standards, for which harvest time is supposed to play a vital role in the management of high quality seed production. Realising its importance, a study was initiated to determine the variation in seed quality associated with harvest time in five soybean cultivars under humid tropical conditions.

MATERIALS AND METHODS

Seeds of five soybean cultivars (PM 78-25, PM 78-13, F 73-14, Bossier and Pb-1) harvested at physiological maturity (development stage R7), harvest maturity (development stage R8; Fehr *et al.*, 1971), and two weeks after harvest maturity were evaluated for seed quality. All the seeds were produced from planting made in October 1983 in the wet season at the Agricultural Research Station in Maha Illuppallama. The Maha Illuppallama area, latitude of $8^{0}5'$ N, could be classified as humid tropical. The experiment was designed as a randomized complete block with split plot arrangement of treatments, with cultivar as main treatment and harvest time as sub-treatment. Each main treatment was replicated four times.

Each cultivar was planted in six rows 5 m long and 40 cm apart. Two rows of each cultivar were harvested when pods turned yellow (physiological maturity) and dried in an open-sided shed under shade until the pods turned brown, another two rows were harvested when 95 per cent of the pods turned brown (harvest maturity), and the balance two rows were harvested at two weeks after harvest maturity. The seeds of each cultivar harvested at different times were sun-dried separately and kept in airtight metal cans under cold storage (10 C and 45% RH) until tested for viability and vigour on 9 March 1984.

Twenty – five seeds from the seed lot of each cultivar harvested at different times, from every replicate, were drawn at random and treated with Captan 80% WP. These seeds were planted in moist sterilized sand contained in plastic boxes. Seeds were germinated under illumination for eight hours a day, using flourescent lamps of 750 – 1000 lux, and at a constant temperature of 30 C $\pm$ 1 C, approximate optimum for soybean germination (Delouche, 1952). Another 25 captan – treated seeds of each sample were planted in the field with conditions favourable for germination.

Emerged seedlings of both tests were counted on five and eight days after planting. The seedlings were carefully uprooted after eight days of planting, examined, and classified in accordance with the criteria of the Association of Official Seed Analysts (AOSA, 1970). Seedling length and dry weight were determined using five seedlings taken at random from each sample. Seedling length was measured from the point of attachment of the cotyledons to the root tip. The same seedlings were used to obtain the dry weight gravimetrically after drying at 60 C in an oven for 48 hours.

Germination percentage was used as a measure of seed viability. Reported germination values included only normal seedlings counted after eight days. The seedling length and dry weight were the measurements assigned to seed vigour, in addition to emergence rate which was computed as

1/2 [(*number of emerged seedlings on the 5th day after planting*) / 5
PLUS
(*number of emerged seedlings on the 8th day after planting*) / 8]

This is a modification of the method suggested by Maguire (1962).

Another experiment of similar nature, consisting of same cultivars, was planted again on 24 April 1984 in the dry season at the same location; however, one more sub – treatment was added *i.e.* harvest at four weeks after harvest maturity. The germination tests were conducted on 10 September 1984 and evaluation was performed as described earlier.

The data obtained on viability and vigour of seed lots of the five cultivars harvested at different times were processed and subjected to the

Table 1. Mean weekly data on weather parameters during the period from physiological maturity to last date of harvest in the wet and dry seasons.

Season	Year	Date	Harvest time	Temp. (^{O}C)	Relative humidity %	Rain fall (mm)	Sunshine (hr)
Wet	1984	04 - 10 Jan.	Physiological maturity	22.2	78.2	10.3	5.9
		11 - 17 Jan.		25.3	81.5	14.4	4.5
		18 - 24 Jan.	Harvest maturity (HM)	25.9	77.7	0.7	8.5
		25 - 31 Jan.		25.2	80.7	0.4	3.2
		01 - 07 Feb.	2 weeks after HM	25.2	82.5	16.2	0.9
Dry	1984	18 - 24 Jul.	Physiological maturity	27.6	76.1	0.1	7.4
		25 - 31 Jul.		28.0	71.7	0.0	7.9
		01 - 07 Aug.	Harvest maturity (HM)	28.5	68.9	0.0	9.0
		08 - 14 Aug.		28.5	64.2	0.0	9.3
		15 - 21 Aug.	2 weeks after HM	29.4	63.7	0.0	7.3
		22 - 28 Aug.		31.2	62.7	0.0	8.0
		29 - 04 Sep.	4 weeks after HM	28.9	62.7	0.0	8.9

standards analysis of variance. Germination percentages were transformed to arcsine degree scale for the purpose of statistical analysis.

RESULTS AND DISCUSSION

The mean germination percentage of dry and wet season seeds of harvest maturity in sand at 30 C was 92.5 and 78.0 and that in the field was 87.1 and 54.8, respectively. (Figure 1) Germination tends to be higher in sand at 30 C as compared to field germination. Sand germination was respectively 9.0, 5.4, 2.3 and 12.7 per cent higher than field germination for seeds harvested at physiological maturity, harvest maturity, two weeks after harvest maturity, and four weeks after harvest maturity in the dry season. The gap between sand and field germination was wider for seeds harvested in the wet season. The lower germination in the field may be explained in terms of high soil temperature during seed germination and emergence which was at 31.0 C $\pm$ 1.1 C (mean) and maximum of 36.5 C. This temperature was found to be above optimal for soybean germination (Delouche, 1952). Also the dry season seeds expressed a higher germination as compared to the seeds of wet season. This may be attributed to the better weather conditions in the dry season such as drier conditions and longer sunshine hours that prevailed at seed maturation and soon after (Table 1).

The wet season seeds of the cultivars PM 78-25 and Pb-1 obtained at physiological and harvest maturity did not show any significant difference in germination percentage but the seeds of PM 78-13 from the same season, harvested at physiological maturity were superior to the seeds of harvest maturity in both sand and field germination (Tables 2 and 3). In addition, seeds of F 73-14 harvested at physiological maturity showed significantly higher germination than the seeds of harvest maturity in sand test and likewise Bossier in the field test.

Dry season seeds of all the cultivars harvested at physiological and harvest maturity showed statistically equal germination in both field and sand tests, except in the case of Bossier in field germination (Tables 2 and 3). Nearly favourable weather conditions of the dry season (Table 1) did not affect the viability of seeds after physiological maturity at which the seeds are supposed to reach maximum quality (Helmer *et al.*, 1982) and germination capacity (Singh and Gupta, 1982).

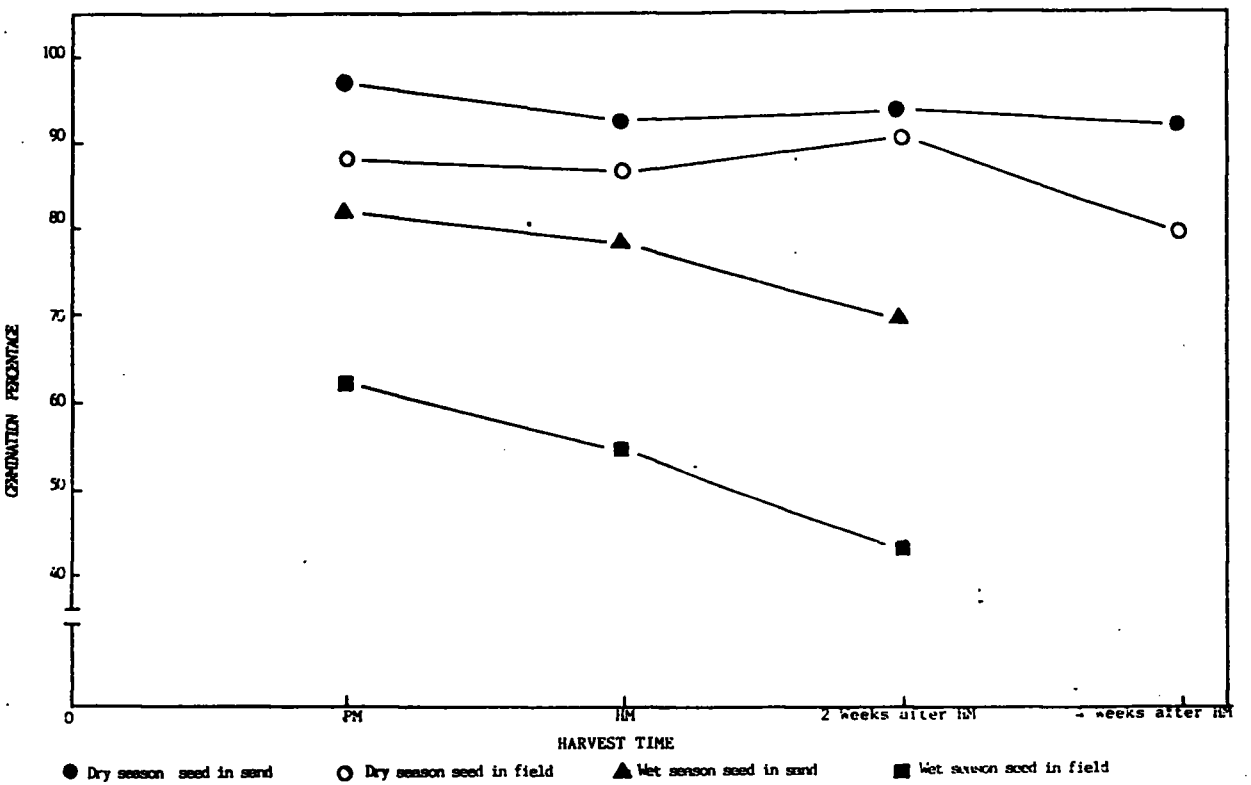

Fig.1. Sand and field germination of seeds harvested at different times during dry and wet seasons.

Table 2. Mean germination percentage (P) of five soybean cultivars harvested at different times during wet and dry seasons in sand germination test at 30 C. (Arcsine transformed values are in column A).

Cultivar	Harvest time	Wet season		Dry season	
		P	A	P	A
PM 78-25	PM	87.5	69.3	94.9	76.9
	HM	89.7	71.3	95.8	78.2
	2 WAHM	88.4	70.1	98.2	82.2
	4 WAHM	-	-	95.2	77.3
PM 78-13	PM	78.1	62.1	95.9	76.9
	HM	68.3	55.7	92.8	74.4
	2 WAHM	69.9	56.7	90.7	72.3
	4 WAHM	-	-	91.6	73.2
F 73-14	PM	82.2	65.1	91.5	73.1
	HM	68.3	53.3	87.9	69.7
	2 WAHM	53.1	46.8	87.7	69.4
	4 WAHM	-	-	85.9	67.9
Bossier	PM	89.4	71.0	98.2	82.2
	HM	87.9	69.7	96.4	79.1
	2 WAHM	83.0	63.6	94.6	76.6
	4 WAHM	-	-	94.4	76.3
Pb-1	PM	88.1	69.8	95.6	77.8
	HM	79.8	67.3	89.8	71.4
	2 WAHM	53.0	46.7	98.0	81.9
	4 WAHM	-	-	93.6	75.4
L.S.D. (P = 0.05) for harvest time within cultivar			3.8		ns

PM - Physiological maturity
HM - Harvest maturity
WAHM - Weeks after harvest maturity

Table 3. Mean field germination percentage (P) of five soybean cultivars harvested at different times during dry and wet seasons. (Arcsine transformed values in column A)

Cultivar	Harvest time	Wet season		Dry season	
		P	A	P	A
PM 78-25	PM	69.7	56.6	89.6	73.2
	HM	63.4	52.8	96.6	79.3
	2 WAHM	71.1	57.5	98.4	81.8
	4 WAHM	-	-	83.1	65.7
PM 78-13	PM	64.1	53.2	79.1	62.8
	HM	57.3	49.2	77.3	61.5
	2 WAHM	53.6	47.1	90.4	71.9
	4 WAHM	-	-	84.1	66.5
F 73-14	PM	54.2	47.4	91.3	72.8
	HM	49.9	44.9	91.5	73.0
	2 WAHM	18.8	25.7	84.4	66.7
	4 WAHM	-	-	84.1	66.5
Bossier	PM	75.1	60.1	96.6	79.3
	HM	59.4	50.4	84.3	66.7
	2 WAHM	40.9	39.7	92.4	70.1
	4 WAHM	-	-	69.6	56.6
Pb-1	PM	48.0	43.8	84.4	66.7
	HM	44.1	41.6	85.9	68.0
	WAHM	31.9	34.4	87.3	69.1
	4 WAHM	-	-	76.2	60.8
L.S.D. (P = 0.05) for harvest time within cultivar			3.9		7.3

PM - Physiological maturity
HM - Harvest maturity
WAHM - Weeks after harvest maturity.

Delayed harvest during the wet season reduced seed viability to a considerable extent but not in the dry season (Figure 1). During wet season, a harvest delay by two weeks significantly reduced the germination in cultivars F 73 – 14, Bossier, and Pb – 1 (Tables 2 and 3). In contrast, during the dry season a delay in harvest did not lower the seed germination significantly (Table 2), except in the case of PM 78 – 25 and bossier at four weeks after harvest maturity (Table 3). Similar observations have been made earlier by the other workers as well (Paschel and Ellis, 1978; Wein *et al.*, 1980; Arulnandhy, 1984).

Emergence rate, seedling length, and seedling dry weight were the measures used in the determination of seed vigour. Emergence rate of the dry season seeds harvested at physiological and harvest maturity did not differ from each other significantly in most cultivars except for Bossier under field germination conditions (Table 4). However, the wet season seeds of PM 78 – 13, F 73 – 14 and Pb – 1 showed significant differences in emergence rate between these two harvests in sand germination. Delaying the harvest by two weeks, during the wet season, significantly reduced the emergence rate in cultivars F 73 – 14 and Bossier in sand germination and in the same cultivars and Pb – 1 under field germination conditions. Also delaying the harvest by four weeks after harvest maturity, in the dry season, significantly reduced the emergence rate in cultivars F 73 – 14 and Pb – 1 in field germination. The different response of cultivar to time of harvest in relation to viability (germination percentage) and vigour (emergence rate), more prominent during wet season, indicated that an interaction did exist between cultivar and harvest time, which was found to be significant at the 5% level (Tables 2 – 4). This would permit selection of cultivars for a situation when harvest delay is anticipated.

Considering both sand and field germination of the wet season seeds, harvest at physiological maturity significantly increased the seedling length of the cultivars PM 78 – 25 and PM 78 – 13 in both sand and field germination (Table 5) and the seedling dry weight of all the cultivars under field germination conditions, compared to harvest maturity (Table 6). On the other hand, delaying the harvest by two weeks in the same season showed a significant reduction in seedling length from harvest maturity in PM 78 – 25; Bossier and Pb – 1 under field germination conditions. A similar reduction in seedling dry weight was observed in all the cultivars, except in Pb – 1 in both field and sand gemination and PM 78 – 25 in sand germination. In the dry season, no significant

Table 4. Mean emergence rate per day of five soybean cultivars harvested at different times during wet and dry seasons in sand and field germination tests.

Cultivar	Harvest time	Wet season		Dry season	
–		Sand	Field	Sand	Field
PM 78-25	PM	3.38	1.94	3.80	3.56
	HM	3.62	1.84	3.94	3.61
	2 WAHM	3.50	2.04	3.98	3.62
	4 WAHM	–	–	3.84	3.36
PM 78-13	PM	3.13	1.50	3.84	3.22
	HM	2.74	1.30	3.68	3.15
	2 WAHM	2.65	1.24	3.67	3.51
	4 WAHM	–	–	3.68	3.01
F 73-14	PM	3.31	1.11	3.59	3.63
	HM	2.60	1.11	3.44	3.60
	2 WAHM	2.00	0.39	3.56	3.48
	4 WAHM	–	–	3.48	3.28
Bossier	PM	3.56	1.50	3.97	3.63
	HM	3.82	1.62	3.95	3.05
	2 WAHM	3.36	0.94	3.78	3.21
	4 WAHM	–	–	3.87	3.06
Pb-1	PM	3.54	1.13	3.82	3.41
	HM	3.16	1.10	3.63	3.53
	2 WAHM	2.95	0.78	3.94	3.51
	4 WAHM	–	–	3.87	2.99
L.S.D. (P = 0.05) for harvest time within cultivar		0.27	0.21	ns	0.27

PM – Physiological maturity
HM – Harvest maturity
WAHM – Weeks after harvest maturity.

Table 5. Mean seedling length (cm) of five soybean cultivars harvested at different times during wet and dry seasons in sand and field germination tests.

Cultivar	Harvest time	Wet season		Dry season	
		Sand	Field	Sand	Field
PM 78-25	PM	34.9	8.1	23.0	10.2
	HM	25.4	7.4	23.6	10.9
	2 WAHM	27.4	6.6	20.9	9.9
	4 WAHM	-	-	21.2	9.8
PM 78-13	PM	31.4	7.3	24.3	11.4
	HM	28.0	6.5	21.1	11.4
	2 WAHM	28.9	6.6	20.1	12.2
	4 WAHM	-	21.3	10.5	
F 73-14	PM	31.7	7.4	21.9	10.2
	HM	28.3	7.7	19.8	11.2
	2 WAHM	27.5	7.2	20.2	11.3
	4 WAHM	-	-	20.2	10.4
Bossier	PM	32.1	7.8	19.3	11.2
	HM	31.1	7.9	20.8	11.2
	2 WAHM	-	37.0	20.7	11.4
	4 WAHM	-	-	20.6	10.8
Pb-1	PM	32.7	7.9	22.0	11.5
	HM	31.0	7.3	19.4	10.7
	2 WAHM	33.5	6.2	20.1	12.0
	4 WAHM	-	-	22.3	12.7
L.S.D. (P = 0.05) for harvest time within cultivar		1.7	0.5	ns	ns

PM - Physiological maturity
HM - Harvest maturity
WAHM - Weeks after harvest maturity.

Table 6. Mean seedling dry weight (mg) of five soybean cultivars harvested at different times during wet and dry seasons in sand and field germination tests.

Cultivar	Harvest time	Wet season		Dry season	
		Sand	Field	Sand	Field
PM 78-25	PM	40.0	123.5	101.9	152.5
	HM	41.0	108.0	124.3	143.9
	2 WAHM	30.0	96.5	118.6	139.5
	4 WAHM	-	-	122.3	147.3
PM 78-13	PM	76.7	126.5	153.0	174.2
	HM	70.5	104.5	202.6	223.6
	2 WAHM	58.0	95.0	251.2	195.8
	4 WAHM	-	-	158.8	187.2
F 73-14	PM	165.5	212.3	203.8	254.1
	HM	117.5	209.5	230.6	235.9
	2 WAHM	76.7	201.0	219.3	177.6
	4 WAHM	-	-	200.6	187.2
Bossier	PM	82.5	177.5	159.3	195.2
	HM	77.3	156.0	189.1	196.6
	2 WAHM	57.5	138.0	160.1	168.9
	4 WAHM	-	-	170.3	175.9
Pb-1	PM	49.1	165.5	176.2	183.1
	HM	40.5	129.5	123.3	220.0
	2 WAHM	43.5	141.0	182.2	212.9
	4 WAHM	-	-	167.5	174.4
L.S.D. (P = 0.05) for harvest time within cultivar		12.4	5.2	ns	23.3

PM - Physiological maturity
HM - Harvest maturity
WAHM - Weeks after harvest maturity.

differences in seedling length was noticed among different harvests of the cultivars tested in this experiment (Table 5). However, delaying the harvest by four weeks significantly reduced the seedling dry weight from harvest maturity in the cultivars PM 78-13, F 73-14, and Pb-1 as indicated by the field germination test. A reduction in seedling length due to harvest delay by four weeks after maturity was reported by Arulnandhy (1984) from his earlier investigation in soybean.

From the available data, it appears that the occurrence or non-occurrence of a significant change in seed quality due to harvest time apparently depends on the cultivar as well as the prevailing weather conditions in the field. Nevertheless, timely harvest of soybean crop is a vital factor to maintain high quality seed in the humid tropics.

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