SOME FACTORS AFFECTING SOYBEAN VIABILITY AND EMERGENCE IN THE LOWLAND TROPICS[1]

D. Nangju, H.C. Wien and T.P. Singh[2]
International Institute of Tropical Agriculture, Ibadan, Nigeria

ABSTRACT

Seed viability and emergence is one of the most important problems affecting soybean production in West Africa. Results from the multi-location yield trials indicated that introduced cultivars such as Bossier, Jupiter and Improved Pelican showed excellent adaptation and high yields provided seedling emergence was high and plant population was optimum. Diseases and insects are as yet not a major problem.

An integrated approach on soybean emergence problem has been carried out by the IITA physiologist, agronomist and soybean breeder to identify factors affecting soybean viability and emergence, and to find a practical solution for this problem. Results obtained so far indicated that poor germination was observed in some cultivars right from the time they were harvested. After harvest, factors such as seed quality, method of threshing, temperature during drying, length and method of storage could also lower the viability of soybean seeds; their effects were more pronounced in some cultivars than in others. At planting, sowing depth, soil temperature and soil moisture were found to influence seedling emergence. Soil temperature up to 42 C during rainy season at Ibadan, Nigeria has been recorded, and 2 hours of 42C soil temperature was found to reduce hypocotyl extension by more than 70% in soybean. Seed dressing with a fungicide, sowing depth between 2.5 - 5 cm, adequate soil moisture at planting and mulching are all beneficial in improving seedling emergence.

The present efforts are being concentrated on developing suitable screening methods for high seed quality and viability, and ability to tolerate high soil temperatures during emergence.

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[2]Agronomist, Physiologist and Soybean Breeder, respectively.

INTRODUCTION

Soybean was first introduced to West Africa some 70 years ago (17,39). With protein content of about 40% and oil content of about 18% it is an excellent grain legume for human food, animal feed and for other purposes. At present soybean production in West Africa is still infinitesimal as compared with production of soybean in the United States, Brazil, China and Indonesia, but the acreage is clearly expanding (3,4,21,39). The reasons why soybean is attractive to African countries are numerous: soybean has been shown to perform well in the lowland tropics (34,35,36,44); unlike cowpea, (Vigna unguiculata (L.) Walp.), a popular food legume in West Africa, it has relatively few insect and disease problems; the world price of soybean is high enough to make it worthwhile to be grown as a cash ~~catch~~ crop; soybean can be rotated with lowland rice which is now widely grown in some parts of West Africa. Introduced cultivars such as Bossier, Jupiter, CES 486, Improved Pelican and Hardee have been shown to perform well with seed yield up to 3.4 metric ton per ha provided the plant population is optimum (35,36).

One major drawback of soybean has been the difficulty in getting a good stand under field conditions. In Ghana this problem frustrated the planned commercial production of soybean when the crop was first introduced (39). The seedling emergence problem is not peculiar to West Africa alone but is well recognized in all soybean growing areas of the world (8,12,42). Soybean is highly sensitive to high temperatures (31,41). It requires higher moisture availability than corn and rice for germination (33). The position of the radicle-hypocotyl axis and the delicacy of the seed covering makes the seed especially vulnerable to injury by mechanical abuse such as harvesting, conveying and processing (12). The soybean viability and emergence problem is more serious in the tropics than in the temperate regions since climatic factors during ripening and harvest are seldom ideal, drying and storage facilities are inadequate, and environmental factors at planting are often unfavorable for germination and hypocotyl elongation. Since germination is the most important phase in the life cycle of a crop plant (45), it is logical that soybean improvement in the tropics including West Africa should begin with the improvement of its germinability and storability. The problem, however, is rather complex since there are many factors involved in affecting soybean viability and emergence (Figure 1). This paper reports the progress of research on soybean viability and emergence at the International Institute of Tropical Agriculture (IITA), and at the same time reviews the work which has been done on this aspect. The objectives and strategy of breeding for high seed quality, storability and germinability of soybean are also briefly discussed.

TIME OF RIPENING AND HARVEST

In West Africa soybean is generally grown in bimodal-rainfall regions. The major rainy season starts in March and ends in August. The minor rainy season begins shortly after the major season ends, and lasts for about 2 to 3 months.

For obtaining high yields soybean ideally should be planted during the major season but the seed quality is often poor because ripening and harvesting takes place during the rainy season. Furthermore, harvesting during rainy season presents a big drying problem. In the minor rainy season plants often suffer from moisture stress particularly during pod filling stage, and therefore, the seed yield is generally low although seed quality is excellent. In Benue Plateau state, where soybean is widely grown in Nigeria, farmers solve this problem by planting soybean in June or July so that both high yields and high seed quality can be obtained.

Studies conducted at IITA in 1974 show that both time of ripening and time of harvest affected seed quality and germination of soybean (Figures 2 and 3). Varietal differences were, however, observed for these characters. In the first (major) season high proportions of Bossier, Hardee and Kent seeds were either purple or cracked, while most of the seeds of Improved Pelican were clean and smooth. In Hardee part of the seeds was black or grey instead of normal, yellow color. The proportions of these types of seeds in the samples generally increased with a delay in harvest. R.J. Williams, our pathologist, showed that purple, brown and wrinkled seeds showed a high degree of fungal colonization as compared with the smooth, clean seed (35). The emergence of these types of seeds was also lower than that of smooth, clean seed (Table 1).

Table 1. Percent emergence of different types of seed in Bossier soybean. Emergence test was conducted in the greenhouse with 50 seeds from each seed type.

Seed type	Emergence, %[a]
smooth, clean seed	89.5 a
seed with purple testa	68.5 b
seed with cracked testa	44.0 c
green immature seed	44.5 c
wrinkled, clean seed	3.5 d
weathered, black seed	0.5 d

[a]Means followed by the same letter are not significantly different at 5% level using Duncan's Multiple Range Test.

In the second season the only visible damage on soybean seed was cracked seed coat (Figure 2). Again percentage of cracked seed increased with a delay in harvest with Hardee showing a higher degree of cracked testa than the other cultivars. The poor seed quality of Hardee in both seasons was reflected in the poor germination of this cultivar at different times of harvest (Figure 3) Hardee is also known to have a serious germination problem in Ghana (39). The percent germination of Improved Pelican remained high even when its seeds were harvested 21 to 28 days after reaching maturity. These results indicate that screening soybean germplasm for resistance to weathering is feasible in the tropics. The crop can be sprinkler-irrigated to simulate rainfall and high humidity if necessary. The results also point out the importance of timely harvest in soybean.

Delouche et al. (14) also found that frequent or prolonged precipitation during the post maturation preharvest period resulted in alternate wetting and drying of the seed in the field and severe deterioration. Soybean germination in Hill soybean was found to drop below 80% when harvest was made 16 days after reaching maturity. In the same cultivar Harris et al. (30) found that high temperatures during the last 45 days of seed maturation were associated with poor seedling vigor in the progeny, persisting throughout the growing season and reflected in seed yield. The effects of weathering on seed quality generally increased in severity as temperature increased (40). Cartter and Hartwig (8) found that cool, dry conditions favoured good seed quality; warm wet weather with frequent rains produced low quality seed of weathered appearance; and very hot, dry weather with drought tension or frost caused small greenish colored seed.

Seeds harvested during the minor rainy season in Ibadan, Nigeria, are often smaller than the seeds harvested during the major rainy season, since moisture stress during pod filling stage reduces seed yield through reduction in seed size and pod number per plant. There has been a controversy as to weather within a cultivar small seeds have lower germination than large seeds. Johnson and Luedders (37) found that seed size had no effect on either emergence or yield. Green et al. (29) found that small seed size was associated with high laboratory germination and high field emergence. Using near-isogenic lines, Edwards and Hartwig (16) found that small and medium-sized seed gave more rapid emergence and greater early root development than large seed, and suggested that small seeds should be used in planting in clay soils. However, Ndunguru and Summerfield (41), Fontes and Ohlrogge (20), and Burris et al. (7) found that large seed germinated better and yielded higher than small seed. Burris et al. (7) studied performance of seedlings from a wide range of seed sizes in four cultivars, and found that only the smallest seed size (8.1 g/100 seed) exhibited lower emergence percentage, smaller cotyledonary and unifoliate leaf area and seed yield. Seed sizes between 12 to 21 g/100 seed did not show any significant differences in emergence, photosynthesis, growth and yield. Our data with cultivars Bossier supported their findings (Table 2). In Bossier seed sizes between 10.63 and 22.68 g/100 seed did not show any differences in percent emergence. Only the smallest seed (8.52 g/100 seed) showed significantly lower percent emergence than the larger seed.

Table 2. Effect of seed size on percent emergence of Bossier soybean. Seeds were obtained from hydromorphic soil experiment during second season, 1974.

Seed size (g/100 seed)	Emergence[a] (%)
8.52	62 b
10.63	82 a
11.43	86 a
12.53	85 a
15.39	87 a
17.52	84 a
22.68	88 a

[a]Means followed by the same letter are not significantly different at 5% level using Duncan's Multiple Range Test.

DRYING METHOD

Drying temperature significantly affects the viability of soybean (35). Germination of Kent was not affected when its seed was dried at either 40 or 60 C for 24 to 48 hrs., but exposure to 80 C prevented germination (Table 3). Seed having wrinkled or split seed coats had lower initial germination and deteriorated more rapidly. No data, however, is yet available to compare the efficiency of sun drying and artificial drying during both major and minor rainy seasons. In West Africa farmers generally dry soybean pods in the sun for 4 to 5 days before threshing and storage. Depending on growing season and weather at harvest, soybean's moisture content at harvest ranges from 15 to 30%.

Table 3. Effect of drying temperature on germination percentage of test soybean seeds (IITA, 1974).

		Drying Temperature		
Seed type	Control	40 C	60 C	80 C
		Germination, %		
Good, clean seed	94	91	85	0
Wrinkled/split seed	77	80	59	0
Mean[a]	86 a	86 a	72 b	0 c

[a]Means followed by the same letter are not significantly different at 5% level using Duncan's Multiple Range Test.

THRESHING METHOD

Decreases in germination resulting from improper threshing, cleaning and handling of soybean have been reported by Colbry et al. (10). Seed damage and loss of viability were found to increase when seed moisture content drops to less than 13%. Soybean seed becomes brittle and susceptible to injury from mechanical forces when moisture content decreases to below 12% (12). Barger and Weber (5) found that there was a rather narrow range of seed moisture contents (about 13 to 15%) that are optimal for harvest without losses in seed yield and germination. A three-year study conducted by Green et al. (25) shows that both seed moisture content and threshing speed influenced soybean seed germination and vigor. Hand-harvested seed lots had a much higher viability than machine-harvested lots of the same variety, the differences being ascribed to differences in seed coat damage (split and cracked seed coats). Increasing threshing speed from 500 to 900 rpm greatly increased percentage of splits and cracked seed coats, and abnormal seedlings, and reduced laboratory germination and field emergence.

In soybean-growing region in Nigeria soybean is often thresed by either beating the whole plants on hard surfaces or beating pods enclosed in a jute sack with a stick. A study is in progress to determine whether such threshing methods increase seed damage in both small seeded and large seeded varieties.

LENGTH AND METHOD OF STORAGE

Soybean seed is inherently short-lived as compared to other major crop species (13). The normal storage period for soybean, from harvest of one crop to planting time of the next, is 6 to 9 months. Soybean seed subjected to weathering before harvest, severely damaged during combining, and/or inadequately aerated during bulk storage does not store well even though it germinates moderately well at time of packaging (23).

Soybean seed harvested above 14% moisture must be dried to below 13% to maintain viability in bulk storage (1). Holman and Carter (32) found that at 10% moisture soybean seed could be safely stored for 1 year with only a slight decrease in viability but at 14 to 15% moisture soybean seed could only be stored over the cold period of winter but later the seed deteriorated with the arrival of warm weather in the next spring.

Seed moisture content, temperature and relative humidity interact closely in their effects on longevity of seed (23). These three factors must be considered in seed storage studies or in practical storage operations. High moisture content seed (15 to 18%) can be stored for a year at a temperature of 10 C or less while low moisture seed (9% or less) can withstand temperatures in the range of 30 to 35 C for the same period without substantial loss of germination (23). At 25 C, moisture contents of soybeans seed in equilibrium with various levels of relative humidity are (12):

Rel. Humidity (%):	15	30	45	60	75	90
Moisture (%):	4.3	6.5	7.4	9.3	13.1	18.1

We tested the germination and emergence of 102 cultivars which were harvested during the end of minor rainy season in December 1973. The first germination and emergence tests conducted in January 1974 showed that 61 of these cultivars had already had germination less than 70%, possibly due to susceptibility to weathering, untimely harvest and/or improper handling. Percent germination was found to be positively correlated with percent emergence but not to seed size and oil content (36). The remaining cultivars which had germination above 70% were stored under ambient temperature conditions in an open building. One portion was stored in an open paper bag, the other was stored in a sealed polyethelene bag. Results in Table 4 show that storing seeds in the sealed polyethelene bag was superior to storing seeds in the open paper bag in terms of percent emergence.

Table 4. Effect of method and length of storage under ambient temperature conditions on emergence percentage of soybean. Means of 41 cultivars.

Length of storage (months)	Storage method			
	Open bag		Sealed plastic bag	
	Emergence, %			
	Mean	Range	Mean	Range
0	85a	70 - 99	85a	70 - 99
3	83a	37 - 99	78b	60 - 96
6	56b	11 - 91	79b	53 - 99

[a]Means within column followed by the same letter are not significantly different at 5% level using Duncan's Multiple Range Test

These results confirmed our previous results (35) and those of Delouche and Baskin (unpublished data, as cited by Delouche, 1975). The interaction between cultivar and storage method was highly significant in that 10 of these cultivars maintained high percent emergence in both methods of storage suggesting that genetic differences in storability do exist in soybean and could be of great importance to tropical soybean production. Results from a recent storage experiment further support this contention (Table 5). Germination and emergence of Kent and Bossier decreased slightly when their seeds were stored in the sealed polyethelene bags and plastic "Seed Buro" jars, but decreased greatly when the seeds were stored in an open paper bag even though there was no apparent change in moisture content. Seed of Improved Pelican deteriorated in all the three methods of storage possibly due to improper handling of the seed prior to storage as indicated by the low germination and vigor of the seed at the start of the experiment. CES 486 maintained excellent emergence and germination up to 6 months even when its seed was stored in an open paper bag at room temperature.

Delouche (12) made three suggestions on how soybean should be stored in the tropical regions:

1. Keeping seed in moderately conditioned storage where temperature can be maintained at 20 to 22C or less and relative humidity at 60% or less. Under these conditions soybean germination can be maintained up to 9 months provided the seed is of reasonably good quality when placed in storage.

2. Conditioning the seed to about 9% moisture and then package it in moisture-vapour-proof package as 10 mil thick polyethelene bags. The plastic bags should be heat sealed and precautions should be taken to prevent puncturing.

3. Concentrating seed production in the minor or dry season under irrigation. Seed yield may be low but the storage period will be reduced from 8 to 9 months to 2 to 3 months.

Table 5. Effect of length and method of storage under ambient temperature conditions on seed moisture content, germination and emergence of four soybean cultivars.

Cultivar	Storage method	Moisture, % Initial	Moisture, % 6 months	Length of storage (months) 0	3	6	0	3	6
				Germination, %			Emergence, %		
Kent	A1)	11.2	11.1	72	59	21	73	14	7
	B2)	10.7	10.4	70	72	62	67	66	60
	C3)	10.3	10.4	68	73	74	70	65	66
Bossier	A	10.5	11.1	70	51	31	77	18	6
	B	10.[illegible]	10.5	77	66	66	6[illegible]	69	42
	C	10.7	10.7	77	64	54	64	63	48
I. Pelican	A	11.8	11.7	67	40	8	51	4	2
	B	11.6	11.8	70	43	19	43	34	12
	C	11.7	12.3	60	50	19	59	38	17
CES 486	A	11.0	11.1	88	79	73	76	63	65
	B	11.3	10.9	88	84	94	76	72	67
	C	11.1	11.1	86	92	87	82	66	62

1A = in open paper bags
2B = in sealed polyethelene bags
3C = in sealed "Seed Buro" jars

TILLAGE AND PLANTING METHODS

Lal (38) measured soil temperature on cleared soil at IITA at different times of the year, and found that maximum soil temperature at 3 p.m. reached 45C between February and May, and then declined to about 35C between May and September as rainfall intensity increased and solar radiation decreased. Because of the irregular rainfall and high soil temperature in April at the start of major rainy season, poor emergence of soybeans with total failure of several cultivars was often observed during this month at IITA.

High temperature greatly affects hypocotyl elongation of soybean (Table 6). Cowpea has a much greater tolerance to high temperature than soybean. Ndunguru and Summerfield (41) found that constant temperature at 43C reduced soybean germination to zero and cowpea to only 60%, and suggested that a screening of potentially tropically adapted soybean germplasms for high temperature tolerance during germination and hypocotyl elongation would seem highly worthwhile as part of a breeding/selection program. Although inhibition of hypocotyl elongation has been demonstrated in certain soybean

Table 6. Inhibition of hypocotyl growth of Kent soybean and Prima cowpea exposed for 2 to 8 hours per day to 42C when grown on agar medium in test tubes (IITA, 1974).

Temperature (oC)	Duration (Hrs.)	Hypocotyl length, mm	
		Soybean	Cowpea
30	24	85 ± 18.3 (100%)	118 ± 23.7 (100%)
42/30	2/22	23 ± 7.0 (27%)	71 ± 13.6 (60%)
42/30	4/20	17 ± 7.3 (20%)	62 ± 13.8 (53%)
42/30	6/18	11 ± 4.6 (13%)	58 ± 18.2 (49%)
42/30	8/16	14 ± 4.2 (16%)	63 ± 13.4 (53%)

cultivars at 25C (22, 24), it is unlikely that this finding would be important in the lowland tropics where temperatures of the bare soil are frequently higher than this (38). Those cultivars with inhibited growth of hypocotyls at 25C emerged well at 30C (22,24). In agreement with our results (35), Hatfield and Egli (31) have shown that soybean germination is prevented by constant 40C temperature. Soybeans germinating in sand in controlled temperature cabinets at 5 or 8 hr.

per day of 40C were delayed in emergence by one day over those kept at 30C but did not differ in final percent emergence. Field tests comparing shaded and unshaded plots in which unshaded soil temperature rose to above 40C on 2 out of 4 days gave similar results (Table 7). These results indicate that seeds of good vigor will be delayed but not prevented from emerging under the high soil temperatures prevalent in the lowland tropics. There may be varietal differences in this respect.

Table 7. Time required for half of the seedling to emerge and final percent emergence of cowpea and soybean in the field.

	Half emergence time, days			Final emergence, %		
	Control	Shaded	Inhibition, %	Control	Shaded	Inhibition %
TVu 76 cowpea, expt. 1	2.22	2.08	6.3	78.1	78.8	0.9
19 soybeans, expt. 1	4.70	3.69	21.2	47.3	59.6	20.6
Kent soybean, expt. 1	5.00	3.99	20.2	54.4	60.0	9.3
19 soybeans, expt. 2	4.21	3.44	18.4	73.9	79.7	7.3
Kent soybean, expt. 2	4.19	3.64	13.1	82.5	90.6	8.9
LSD 0.05 expt. 1	0.81			19.8		
expt. 2	0.56			12.0		

The effect of planting depth on soybean emergence is shown in Figure 4. Increasing planting depth from 2.5 to 10 cm significantly reduced percent emergence and increased days to 50% emergence of soybean. In contrast, cowpea and pigeon pea (Cajanus cajan Millsp). could be planted as deep as 10 cm without any significant reduction percent emergence. Lima bean (Phaseolus lunatus L.) was also as sensitive to deep sowing as soybean. In most soils a 2.5 to 5.0 cm depth is optimum for soybean (19, 42).

Tillage method and mulching technique have been shown to influence soil moisture and soil temperature (38). Minimizing soil disturbance and leaving soil residue in the soil conserve soil moisture and reduce soil temperature. These two factors improved soybean emergence particularly at the beginning of the major rainy season when the soil temperature is still high. Table 8 shows that percent emergence of both cowpea and soybean was significantly higher in strip tilled and zero tilled plots than in conventional tilled plots. Soybean was more severely affected by tillage method than cowpea. Soybean emergence on ridged plots was almost zero

Table 8. Effect of tillage methods on seedling emergence, seedling fresh weight, soil temperature and soil moisture in cowpea and soybean.

Tillage Method	Max. soil[1] temp., °C	Soil moisture[1]	Emergence, %	Days to emergence	Seedling fresh weight (g.)[2]
			Cowpea, cv. vita [3]		
Conventional tillage + ridges	43	8.3	83.2 b	12 e	0.49
Conventional tillage + flat	41 41	11.2	89.4 b	4 b	1.32
Strip tillage	39	15.8	96.7 a	3 a	1.55
Zero tillage	36	14.4	97.8 a	3 a	1.60
			Soybean, cv. bossier		
Conventional tillage + ridges	43	8.5	0.9 e	12 e	0.24
Conventional tillage + flat	41	11.6	33.4 d	6 d	0.53
Strip tillage	39	16.9	50.7 c	5 e	0.46
Zero tillage	36	14.3	53.9 c	5 e	0.43

1. Mean of the first 10 days after planting
2. Determined at 20 days after planting
3. Rainfall 6.4 mm one day after planting, 33.3 mm at 9 days after planting

since traditional method of ridges and heaps greatly increases soil temperature and reduces soil moisture storage (Lal, 1975). This tillage method should be avoided in West Africa if soybean is to be successfully introduced to this region.

Mulching has also been reported to favour soybean emergence (11, 35, 39). Transporting mulch material from elsewhere, however, may not be practical and economical. Lal (38) suggested that mulch tillage method whereby soil is prepared in strips and crop residue is maintained in the inter-row zone is a much better and practical method.

In the field soil temperature and soil moisture interact and their effects on emergence are difficult to separate. An experiment conducted during the early part of major rainy season, 1975 at IITA shows that irrigating soil every other day not only increased soil moisture content but also reduced soil temperature by 3 to 9C as compared with unirrigated soil. In this experiment both seed dressing and irrigation significantly improved the emergence of the ten cultivars (Table 9). The initial germination of the cultivars just before planting was high (85 to 98%) but the emergence percentage was generally rather low even under irrigation, possibly due to inhibition of hypocotyl elongation at high soil temperature as shown in Table 6. Maximum soil temperature reached 43C for 2 to 3 hours in the afternoon. The differential response of the cultivars at these temperatures was noted. Malayan, SJ-1 and CES 486 showed significantly higher percentage of field emergence than the rest of the cultivars.

Table 9. Effect of seed dressing and irrigation on percent emergence of 10 soybean varieties. First season, 1975

Cultivar	No irrigation		With irrigation		% emergence mean	% Germination
	None	chloroneb	None	chloroneb		
			Emergence, %			
Kent	9.0	21.5	25.5	30.5	21.6	85
Hardee	6.0	14.0	11.5	15.7	11.8	84
Bossier	7.5	25.3	39.8	52.3	31.2	81
TGm 240-2	18.3	30.5	28.0	46.5	30.8	94
Americana	21.8	27.0	50.5	56.8	39.0	94
Malayan	30.8	46.5	71.5	71.3	55.0	98
Imp. Pelican	8.3	27.8	38.8	45.5	30.1	96
TGm 280-3	20.3	37.8	50.5	56.0	41.2	98
CES 486	27.0	29.8	61.0	70.8	47.2	87
SJ-1	35.3	56.0	64.5	65.5	55.3	98
Mean	18.4	31.6	44.2	51.1		
Emergence date (DAP)	10	7	4	4		
Rate of emergence/day	2	4	11	13		

The beneficial effect of seed dressing with fungicides such as captan, thiram and spergon has been reported by several other workers. Seed dressing improves germination or emergence when the seeds have low or medium vigor (15), the germination is less than 80% (2, 8, 41) or the seed is infested with fungi or diseases (9).

Pendleton and Hartwig (42) reported that heavy rainfall immediately after planting can cause compaction and crusting on some soil types making emergence difficult especially if the seeds are planted too deeply. They suggested the use of high quality seed and the rotary hoe to help reduce this problem. It is not known whether the farmers practice of planting 2 to 3 seeds per hill instead of only 1 seed per hill also helps in overcoming compaction and crusting effect. Mercer-Quarshi and Nsowah (39) have tried this method and found that percent emergence was improved by 47 to 107% when 2 to 3 seeds were planted.

BREEDING FOR HIGH VIABILITY AND EMERGENCE

Throughout the discussion the variability among the available genetic stocks in response to weathering at ripening, adverse storage conditions and high soil temperature was emphasized. This indicates the feasibility of breeding and selection for high viability and emergence in the lowland tropics. The main objectives of breeding for high viability and emergence should include among other things:

1. Resistant to weathering and seed deterioration during ripening and maturity irrespective of rainfall pattern,

2. High storability under ambient temperature and relative humidity conditions, and

3. Tolerance to high soil temperature during emergence.

The methodology for screening soybean germplasms for all these characteristics have only been partly worked out, more needs to be done, and some are now being investigated at IITA. Breeding methodology for tropical soybean in general, however, has been discussed in details by Rachie and Plarre (43). It is not known whether those cultivars which are resistant to weathering at ripening, can also maintain vigor and germinability during storage under ambient temperature and relative humidity conditions of the lowland tropics. An experiment is in progress to test this hypothesis.

The most important step is to identify cultivars which consistently show high emergence under adverse soil environmental conditions. This will require more emphasis on rate and percent emergence in the field than has been given up to now.

The inheritance of the various traits which a breeder wish to include in a cultivar with high emergence should be established before effective breeding or crossing program can be carried out. Green and Pinnel (27, 28) and Green et al. (26) have studied the inheritance of soybean seed quality in details. They found that low incidence and severity of wrinkled seed coat, shrievelled cotyledons and green cotyledons during maturation were generally associated with high field emergence percentages and that estimates of heritability for the visual ratings generally were higher than for field emergence. They suggested that the most efficient method of improving soybean seed quality in a breeding program is to use an overall visual rating and a laboratory germination test in which normal seedlings are counted early in the germination period, about 5 days. An alternative method is to concentrate on improving visually rated characters by selection when environmental conditions cause adequate expressivity. At Ibadan, Nigeria, this probably can be done simply by planting the varieties or lines every 2 to 3 weeks during the major rainy season.

Selection for soybean lines that can germinate and produce long hypocotyls at high temperatures might be rewarding. The studies of heritability of soybean hypocotyl length at 25C by Fehr (18) provide encouragement for such an approach.

Simple introduction of soybeans from temperate countries such as the United States is not going to solve the germination and emergence problems in the tropics. We have found that cultivars such as Bossier Hardee, and Jupiter, though high yielding and resistant to lodging and diseases, have serious storage and emergence problems in West Africa. To successfully introduce soybean to low elevation, tropical regions, an intensive breeding program involving the cooperation of the international institutes (IITA, INTSOY and AVRDC) and the national programs will be required if the objectives are to be achieved within the shortest possible time.

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FIGURE CAPTIONS

Figure 1. Schematic diagram showing the various factors involved in affecting soybean viability and emergence.

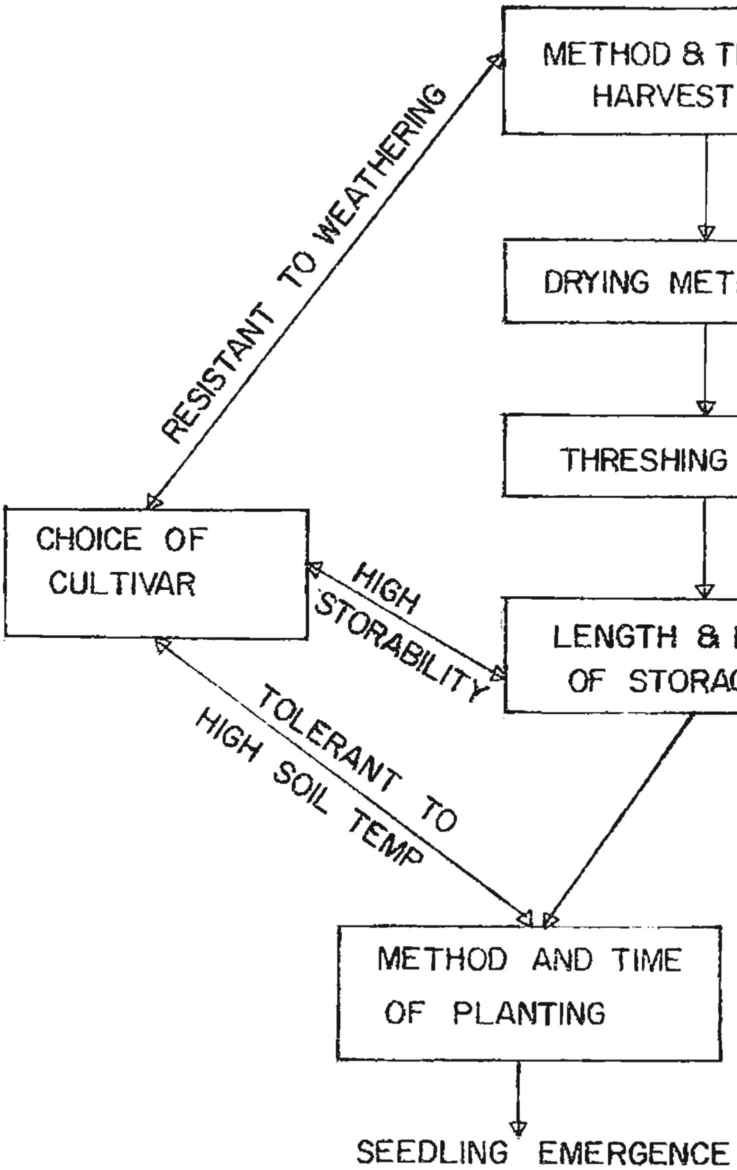
Figure 2. Effect of harvest time on seed quality of four soybean cultivars. First harvest was done when 85-90% of the pods had ripened.

Figure 3. Effect of harvest time on germination percentage of four soybean cultivars. First harvest was done when 85-90% of the pods had ripened.

Figure 4. Effect of sowing depth on the emergence of cowpea, cv. VITA 3, Soybean cv. Improved Pelican, Lima bean TPI 191, and Pigeon pea CITA 2 in sandy soil.

Figure 1

FACTORS AFFECTING SOYBEAN VIABILITY AND EMERGENCE



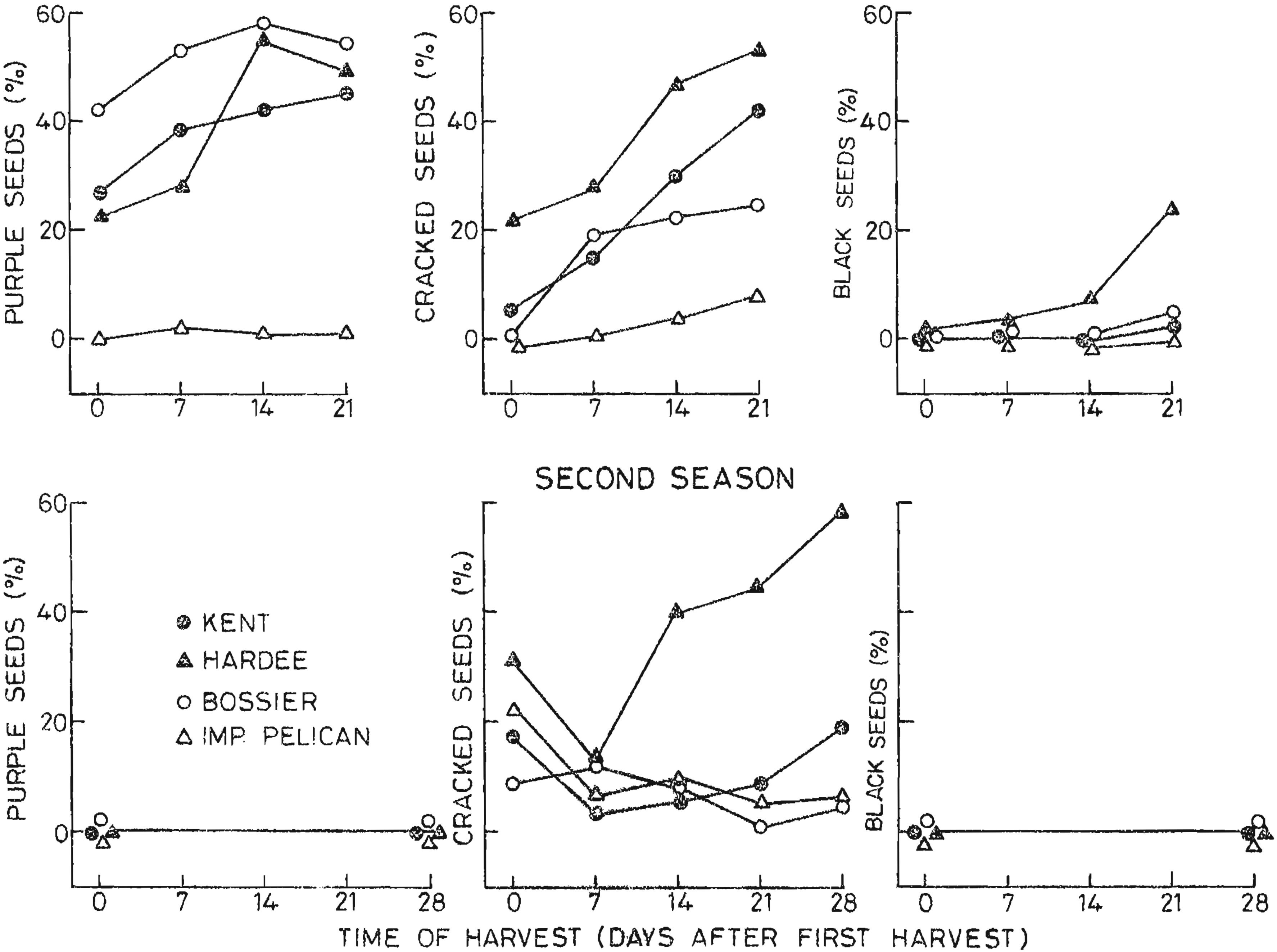

PURPLE SEEDS (%)
CRACKED SEEDS (%)
BLACK SEEDS (%)
SECOND SEASON
KENT
HARDEE
BOSSIER
IMP. PELICAN
TIME OF HARVEST (DAYS AFTER FIRST HARVEST)

Figure 2

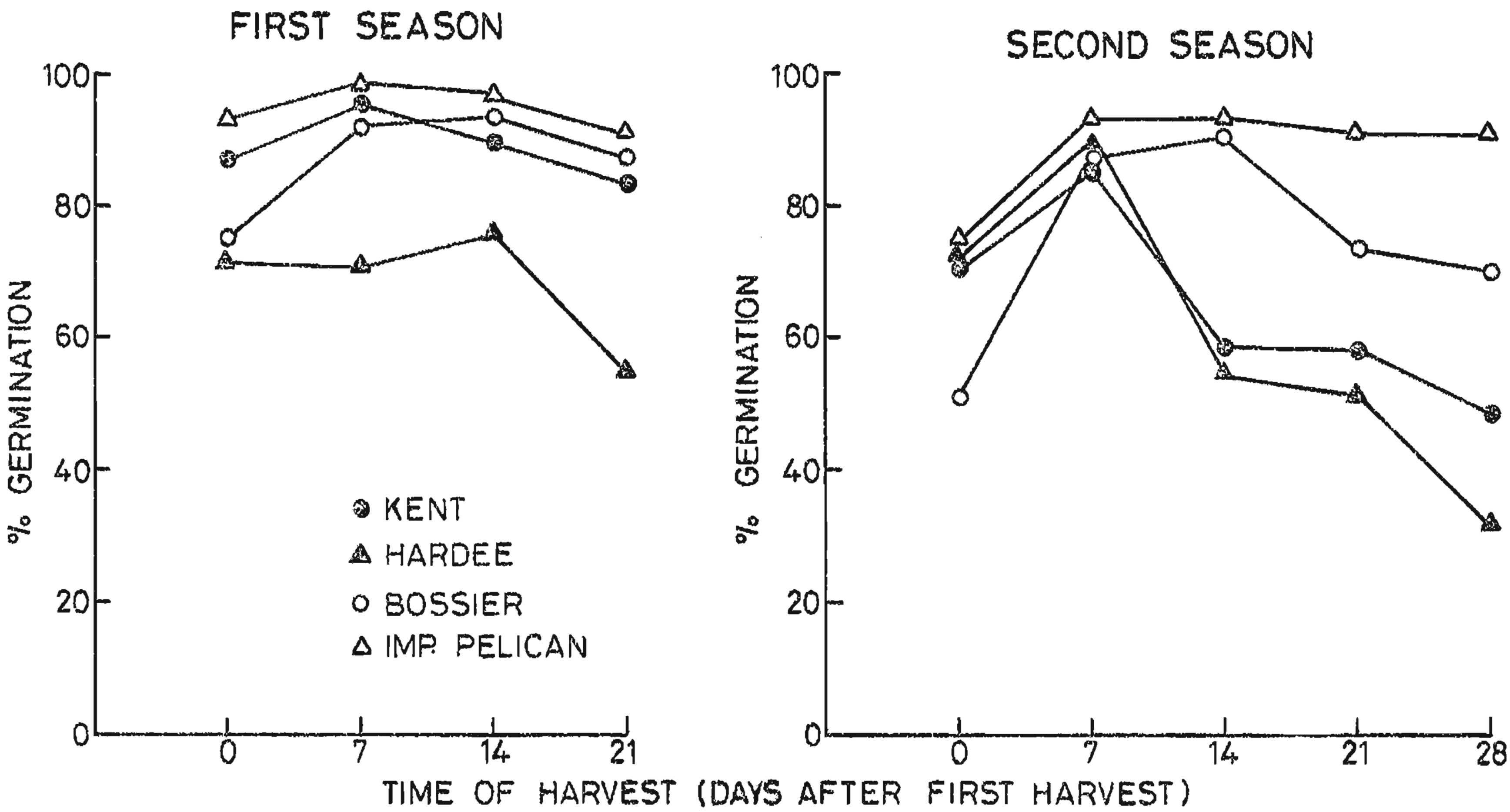

FIRST SEASON
SECOND SEASON
% GERMINATION
100
80
60
40
20
0
0
7
14
21
28
KENT
HARDEE
BOSSIER
IMP. PELICAN
TIME OF HARVEST (DAYS AFTER FIRST HARVEST)

Figure 3

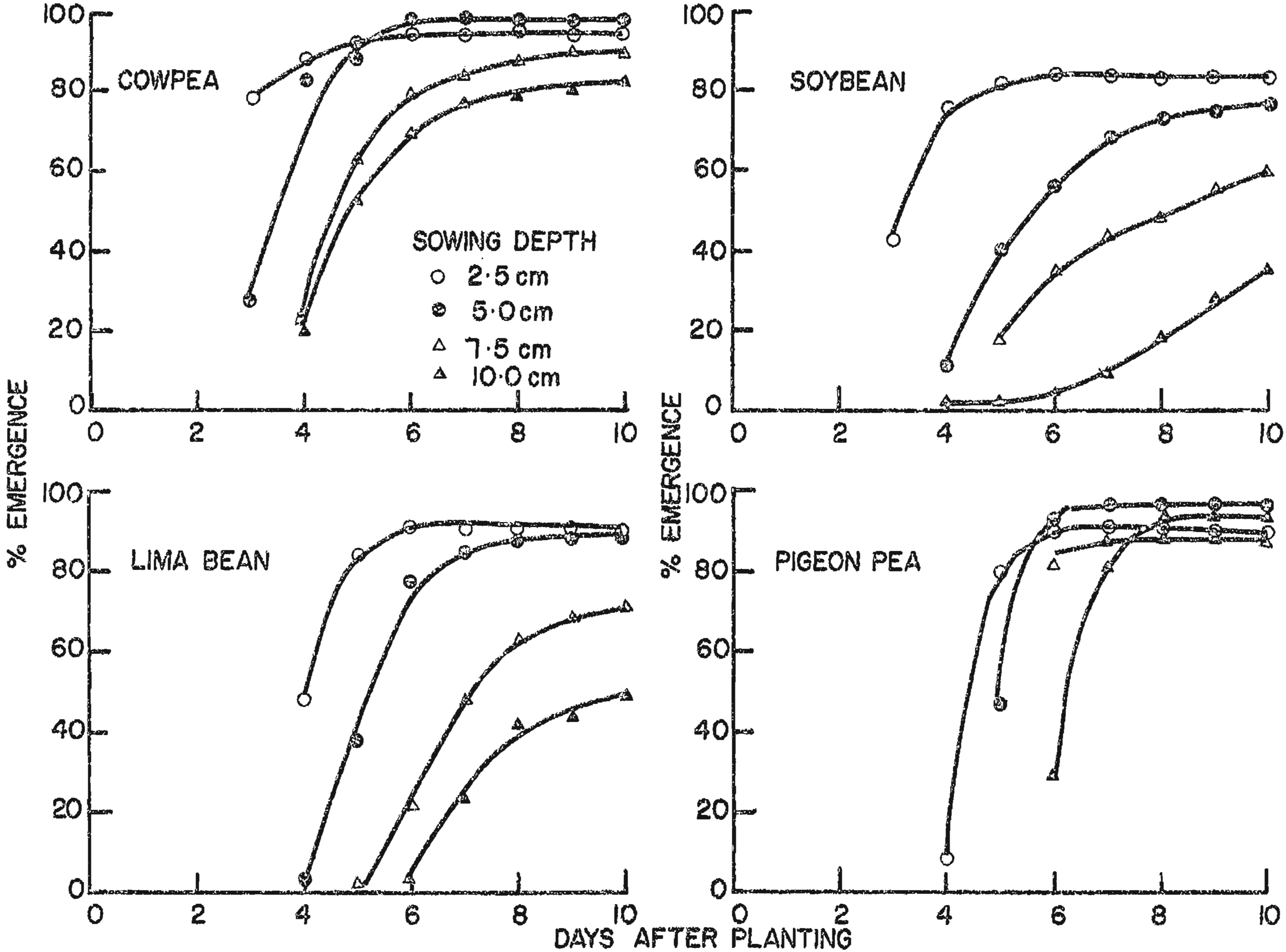

COWPEA
SOYBEAN
LIMA BEAN
PIGEON PEA
SOWING DEPTH
2·5 cm
5·0 cm
7·5 cm
10·0 cm
% EMERGENCE
DAYS AFTER PLANTING
0
20
40
60
80
100
0
2
4
6
8
10

Figure 4