Chin Hoong Fong (1976), *Seed Technology in the Tropics.*, 75–83

3.1 Influence of seed quality on plant growth and development

CHIN HOONG FONG

Universiti Pertanian Malaysia, Serdang

Abstract

Seed quality plays a very influential role in plant growth and development. Various defects and disorders have detrimental effects such as slow seedling growth rate, uneven maturity and reduced yield. Whereas high quality seeds, which are graded, selected and undamaged promote vigorous seedling growth, an even stand establishment and maturity and most important, higher yield. Agronomic practices and seed technology can be used to control plant growth and development for efficient crop production.

Introduction

Farmers often encounter losses in terms of monetary returns and precious time from sowing poor or unsuitable seed. Although the resulting crop may largely depend upon weather conditions and proper cultivation, the quality of the seed used is of fundamental importance. As has been recognised, agricultural and horticultural production becomes more specialised, with more emphasis on efficiency of production, the choice of the right seed for the intended purpose becomes increasingly important.

What is 'seed quality'? This term can be interpreted in a number of ways depending on who is the assessor. Quality in seeds represents their potential performance in factors such as trueness to variety, germination percentage, weed and other crop seed contents, vigour, appearance and freedom from disease and inert contaminants. Generally, most people accept the minimum standards as the bases of classification or yardstick of measurement as to whether they are of high or low quality. Failure to meet in one or more characteristics will be considered as low quality seeds.

Since seed quality has so many facets, in this paper emphasis is given to the physiological aspects. This covers size, composition, disorders, age and vigour of seeds. Botanically, these characteristics have marked influences on plant growth and development and agronomically they have very important implications on crop production. In the literature, the significance of seed quality and its influence on growth and development have been well documented on temperate species. In this paper results of tropical field crops pertinent to Malaysian Agriculture are reported and compared with other species.

Materials and methods

Seed size

Freshly hand harvested seeds of French bean cv. 'Brown Beauty' and soybean cv. 'Harosoy' were graded into 3 classes: big, medium and small. Batches of 125 seeds of big and small seeds of each species were planted one seed per pot. The pots were placed in a growth cabinet at 25°C and 16h photoperiod. The seedlings were harvested every alternate day from 8th to 28th day from sowing and growth parameters recorded. For maize, seeds were classed into 3 groups, those from the tip, middle and base of the cobs.

Seed composition

French bean cv. 'Brown Beatuy' were grown and supplementary nitrogen (0.5 g of ammonium sulphate) was given to each pot in the 2nd, 4th, 6th week from planting as treatment. At harvesting protein content was estimated. Treated plants produced seeds with higher protein. Two batches of seeds were planted from the control and treated plants and resultant growth compared.

Disorders

Freshly mechanically harvested soybean seeds, cv. 'Harosoy' were examined with soft X-rays to separate the damaged seeds from the undamaged. Batches of damaged and undamaged (control) seeds were sown individually in pots and grown to seedling as well as to maturity when yield was compared.

'Hollow heart' in peas was detected after germination and the abnormals were separated from normals. Seedling studies and yield comparisons were made. To determine flower initiation, leaf number as well as random dissection were used as a guide.

Age, moisture and vigour

Maize cv. 'Guatemala' seeds were harvested and dried to 3 levels of moisture content: 8%, 12% and 16% (±0.2). Four replicates of 1 lb sample from each moisture level were stored in sealed bottles at 20°C ±1, 28°C ±2 and 38°C ±1 for a period of six months. Seeds were tested for percentage germination and vigour index was determined by two methods using the speed of germination (Rushing, 1968) and the seedling growth rate.

Results and discussions

Seed size

Seedlings obtained from the big seeds of French bean (*Phaseolus vulgaris*) and soybean (*Glycine max*) were much larger and heavier than those from small seeds as indicated by the differences for the various growth parameters measured at 1 and 4 weeks from sowing (Table 1).

Table 1. Effect of seed size on growth of French bean and soybean seedlings in the first and fourth weeks from sowing.

	French bean		Soybean	
	Big	Small	Big	Small
1 *week from sowing*				
Total dry weight (mg)	182	77*	53	25*
Root weight (mg)	46	22*	18	7*
Leaf weight (mg)	86	30*	15	5*
Leaf area (cm)	32.1	14.3*	5.9	2.3*
4 *weeks from sowing*				
Total dry weight (mg)	3570	2930 ns	1730	1310*
Root weight (mg)	680	610 ns	370	310*
Leaf weight (mg)	1770	1460 ns	740	590*
Leaf area (cm)	558	525 ns	261	239 ns

* Means significant at P = 0.05

Differences were exceptionally large in the first week. In French beans and soybeans values of total dry matter, root weight, leaf weight and area for seedlings from small seeds were less than 50% of the corresponding values for seedlings from the big seeds. However, in the 4th week the seedlings from small seeds on a relative basis had caught up; to a larger extent for the most parameters, their values were close to 80% of those of the seedlings for the big seeds.

The total dry weight (W) plotted as $\log_e W$ against time showed that in the first week, there was a significant difference ($P = 0.05$) between big and small. The relative growth rate of seedlings from small seeds was higher than that of the large seeds, and a similar trend was observed in the net assimilation rate.

One of the findings of this work was the tremendous variation which exists in seed size, individual seeds of French bean cv. 'Brown Beauty' ranged in weight from 110 mg to 410 mg, seeds of soybean cv. 'Harosoy' ranged from 80 to 220 mg. There is no doubt from the results that seedling size is proportional to seed size. The difference in size between seedlings from big and small seeds was greatest soon after germination; however, although the size difference in relative terms diminishes with age, the superiority of plants from big seeds persists till maturity. Similar findings were reported by (Burris, *et al* 1973), with the operation of the compound interest law of Blackman (1919).

With maize seeds even within the same cob, there exist great differences in size of seeds from the tip, middle and basal parts of the cob. In size and volume the seeds from the middle portion were highest (Table 2). The bigger seeds store better and produce more vigorous seedlings (results are given in section on age and vigour).

Table 2. Physical data of grains of the tip, middle and base of the maize cob (variety — 'Guatemala').

Portion of the maize cob	Average Greatest Dimension in mm.	Average Weight per 1,000 in gm.	Average Volume per seed in cc.
Tip	8.3 (6.5–10.3)	195.5	0.15
Middle	9.2 (8.5–11.1)	269.5	0.25
Base	8.7 (6.7–10.3)	256.1	0.25

Nevertheless, plants grown from small seeds seem unable to attain the same size as is reached by plants from the big seeds. There seems a clear case, therefore, for grading seed for agricultural use, otherwise competition between plants from a mixture of big and small seeds leads to a non-uniform stand with consequent harvesting problems and possibly reduction in yield. In addition, the use of big seeds should improve the competitive ability of seedlings and help to offset competition from weeds.

Seed composition

Until recently there was little research on the relationship between seed composition and yield. It has been recently established that there is positive relationship between protein content of wheat and oat seed of particular genotypes and seedling vigour and yield of the crop grown from it (Ries, *et al* 1971; Schweizer and Ries, 1969).

With French bean and soybean, seeds from plants given supplementary nitrogen, which were 'high protein' seeds (Table 3), produced bigger seedlings than those from seeds without supplementary nitrogen or 'low protein' seeds. This was seen in all the growth parameters measured in the 4th week from planting.

Table 3. The effect of high and low seed protein on the growth of French bean and soybean seedlings 4 weeks from planting.

	Seed protein content			
	French bean		Soybean	
	High (23%)	Low (19%)	High (46%)	Low (38%)
Total dry weight (g)	3.9	3.1*	2.3	1.9*
Shoot weight (g)	3.2	2.5*	1.8	1.5*
Root weight (g)	0.7	0.6	0.5	0.4*
Leaf weight (g)	2.0	1.6*	1.0	0.8*
Leaf area (cm)	692.7	540.6*	300.4	260.4*

* Difference is significant at P = 0.05.

Thus, altering the protein content of seeds not only produces more vigorous seedlings but in itself the food value is increased in terms of protein quality. Ries (1971) has suggested that in beans protein content itself does not increase with a second 'factor' which increases the vigour and yield. Sublethal concentrations of simazine and other triazine compounds which have been used to raise seed protein content, have been shown to stimulate activities of nitrate reductase, transaminase, amylase, ATPase, phosphorylase and pyruvic kinase (Tweedy and Ries 1967; Ries, et al 1967). Hageman and Flesher (1960) established a positive correlation between nitrate reductase activity and protein content in two strains of corn.

Disorders in seeds

Damage in seeds is hard to detect as the testa and sometimes the pericarp cover the embryo. Various tests are used and lately Kamra (1966) has used the X-ray method to reveal internal injuries in seeds. The effects of mechanical damage to seeds on subsequent growth are very variable. Soybean cv. 'Harosoy' showed no decrease in viability of seeds under favourable conditions, with germination percentage in the order of 95% to 98%. However, at emergence the seedlings from damaged seeds were very weak and stunted compared with the vigorous seedlings from the undamaged seeds. There was a general reduction in total dry weight, leaf area and root weight (Table 4). The final seed yield of plants grown from damaged seeds was lower and more erratic than the undamaged (control) seeds.

There seems no doubt that cotyledon damage has adverse effects on growth and development of soybean plants (Chin, *et al* 1974). This is also observed in French beans (*Phaseolus vulgaris*) (Chin, *et al* 1975). Cotyledons and endosperm can exert profound influence on the growth and development of plants in many ways. Reduction in growth is directly related to the reduction in food reserves but delay in flowering and decrease in yield involves *de novo* synthesis of certain enzymes (Varner 1969). The cotyledons of angiosperms, in addition to serving as a source of stored energy for the seedling also influence seedling morphogenesis. For example, Fries (1953) observed cessation of growth in cultures of totally decotylated embryos of peas (*Pisum sativum*). Flowering in

Table 4. The effect of mechanical damage of soyabean seeds on seedling growth, assessed at 1, 2, 3 and 4 weeks after sowing for undamaged — control (C) and damaged (D) seeds.

Time (weeks)	Total dry weight (g)		Leaf area (cm^2)		Root weight (mg)	
	C	D	C	D	C	D
1	0.08	0.03*	6.5	2.0*	34.7	7.7*
2	0.26	0.15*	34.1	25.7*	85.7	32.0*
3	0.72	0.51*	109.8	93.6*	213.3	98.0*
4	2.09	1.61*	245.5	195.8*	542.0	405.0*

* Difference, significant at P = 0.05.

the late varieties of peas has, according to Barber (1952) and others, been promoted by removal of an inhibitor which can be leached out or removed by cotyledon excision. Chin and Aitken (1976) found there was delay in flowering of peas.

Beside mechanical damage, seed borne diseases and other physiological disorders in seeds affect plant growth and development. 'Hollow heart' in peas is a well known, though hard to detect, physiological disorder which affects the cotyledons of peas. The gross results are similar to that of mechanical damage in that there was a general reduction in growth (Table 5). There was a delay in the whole flowering process in that flower initiation, time of appearance of first and last flower and maturity was delayed by 2 weeks. Delay in maturity is common to both mechanically damaged and 'hollow heart' peas, as both involve the reduction in functional cotyledonary tissues. There was a delay in senescence of the whole plant in mechanically damaged soybeans and also 'hollow heart' peas in the order of 30 and 14 days respectively.

Table 5. The effect of 'hollow heart' on seedling growth from 1st to 4th week after sowing.

Weeks from sowing	Normal			'Hollow heart'		
	Total wt. (mg)	Leaf area (cm^2)	Root wt. (mg)	Total wt. (mg)	Leaf area (cm^2)	Root wt. (mg)
1	54.0	6.1	24.0	23.0	1.7	10.6
2	180.0	43.2	67.3	84.6	20.2	31.0
3	465.0	87.9	191.6	266.3	84.5	103.0
4	760.0	146.6	314.6	612.0	116.4	236.6

Age, moisture and vigour

Seed age can be viewed from two aspects; namely chronological and physiological with the latter being the more important. Two lots of seeds of the same chronological age can differ physiologically. Barton (1961) in her review on the preservation and longevity of seeds concluded that the actual age is much less important in determining maturity than the environment in which they are held. Barton and Garman (1946) found little or no loss of viability in pepper (*Capsicum frutescens*), tomato (*Lycopersicon esculentum*) and lettuce (*Lactuca sativa*) seeds which had been stored for 13 years.

Results from short term storage of maize of 8, 12 and 16% moisture content indicated that seeds of low moisture content (8%) were stored at a temperature of 38°C for a period of six months without deterioration, that is, without loss in percentage germination and vigour. Both vigour index and dry weight were higher than the rest.

All the data indicate that the most important factor in storage is the moisture content of seeds. When seeds are dried properly to a low moisture level, storage temperature is much less important as the seeds can be stored over a wide range of temperatures.

The vigour of seed is at its peak at maturity. Within the same maize cob, the seeds vary in maturity with the basal seeds being the oldest and those at the tip the youngest and also they differ in size and composition. Seeds from the middle portion of the cob store better at various levels of moisture content for a period of six months. Moisture content had a greater effect on percentage germination than the maturity of the seeds as indicated by position on the cob. There was not much difference between the average percentage germination of all seeds at 8% and 12% moisture content but a great difference occured between these and seeds of 16% moisture content. On the whole, at the 3 different moisture content levels, seeds from the middle portion of the cob performed best after 6 months storage at 28°C (Table 6).

Table 6. Summary of effect of moisture content and maturity (seeds from different portions of the maize cob) on % germination.

Moisture	Portion of cob			Average Moisture
	Tip (P_1)	Middle (P_2)	Base (P_3)	
	Moisture × Portion Mean			
M_1 (8%)	94.75	99.25	98.75	97.58
M_2 (12%)	90.75	97.60	98.00	95.45
M_3 (16%)	1.25	16.25	8.50	8.67
Average Portion	62.25	70.83	68.41	

$LSD_{0.01}$ M = 2.17, $LSD_{0.01}$ P = 2.17, $LSD_{0.01}$ M×P = 3.76.

Table 7. Summary of effect of moisture content and maturity (seeds from difference portions of the maize cob) on the vigour index.

Moisture	Portion of cob			Average Moisture
	Tip (P_1)	Middle (P_2)	Base (P_3)	
	Moisture × Portion Mean			
M_1 (8%)	84.75	94.75	91.00	90.18
M_2 (12%)	72.50	92.00	90.25	84.91
M_3 (16%)	1.00	8.00	4.75	4.58
Average Portion	52.75	64.91	62.00	

$LSD_{0.01}$ M = 1.69, $LSD_{0.01}$ P = 1.69, $LSD_{0.01}$ M×P = 2.92.

In terms of vigour as measured by the vigour index and total dry weight, they differed significantly between 3 different portions at the 3 different levels of moisture content. The highest was from the middle followed by base and tip. There was also a significant decline in vigour index with each increase of moisture content level (Table 7).

Results indicated that maize seeds from the middle part of the cob gave higher percentage germination after storage of 6 months at 8%, 12% and 16% moisture levels. Therefore seeds as planting material should be sized and graded, to ensure better storability and to maintain their vigour.

Conclusions

Seed quality is a very important determinating factor influencing the growth and development of plants. These effects can either be beneficial or detrimental to the plants. For example; big, mature and high protein seeds produce vigorous seedlings maturing evenly and yielding more than the inferior small, immature and low protein seeds. On the other hand, mechanically damaged, aged, diseased and small seeds do not grow vigorously and have uneven maturity and lower yield.

Therefore, in any form of crop production, emphasis must be given to seed quality. In cases where there is a response to supplementary application of nitrogen or triazine compounds during crop growth, this can be exploited for a seed crop to produce seeds with higher protein content, as these subsequently perform better. Seeds have to be harvested at the peak of their maturity and at the right moisture content to ensure that they are mature and to minimise mechanical damage during harvesting. By proper processing, seeds are graded according to sizes and the evenly big sized, undiseased and undamaged seeds are selected for planting. Seeds for planting have to be tested for their viability as well as their vigour so as to ensure that the planting of a crop will not result in crop losses.

1. *Ques.* Lim Jit Kim
In perennial crops such as coffee, rubber, oil palm and cocoa, does variation in seed size affect the subsequent growth and yield because if there is no effect then seed size should not be considered as one of the factors governing seed quality.

Answer Only information on annual crops is available and no reports on perennial crops have been seen. However, as the seeds of perennial crops are large in comparison with those of field crops, the food reserves may be in excess of the seed requirements so that growth differences would not be detected.

Comment J. Rajaratnam
One bunch of oil palm fruits will contain up to fifteen hundred fruits and if these are all planted there is no difference in subsequent growth between plants from small seeds and plants from large seeds.

Answer Oil palm seeds are large and the food reserves may be in excess of the requirements for seedling growth even in the smaller seeds, so that differences in seedling growth characters would not show.

2. *Ques.* Tan Sing Ming
Could you give some information on the after-ripening effect on seed quality? For example tomato fruits are harvested while they are green, and are stored at room temperature until they become red, after which, the seeds are extracted. Can you quote local examples if possible.

Answer It should be emphasized that seeds must be harvested at the mature stage when the vigour will be at its peak. No local examples can be quoted but results would need to be established by trial and error methods.

Comment Yap Thoo Chai

Seed quality is determined by both physical and genetic factors but according to your definition it refers to the physical factors only which indicates the confusion regarding the merits of seed size. Johansen's experiments have shown that selection within a pure line, with respect to seed size, was not effective. Therefore seed size should not be overstressed. The genetic factor should be involved as the genetic unity will decide the growth and yield performance.

3. *Ques.* Lim Cheng Wah

Is there any correlation of seed composition such as protein content and growth between large seeded and small seeded varieties of soya bean? Some factories prefer large seeded to small seeded varieties.

Answer The differences in protein content depends on the variety and a small seeded form may have as high a protein content as a large seeded one. Within a variety the larger seeds are preferred.

Comment Eddie Chew

Seed size should not be a criterion for seed quality control because the size of seed varies even within the same fruit and this is possibly due to variation in nutrient distribution. The paper showed significant vigour during the initial stage but there were no differences in growth and yield subsequently because other factors came into operation. These would include physical factors such as soil, climate, temperature and moisture condition; management practices in the field; fertilizer programme and pest and disease control. Under good management good plants will develop so that it is not correct to list seed size as a criterion for seed quality.

Answer Seed size is a very important criterion and in all seed processing the aim is to grade seed into sizes. The larger seeds of any variety or seed lot will grow more vigorously than small ones. In an established plot of seedlings, those from small seeds will be overshadowed by those from large seeds resulting in very uneven growth. Therefore management practices will be difficult and costly. Larger seeds give seedlings which are more easily managed and plants from small seeds behave differently in the field so that no special treatment can be given to them. Uniform treatment is necessary in a stand of seedlings in order to minimize costs.

References

Barber, H.N. and Paton, D.M. (1952). A gene controlled flowering inhibitor in Pisum. *Nature* 169:592.

Barton, L.V. and Garman, H.R. (1946). Effect of age and storage conditions of seeds on the yield of certain plants. *Contr. Boyce Thompson Inst.*, **14**:243–255.

Barton, L.V. (1961). Seed preservation and longevity. Leonard Hill Ltd., London 216 pp.

Blackman, V.H. (1919). The compound interest law and plant growth. *Ann. Bot.* **XXXIII**. 353–360.

Burris, J.S. Edje, O.T. and Wahab, A.H. (1973). Effects of seed size on seedling performance in soybeans: II Seedling growth and photosynthesis and field performance. *Crop Sci.*, **13**: 207–210.

Chin, H.F., Neales, T.F. and Wilson, J.H. (1974). Effect of mechanical damage in soybean seeds on seedling growth and final seed yield. *Malaysian Agric. Res.*, **3**: 184–189.

Chin, H.F. and Aitken, Y. (1976). Effect of seed damage on growth and development of pea *Pisum sativum* L.) and wheat (*Triticum aestivum* L.) *Ann. Bot.*, **40**: 91-98.

Chin, H.F., Neales,' T.E. and Wilson, J.H. (1975). The effects on seedling growth of simulated seed damage in French beans. *Seed Sci. & Technol.*, **3**: 837–841.

Fries, N. (1953). Limiting factors in the growth of the pea seedling root. *Physiol. Plant.*, **6**: 292.

Hageman, R.H. and Flesher, D. (1960). Nitrate reductase activity in corn seedlings as affected by light and nitrate content of nutrient media. *Plant. Physiol.*, **35**: 700.

Ries, S.K., Chmiel, H., Dilley, D.R. and Pilner, P. (1967). The increase in nitrate reductase activity and protein content of plants treated with simazine. *Proc. Natl. Acad. Sci.*, (U.S.) **58**: 526.

Ries, S.K., (1971). The relationship of protein content and size of bean seed with growth and yield. *Proc. Amer. Soc. Hort Sci.*, **96**: 557–60.

Ries, S.K., Moreno, O., Meggit, W.F., Schweizer, C.J. and Ashkar, S.A., (1971). Wheat seed protein: Chemical influence on and relationship to subsequent growth and yield in Michigan and Mexico. *Agro. J.*, **62**: 746–748.

Rushing, T.T. (1968). Use of stress test to determine the storage and field stand potential of seeds. *Proceedings of short Course for Seedsmen. Miss. State. Univ.*

Schweizer, C.J. and Ries, S.K. (1969). Protein content of Seed: Increase improves growth and yield. *Science*, **165**: 73–75.

Varner, J.E. (1969). Seed development and germination. 763–792 In: *Plant Biochemistry* ed. by J. Bonner and J.E. Varner, Academic Press. London 1054 pp.