SOYBEANS IN TROPICAL AUSTRALIA
- SOME SEED QUALITY ASPECTS

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SOYBEANS IN TROPICAL AUSTRALIA - SOME SEED QUALITY ASPECTS

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ABSTRACT

The production of high quality soybean seed in the monsoonal rainfall environment of tropical Australia can be a difficult task. As well as the intrinsic problems of handling soybean seed which is known to be pernickety, there are particular problems of the tropics which add difficulty to the task. General factors of seed quality are examined, and then aspects particular to soybeans.

These include seed quality and storage including pre harvest quality deterioration and the influence of fungi, post harvest quality losses and storage, mechanical damage and the measurement of seed quality parameters with reference to soybeans. The improvement of quality in soybeans is examined using a system approach with the analysis indicating greatest improvements are likely in the late production/harvest and the immediate pre sowing phases. The actual methods for analysing components of seed quality are also discussed. Improvements can be made in the detection of weed seeds in seed lots, the determination of vigour and in some aspects of seed health. There is also opportunity for genetic improvements which would result in improved seed quality in this tropical area.

Much of the discussion on seed quality is also relevant to other grain legumes grown in tropical Australia.

1. SEED QUALITY IN SOYBEAN

Introduction

Successful establishment of a crop production industry requires adequate and timely supplies of good quality seed. Most western agriculture systems have sufficient flexibility in their systems to accommodate periodic fluctuations in supply from an individual source. The same cannot be said for some crops in the Northern Territory, particularly soybean, mung bean, sesame and to a lesser extent, some pasture species, due to the nature of cultivars developed for this part of Australia. Alternative sources of supply are restricted to the Ord River Irrigation Area (ORIA) and possibly some parts of Queensland. Quarantine problems may constrain these further.

Although production volumes need to be calculated, using some assumptions, much of these figures depend on the seed quality that can be produced. Thus it becomes desirable to produce quality seed, as well it should, to be available to growers, from local sources.

Seed Quality

In this discussion seed quality is thought of as the sum total of the seed lot characteristics determining performance in the field. There are a number of factors involved in the resultant expression of quality, both intrinsic and extrinsic. The testing of the seed may determine four aspects: analytical purity, germination percentage, seed vigour and seed health.

- analytical purity: Problems in this area include admixtures of weedy cowpea types (also a problem in the USA) and other weeds eg *Cassia obtusifolia* (sicklepod). Cleaning has generally been adequate to remove splits and broken seeds. These are long term problems, and need to be considered in planning seed production.

- germination percentage: Most people have considered this the primary determinant of seed quality. Generally speaking, one should be aiming for germination figures of 95% or better; realistically 85% is satisfactory. This figure should indicate the potential for field performance of the seed.

- seed vigour: Vigour is a difficult characteristic to measure meaningfully, but it should provide a reinforcement of germination values, indicating the ability to emerge under a wide range of field conditions.

- seed health: There are two aspects to this in relation to quality. One, the group of organisms that are benign during establishment, but manifest themselves later, the other a group of organisms that may be both or either seed or soil borne and cause seed or seedling destruction and poor emergence.

Given the above situation a system analysis approach was adopted to characterise the seed production systems.

This is attached as Appendix 1.

Following the elucidation of this it is probably best to discuss the causes of reduced seed quality in broad terms and to look at methods of minimising this damage.

Seed Quality and Field Performance - Soybeans

It is generally considered that high germination and high vigour go hand in hand. Delouche in the USA, has shown that this is not so. He tested 94 different lots, all with germinations in the lab of over 80%. Of these, 13 emerged at less than 50% and 38 emerged at 50-69%, that is approximately one half were of lowered vigour. However, it is also known that as lab germination declines, the difference between lab and field performance tends to increase correspondingly. There are further indications that for high quality lines eg germination figures of 88-90% or more, field emergence (vigour tests) may not be well correlated with field performance. This may well be arguable, depending on which authors are selected.

However, given all this, it is desirable to have seed with high germination ability. On the other hand, where seed will be sown into stress conditions, high seed vigour is generally important as well. In much of tropical Australia, soil temperatures are supra-optimal during the sowing period so that stress conditions are quite common.

Having considered germination and vigour as intrinsic factors affecting quality, the problem would seem to be the consistent production and delivery to the farmer of seed capable of good field performance, and the use of this seed in a manner capable of expressing this quality.

Poor initial seed quality also influences the storage potential of soybean seed (Bryd and Delouche 1971, Burris 1980 and Ellis et al. 1982).

It is probably easier to discuss the causes of problems in seed quality, rather than methods of improving it directly.

<u>Physiological Problems - Ageing and Imbibition Damage</u>

In soybean, maximum seed quality is said to be reached at physiological maturity (Wahab and Burris 1971, Delouche 1974) when maximum germination and vigour occurs (Andrews 1966, Mondragon 1976). Harvesting prior to that, does not appear to effect germination and vigour. Seed size appears to have little influence on seed germination levels (Green et al. 1965, Burris et al. 1971, Nangju et al. 1980). However, there are major physiological effects after physiological maturity (pm). The first, seed ageing, occurs at any time between pm and sowing and the second, imbibition damage, affects germination and vigour after sowing.

- Ageing. The process of deterioration begins from the moment of pm. Aged seeds tend to be characterised by a reduced rate of germination, reduced tolerance to sub optimal conditions for germination, an increase in abnormal seedlings, reduced field emergence, poorer seedling growth in the seedlings that do establish and even poorer mature plants from these seeds (Bryd and Delouche 1971, Burns et al. 1969, Gelmond 1970).

- This ageing is generally considered to be associated with membrane damage (Koostra and Harrington) and is reflected in leakage of solutes from damaged (aged) seeds. The measurement of these changes is the basis of some vigour tests (Matthews and Bradnock 1968, Edje and Burris 1970 and McDonald 1986). High values have generally been negatively correlated with seed vigour tests for soybean, which will indicate changes in vigour before germination changes. However, the correlation of these tests with field results has not always been satisfactory.

- Imbibition damage. This damage, which occurs as a result of rapid water uptake by dry embryos, was first described in peas by Powell and Matthews (1978) and subsequently in soybean by Semple (1981). The testa has a major role in regulating the rate of water uptake and damage to it can result in poor field emergence. Reduced emergence associated with imbibition damage may occur because of physiological death in weak or susceptible lots and/or because of increased predisposition to infection by soil borne fungi, or seed borne disease. Predisposition to infection is the more significant cause as indicated by the fact that fungicidal chemicals nearly always improve emergence. (Oliveira et al. 1983, Matherson 1983). Although the condition of the testa, and rate of water uptake are important, embryo condition is also important. Aged seeds appear more susceptible (Woodstock and Tao 1981) to imbibition damage.

The Influence of Pathological Factors - Fungi and Bacteria

(a) Fungi

There are generally two groups of these organisms affecting seed quality. The first is the field fungi which invade the seeds while they are on the plant. These may be saprophytes eg *Cladosporium* sp or pathogens who will be seed borne. The other is storage fungi which will be discussed later.

On soybean, there are several problem fungi.

The pod and stem blight complex (*Phomopsis* and *Diaporthe phaseolorum var. sojae*) is the most serious on a world wide basis. This disease has not been recorded in the NT and only on few occasions in Queensland.* As such it can be dismissed, until more evidence is available. Most overseas literature refers to the control of this disease. It is a major seed borne disease problem in the subtropical USA (Shortt et al. 1981). However, it is generally considered less of a problem in the low latitude, lowland tropics.

The purple seed stain *Cercospora kikuchii* colonizes the seed late in the season, discolouring the seed and causing coat cracking. Infection will reduce both germination and field emergence (Wilcox and Abney 1973) although Nangju (1980) observed no effects on field emergence. This is considered the most common seed disease by some authors (Hebblethwaite 1978).

There are a range of other species associated with reduced germination and/or field emergence. These include *Macrophomina phaseolina*, *Colletotrichum dematicum var. truncata*, *Alternaria* spp, *Myrothecium roridium*, *Sclerotina* spp, *Aspergillus* spp and *Fusarium* spp (Sinclair 1978). Nearly all of these are associated with the seed coat but are occasionally deep inside the seed itself and therefore normally seed borne.

* See also Stovold and Francis Aust. J. Exp. Agric (1987) 27:317-21 for most recent discussion in Australia, available from May 1987.

The predominant fungus species associated with soybean seed problems in the NT has not been determined. However it is known that it is not a pod/stem blight complex. The US literature on this problem is thus in many ways irrelevant, and experiments designed to ascertain the effects of fungicides during production need to take account of this. *Macrophomina phaseolina* causes problems in hot soil conditions, above 28°C, and is further enhanced by moisture stress. Infected seedlings, if they do not die, will carry a latent infection, likely to manifest itself in the later production stages. From laboratory observation, it is very common on seed of lowered germination level. Recent field experiments and observations tend to implicate both this species and *Colletotrichum* spp, as being associated with seed problems.

(b) Bacteria

Few seed borne bacterial diseases occur in grain legumes, and only two species are known to influence seed quality. These are *Pseudomonas glycinea* and *Bacillus subtilis*. The latter is reported as being associated with seed quality problems, especially where germination is occurring in high temperatures, eg 30°C or more. Complete loss of stands have been reported where soil temperatures exceed 25°C.

In general terms, viral diseases have not been a major problem, even worldwide, and have not been recorded in the NT.

2. SEED QUALITY AND STORAGE

The entire period between pm and the time the seed is sown is seed storage. Seed quality can deteriorate both on and off the plant and can be influenced by many factors in this period.

(a) Pre harvest deterioration of quality

(i) Physiology

There are numerous studies which have investigated the effects of delayed harvest after the point of harvest maturity (hm) has been reached. Work by Green et al. (1966) Mondragon (1974) and Nangju (1979) (among others) all showed that delayed harvest reduced seed germination. TeKrony (1980), however did not observe such a decline and germination did not decline for at least 50 days although vigour fell rapidly.

However, in periods of high temperatures, high humidity and possibility of rain or heavy dews, the idea of delayed harvest for soybean seed should not be countenanced, due to a high probability of lowered quality in what are obviously poor storage conditions.

The period between pm and hm should not be disregarded in its influence on seed quality. Several studies (TeKrony 1980, Green et al. 1965) indicate that soybean seeds which mature in hot, dry weather have lowered vigour and viability. It is unlikely that, in the production of soybean seed in the Top End of the NT, this situation can really be avoided. Day temperatures are always hot, by standards in America, where soys mature in the fall, a period of much cooler weather.

Pre-harvest deterioration of soybeans under wet or fluctuating moisture conditions was examined by Moore (1971). He showed that rapid and uneven contact of seed tissues with water, followed by drying, causing uneven hydration and dehydration, could produce fissures in the seed coat and cause embryo membrane rupture leading to cell death. Seed with light coloured coats appeared more susceptible and so did early maturing cultivars, presumably because of more rain during the dry down period. Hard seeded cultivars were less susceptible (Potts et al. 1978). (See Hartwig and Potts (1987) Crop Science 27:3, 506 - 508 for a more thorough analysis of this concept).

Obviously then, the idea is to shift maturation to a period where this does not occur, if at all possible, and to use cultivars with hard seed.

(ii) Fungal Infection

Delayed harvest can result in an increase in field fungal infections, which in turn may reduce seed quality. This has been demonstrated by Athow and Laviolette (1973) and also by Wilcox et al. (1974). This evidence of field deterioration is greatly influenced by environmental conditions. Most infection of *M. phaseoli* and *S. sclerotiorum* in soybean was found in seed subjected to extended rainy periods (Wilcox 1974). Some control of diseases such as the Diaporthe/Phomopsis complex has been achieved by the use of systemic fungicide sprays during later reproductive phases in soybean, affected by moisture (see attached Appendix).

Thus pre harvest deterioration in the field is associated with both physiological deterioration (ageing) and increased infection by field fungi. Both forms of deterioration are accelerated by high temperatures and higher seed moisture contents (rainfall and/or high RH) and they are obviously inter related. Thus, for the soybean seed production system in the NT, improvements could be expected when seed matures in drier conditions. This is exemplified in the production of high quality seed several years ago when weather conditions were benign, and the generally satisfactory production of seed for late planted, irrigated crops on the ORIA. However, few of these crops have produced seed with both high vigour and germination figures of above 90%. It may well be that this may not be practically achievable due to factors that cannot be modified.

3. POST HARVEST DETERIORATION OF QUALITY

It is generally accepted that conditions of high temperature and high humidity (our normal situation) are detrimental to seed quality. Work by Boatye-Boateng and Hume (1975) in Ghana, demonstrated this for soybean, as has Ellis (1982) and unpublished work in the NT, by Harrison.

Furthermore it would be accepted that, with current cultivars, cool storage of dried seeds at say 5-10°C and 30-50% RH is adequate to hold seed from season to season (Harrison: in preparation). The technology to maintain seed quality after processing is generally well understood.

However, there are several areas where problems are likely to occur in a tropical environment. The first of these is related to immediate conditions post harvest. Work by Harrison (1987) has shown that lack of attention at this period can result in decreased germination and increases in fungal problems on the seed in the field and in storage. It could also be postulated that a decline in seed vigour would occur if conditions were inadequate, even if the period was too short to affect germination, after the results obtained by TeKrony (1980). Of greater importance is the influence of conditions prior to this and the degree of pre and post harvest deterioration, fungal infection, etc, that has already occurred, on the plant.

Mechanical damage to seed, caused during harvesting, transport and processing will affect storage potential. Damaged soybean store poorly (Grabe 1963, Harrison unpublished data) and efforts should be made to reduce or eliminate damage to the seed.

Soybean seed has a reputation as an inherently poor storer (Delouche et al. 1973) and this has been confirmed in numerous studies over the years. It is particularly sensitive to temperature during storage and much less sensitive to moisture (Ellis et al. 1982). Unpublished work (Harrison) confirms this, where soybean seed at 6% mc lost viability very rapidly when stored at ambient conditions, whereas seed stored at 22°C and approx 11% mc retained viability for a considerably longer period.

Of the seed storage fungi *Aspergillus* spp is the major organism. Lowered temperature and RH (seed moisture) help to alleviate the problem. The most significant effect of fungi is to reduce germination, although changes to seed physiological function has also been reported, reputedly due to toxin effects (Harman and Nash 1982).

Insects may also cause major problems in seed quality, but generally activity is restricted by low temperatures and lowered RH, a condition required to maintain seed quality on physiological grounds. Field infestation of insects, (not discussed earlier) can cause initial problems, but processing often eliminates this smaller, shrivelled seed. Storage insects are most likely to be a problem prior to processing or after seed leaves cool storage for use on the farm. The use of fumigation or insecticidal compounds can solve the problem without damaging seed.

The greatest effect on quality of soybean seed occurs during the phase of post processing storage. Lowered temperature and humidity is essential in this region for successful storage between seasons, of present cultivars. It is known that there are genetic differences between cultivars in tropical storage ability and these are important criteria in soybean improvement programs. Control of RH (seed moisture) by superior packaging is unlikely to be entirely successful in the tropics for soybeans, as it has been elsewhere, due to the sensitivity of soybean to high temperatures.

Locally, the present system of storing soybean seed at 10°C/50% RH, is satisfactory for several seasons storage and should be continued, until a cultivar with superior storage ability becomes available. It is likely that any improvement in conditions over ambient, would provide better storage conditions and maintain superior seed quality.

4. SEED QUALITY AND MECHANICAL DAMAGE

Mechanical damage to seeds may be both internal and external. The most common internal damage is transverse cracking (TVC), in which breaks extend partially or completely across the cotyledons, rupturing vascular tissue and impeding the flow of reserves from the cotyledons to the embryo. In soybean, this has been associated with rapid water uptake in dry seeds under conditions where soil moisture content increases rapidly to saturation point, ie essentially free water, and initial seed moisture is below 12%. These conditions would occur in irrigated areas. Some reports associate the problem with mechanical injury (although it can occur in hand harvested seed), hydration/dehydration cycles and rapid desiccation at maturity.

I believe this has occurred on a number of occasions in the NT, based on discussions with both farmers and DPP staff, especially where dry seed (<10%mc) has been used. This will continue to be a problem due to natural drying of soybean in this climate to 10%mc or less, and rapid increases in soil moisture associated with tropical rain storms, which of course may also cause soil physical problems such as crusting, detrimental to seed emergence.

External damage can be severe, but processing tends to eliminate much of the worst seed of this type. Damage to remaining seed is generally in or under the seed coat - seen as cracked, chipped or shattered seed coats, although it may not always be visible to the naked eye. This damage manifests itself at imbibition. Work by Moore (1971) has been outstanding in defining this damage. Germination is reduced, with reductions generally being more severe as damage increases (Green et al. (1966), Luedders and Burris 1979). Where germination is not affected, vigour can be (Mason 1982), often resulting in lowered field performance (Luedders and Burris 1979).

As well as immediate effects, mechanical damage can reduce seed longevity even in good storage conditions, rendering seeds unsuitable for sowing within a short time (Harrison unpublished).

The Causes of Mechanical Damage

Three areas are generally implicated - harvesting, processing and sowing. It is also worthwhile in this area to consider transport and handling, as part of the processing area. When large seeded legumes are harvested with a conventional header, mechanical damage is controlled by manipulation of seed moisture content and drum speed of the combine. For soybean, low drum speeds, 14-16% seed moisture and adequate concave clearances can produce satisfactory, undamaged seed. However, axial flow harvesters, with an improved more gentle threshing action have generally superseded drum headers for quality grain legume seed production, yielding an improved product with little mechanical damage. Poor control of harvesting - too wet or too dry will yield seed with substantial mechanical damage and considerably reduced seed quality.

Processing, although designed to eliminate severely damaged seed, may produce damage, when seeds fall into metal bins or impact on metal surfaces or other seeds. In transport and handling, impaction damage is generally considered cumulative, with many small injuries just as severe as large ones, but the visible damage is often not as apparent. Seed coat cracks from processing injury cause imbibition damage, reduced vigour and lowered seed quality. There are simple means of preventing, or at least substantially curtailling, damage due to many of these points by the use of better mechanical plant design and equipment eg bean ladders.

Sowing may also be a cause of mechanical damage. Gould (pers. comm) has implicated planter damage to maize seed locally while damage to grain legumes has also been reported. Damage at sowing is often not recognised, with problems due to this damage attributed to other sources, because the usual manifestation of this problem is failure to emerge and/or establish and often climatic problems are blamed.

Factors Involved in Mechanical Damage

The two most commonly recognised factors governing susceptibility to mechanical damage are seed moisture content and handling severity. An attached graph indicated that damage to soybean increases as seed moisture content both increases and decreases outside the range of 14-20%, during combine harvesting. Increasing drum speed also increases the severity of damage.

There are some limited and conflicting reports regarding damage at planting. Dexter (1966) has reported increased emergence by raising moisture content from 11% to 16% (in Phaseolus beans), although raising it to 18% caused damage as compared to 8.5% and 14% in some other reports. Logically, it would seem that moisture contents outside the range of about 10%-20% could create problems of planter damage. It must also be remembered that the planter is at the end of a long chain of events from growth to use. Latent problems may manifest themselves as damage during planting if the planter is even marginally inefficient.

Larger seed size tends to make seed more susceptible to mechanical damage both within and between cultivars according to Paulsen (1979) for soybeans.

5. MEASURING SEED QUALITY

(a) Germination Test

An increased number of abnormal seedlings or dead seeds, when seed is tested according to prescriptions, provides classic information on seed quality. When abnormalities are examined by competent personnel, some conclusions may be drawn about the causes.

(b) Purity Test

The ordinary purity test may not be sufficiently precise to detect problems of quality in soybean. Measurements are made to 0.1% and this may represent a wide range of seed numbers. In soybean, where the sowing rate is regularly 100kg/ha, it may represent a few weed seeds sown per hectare or thousands. To improve precision a larger sample should be examined and seeds expressed as number per mass. This issue is currently receiving the attention of the Australian Oilseeds Committee, and has also been examined by Harrison and Riley (1985) in relation to the detection of very small numbers of contaminants in grain legume seeds.

(c) Seed Health Tests

These have generally been accorded low priority by most agronomists, although their use to predict planting value or in seed certification schemes has been relatively widely used at various times. There has been no routine development of these in the Northern Territory.

(d) Vigour Tests

There have been numerous vigour tests developed over the years, to relate laboratory determined values to field performance. For soybean a variety of tests are used and these have been the subject of much debate over the years. Some of those available include the cold test, accelerated aging, conductivity testing, Hiltner Test, 4 and 7 day germination values, seedling growth rate, tetrazolium test and the aldehyde reduction test. Variable correlations with field performance have been achieved, usually after the event.

The use of vigour tests is really a "horses for courses" approach, with the choice depending on the circumstances. As ageing in seeds is associated with membrane breakdown, the conductivity, aldehyde reduction and accelerated ageing tests best mimic the physiological causes underlying loss of vigour and are probably now considered the most appropriate.

However the TZ test is extremely useful for detection of mechanical damage, dehydration/hydration damage, heat damage and ageing and has been used routinely by Woodstock (1976).

None of these techniques have been seriously evaluated for use in tropical areas, including tropical Australia.

6. IMPROVING SEED QUALITY

The previous discussion has outlined problems of soybean quality and its measurement.

An analysis of the systems involved in seed production and their influences on quality provides us with some insights into ways of improving quality.

(a) Production - Harvest: Little is stated about the vegetative phase influencing seed quality (as distinct from <u>quantity</u>). However it appears important that seed is produced and then matures in a period of low moisture stress, without hydration/dehydration cycles after pm and is harvested as soon as it reaches 16-18%mc, with a header which causes as little mechanical damage as possible. This implies use of an axial flow header or very low drum speeds (350rpm). Ideally maturation should be in a period of cool weather, but this is not possible in this environment. Studies on climatology may enable selection of ideal planting dates either for dry land or irrigated plantings. Dry season seed production with cv Buchanan is not a preferred option due to low plant height and associated harvest problems plus low yield.

(b) Harvest - Storage: Following harvest, seed should be pre-cleaned immediately, dried to about 12-14%mc, by aeration, and kept in cool conditions (this may be in a well ventilated shed) prior to processing and packaging. Storage should be at 10°C 50% RH, where seed will reach a moisture equilibrium of 9-10%mc. It is noted that transport and processing tends to remove 2-4%mc from seed in this environment. All processing should utilise gentle handling and be undertaken rapidly. If this is not possible, then cool storage is desirable (20°C or less).

(c) Storage - Sowing: Since storage at 10°C/50%RH or better is required there is a potential problem in farmer storage prior to sowing, due to high temperatures at this stage, particularly if this period is extended. Ideally, seed should be conditioned to 12%mc for sowing. This tends to avoid imbibition damage. Provided seed is not too brittle, there should not be major problems with planter damage at sowing. However, moisture conditions and temperatures at planting will greatly influence performance, and disease problems. There are apparent advantages for minimum tillage at this stage. Fungicidal seed dressings may also be beneficial, depending on inoculum load, soil moisture and temperature. Selection of planting date may be important to avoid emergence problems and also to avoid quality problems at maturity due to rainfall.

(d) Sowing - Production: Use of a seed dressing fungicide may provide protection from latent infections of *Macrophomina* which could manifest themselves at maturity. Adequate weed and insect protection to improve seed yield and analytical quality is also necessary. Improved genotypes offer advantage in this area. The use of minimum tillage may also be important through its ability to reduce soil temperatures and improve moisture retention.

Stages (a) - production - harvest and (c) storage - sowing are likely to have the greatest influences on seed quality and seed performance. Stage (b) is already reasonably set up in this environment and tends to function quite smoothly following earlier work and discussions by Harrison and ADMA staff several years ago. Thus improvements in stages (a) and (c) are likely to yield most rapid benefits to seed quality.

Determination of Quality

(a) The adequate detection and reporting of contaminant seeds in soybean is essential. The number of contaminant seeds per unit mass of soybean seeds is reported because small numbers in a sample constitute large numbers per hectare when planted at the sowing rates used for soybean. Problem contaminants include weedy cowpea types (several colours), *Operculina inaequalis* and a potential problem weed, sicklepod, *Cassia obtusifolia*.

(b) Measurement and reporting of germination is generally adequate.

(c) The identification and measurement of vigour in the various seed lots is useful, but is of limited value commercially as there is little opportunity for discriminatory buying or marketing when only one or two lots comprise the entire market. There is opportunity to measure vigour and monitor performance in the field. There is greater opportunity to look at this concept in experimental areas where greater differences may occur in the seed/grain produced.

(d) Seed health is an area in which some advances could be made which may contribute to better information on seed quality. Standard germination tests are not structured to detect seed pathogens, although sometimes the common species can be qualitatively evaluated and identified. Because of this, some germination tests have failed to detect quite severe cases of *Macrophomina phaseoli* on seed in a standard laboratory test and the seed germinated well since there was little stress. However seed coats were extremely and comprehensively covered by sclerotia, and this condition would most likely lead to problems in the field. More such information could be gained to forewarn growers of problems.

CONCLUSION

The production of significant quantities of high quality soybean or other grain legume seeds in this environment requires an understanding of the production systems and how the parts interact and influence each other.

Some parts of the system can be manipulated and improvements made while others are more difficult to modify and others may not even be changeable eg temperatures, so avoidance may be the answer.

The system needs to be looked at holistically, realising that each and every change will influence the remainder of the seed production system and also the next grain production cycle.

High quality seed on a consistent basis requires a bias towards a system that provides optimal conditions at all stages. Where this is not achievable, a loss of quality and often quantity must be expected.

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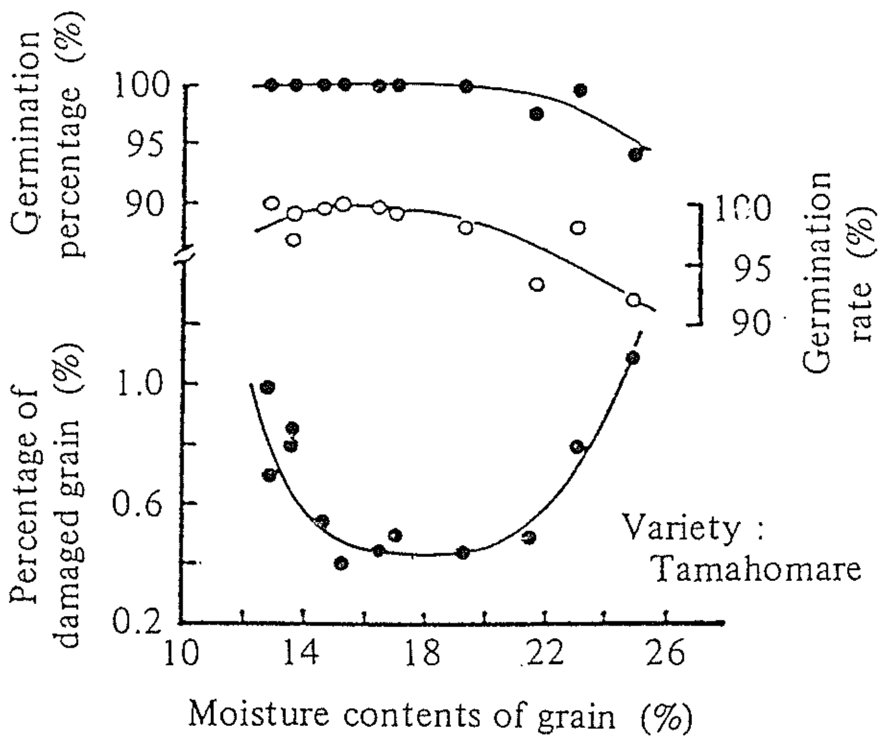

Fig. 1 Relation between moisture contents of grain and soybean qualities

APPENDIX 1

PRODUCTION PHASE		CAUSE OF QUALITY REDUCTION	FACTORS INVOLVED
Physiological Maturity		preharvest deterioration Infection by pathogens	high temperatures, moisture fluctuations, high RH,inocutum load, moisture/temperature stress, varietal susceptibility
Harvest maturity		preharvest deterioration infection by pathogens	
Harvest		mechanical damage	header type, header settings, temperature, seed moisture content, air R.H., amount of leaf material, drying, pre-cleaning, handling methods, delivery/duration method
	Transport	deterioration, mechanical damage, infection by pathogens	
Processing		mechanical damage	machine type, configuration, no. of passes, seed moisture content, seed transfer mechanisms, system design, fluctuation in seed m.c.
	Transport?		feeding systems, packaging, duration
Storage (season-season)		post harvest deterioration, growth of storage fungi, growth of storage insects rodents, length of storage	high temperature, seed m.c., R.H. storag atmosphere, gas in storage, genotype, past history, fluctuations in temperature, moisture retent, packaging type and methods
	Transport	mechanical damage/deterioration	poorhandling systems, time/duration, moisture fluctuations, high temperature and high R.H.
Farmer storage		post harvest deterioration damage by rodents, fungi and insects, duration of on farm storage, mechanical damage	storage conditions - temperature, R.H. seed moisture content, packaging and handling
Sowing			
Emergence		Seed borne disease imbibition damage transverse cracking seed bruising	seed coat condition, seed m.c., temperature, planter design, planter, seed quality, soil temperature, solar radiation, soil m.c., rainfall (soil crusting), fungicide, planter depth, conventional tillage, min-tillage, seed borne disease, soil borne disease, inoculum load, herbicide effect
Production		weeds plant/seed disease nutrition stress-moisture insect damage genotype	planting date, variety, fertiliser type/amount, rainfall/irrigation, amount and duration, use of insecticides herbicides, fungicides, genotype (resistance), improved seed quality, genotypes

SOYBEAN SEED PRODUCTION AND SEED QUALITY
SYSTEM ANALYSIS