Immaturity as a Cause of Low Quality in Seed of *Panicum maximum*[1]

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ABSTRACT

Methods were devised for measuring the mature seed content of samples of pure seed of *Panicum maximum* cv. Petrie (green panic) and cv. Gatton. Tests conducted on mature and immature fractions confirmed the great inferiority of immature seed in terms of laboratory germination, field emergence, viability and longevity. A close correlation was obtained between mature seed content of commercial seed samples measured shortly after harvest and subsequent viability, germination and planting value. Mature seed content of numerous samples from seed crops of both cultivars averaged just below 60%, with variation between about 30 and 90%. It was concluded that immaturity was a reason for the low general quality of seed of these grasses and a major cause of variation in quality. Possible reasons for variation were suggested.

Additional index words: **maturity, germination, emergence, viability, longevity, tropical pasture grass.**

INTRODUCTION

Seed of most species of tropical pasture grasses has a reputation for low quality. Examination of many seed samples over a long time led us to the opinion that one reason was the presence of high proportions of immature seed. The condition generally passes unnoticed because its detection in most grass seeds requires spikelet dissection, and there is little specific, useful, published information on the subject.

Descriptions of the behavior of other species were of some value. They provided evidence of the general inferiority of seed harvested before maturation (Austin, 1972) and ample indication of the presence and low quality of immature seed in temperate grasses (Hill, 1980).

It could be inferred that a proportion of the seed of standing crops of at least one tropical pasture grass, *Panicum maximum*, must be immature, even at harvest ripeness, because of the combination of unsynchronized spikelet development and brief retention after ripening (Hopkinson and English, 1982a). Immature seed would then be carried through in unchanged proportions to the marketed product, first because conventional combine harvesting does not selectively exclude immature seed (Hopkinson and English 1982b), next because the pure seed fraction is never altered during cleaning.

There was thus little doubt about the ubiquity of immature seed in *Panicum maximum* seed lots. There was, however, no indication of how much is normally present, how low is its quality, or to what extent its content varies and causes quality to vary. The objective of this investigation was to obtain information on the importance of seed immaturity to low seed quality.

The first task was to reach practicable definitions of maturity and immaturity and to devise methods for their quantification. The methods were then used on seed from both commercial and experimental sources to provide an accumulation of information. Several species were covered, but this account is restricted to two cultivars of one species for which the most thorough records were obtained. These are green and Gatton panic of *Panicum maximum* (described as cv. Petrie and cv. Gatton, Barnard, 1972).

METHODS AND RESULTS

Definition and Measurement of Maturity

Measurements were made on dried samples of pure seed as defined by the International Seed Testing Association (Anon., 1985). The unit of seed was thus the individual spikelet containing a single recognizable caryopsis.

After much preliminary trial, it was decided to measure maturity in terms of the percentage content of mature seeds. Two classes only of seed were to be recognized, mature and immature. This was obviously artificial, since maturation is progressive and a gradation of stages of maturity must exist. Nevertheless, it was practical and realistic. Intermediates were few, normally less than 5% of a sample, and could readily and consistently be allocated to the class they resembled the more closely. Germination tests failed to detect differences between fractions created within the mature seed class. From this and from the difference between classes (see later results), we concluded that our point of separation between classes was appropriate.

A mature seed was defined as one in which the caryopsis had completed, or virtually completed, its development based on visual evaluation. The caryopsis fully occupied the husk cavity, its final growth having forced the overlapping edges of the lemma and palea together in a tight seal which was maintained after drying because the caryopsis did not shrink.

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The embryo was outwardly perfect, the endosperm plump and translucent.

The caryopsis of an immature seed did not fully occupy the husk cavity when dry, and the seal between lemma and palea was consequently slack. The embryo might or might not be full sized, but the endosperm was always undersized, opaque, and usually chalky in texture.

Normally at least two sub-samples of 100 seeds each were taken for maturity measurement. With proper attention to mixing and sub-sampling, reproducibility within the theoretical range was readily achieved. Each seed was examined individually at x12 magnification under a dissecting microscope, the caryopsis being exposed for observation wherever necessary. This will be referred to as the direct method.

Two other methods were sometimes used. One was employed when seed was needed for germination testing and must not, therefore, sustain husk damage. It involved detaching the membranous tissues of the spikelets by rubbing the sub-sample gently with ball of thumb on palm of hand, then aspirating in a blower of the type used in purity analysis. Using a setting determined by prior trial and error, this neatly separated mature and immature seeds with the same degree of reproducibility as that of the direct method. Its accuracy of separation was monitored by observation under magnification. We refer to this as the aspiration method.

The third method was used to obtain retrospective estimates of mature seed contents from old records, and consisted simply of the establishment of a regression equation relating mature seed content to 100 seed weight. Values were obtained for 43 different seed lots of Gatton panic, mature seed content being measured by the direct method and 100 seed weights from the means of paired sub-samples (standard errors averaged $\pm$ 2.4% of the mean). The equation $y = 0.989x + 0.1$ was derived (y = mature seeds per 100 spikelets; x = 100 seed weight in mg of intact spikelets dried to about 10% moisture; $r = 0.883$). This is referred to as the regression method.

Comparisons Between Mature and Immature Seed

Three sets of records are summarized to illustrate the differences in quality between mature and immature seed (Table 1). The following details apply to them:

Germination tests. Results reported are average germination percentages of mature and immature fractions, separated by the aspiration method, derived from 89 separate tests conducted on 30 different seed lines of Gatton panic. Each test consisted of 100 seeds germinated in standard conditions (35/15 C, 8 hour day, 0.2% KNO_3). Seed was one year old at test, having been stored since harvest at about 10% moisture and ambient temperature (average about 22 C).

Field emergence. Records are of seedlings emerging from soil as a percentage of seed sown. They are average values derived from 18 separate tests on 6 different lines of seed of both green and Gatton panic, each test consisting of three replicates of 200 seeds of either fraction separated by the aspiration method. One year old seed stored as for the germination tests was sown into conventional field seedbeds in summer in Atherton, north Queensland.

Table 1. Comparative quality of mature and immature seed of Gatton panic. Values are averages of many tests, with standard deviations of means for different seed lines quoted where legitimate for untransformed data.

	Mature	Immature
Laboratory germination (%)	69.3 $\pm$ 25.0	13.2
Field emergence (%)	34.4 $\pm$ 5.2	3.8 $\pm$ 1.6
Viability (%)		
Storage age (years)		
0.2	96.7	49.0 $\pm$ 17.5
1.5	88.9 $\pm$ 8.9	16.2 $\pm$ 12.1
2.2	83.2 $\pm$ 13	8.6
Estimated mean viability period (years)	4.3	0.1

Retention of viability. Records are of percentage viability of stored seed of green panic measured by tetrazolium after various intervals of storage. Each figure is the average value for 29 different lines of seed. Each test on each line used 100-300 seeds in various replications. Methods of testing were similar to those described in an earlier paper (Harty, Hopkinson, English, and Alder, 1983). Mean viability period (Roberts, 1972) was estimated from the linear regression of probits of viability on time rather than by formal probit analysis. Storage age means time spent at ambient temperature (average about 22 C) and 10% moisture. Mature and immature seeds were separated by the direct method.

The results confirm the inferiority of immature seed and illustrate just how poor its quality is. The initial viability is low and subsequent deterioration rapid. Performance at the age and conditions when the seed is most likely to be used is very weak in both laboratory and field. Though not entirely worthless, the immature fraction of a seed lot clearly contributes so little to overall performance.

Relation Between Mature Seed Content and Quality

In view of the differences between mature and immature seed, it was to be expected that a relationship would exist between mature seed content and potential quality. Provided other factors affecting quality did not blur the relationship it ought to be possible to use mature seed content measured on newly harvested seed as a guide to future usefulness.

The opportunity to check these expectations arose with the collection for other purposes of green panic seed from seven separate commercial harvests in 1981. Mature seed content was recorded during initial processing. Details of harvest, handling and drying differed between lots, but storage conditions were identical. Tests of quality were conducted over the following three years. The quoted values (Table 2) are average viability over four occasions by the tetrazolium test; average germination on three occasions by the routine test; and average soil survival of seed of three ages (the value quoted is the sum of emerging seedlings and surviving dor-

Table 2. Correlations between mature seed content and three indices of quality, obtained with seven lots of commercial green panic seed. Each row represents a separate seed lot.

Mature seed content	Viability	Germination	Soil survival
	(%)		
72	74	34	51
88	89	59	73
55	64	37	46
54	54	26	39
59	64	30	44
61	62	29	43
70	80	45	66
Correlation coefficient (r)	0.943	0.865	0.898

mant seeds from pot tests). Each value is the average of determinations made on 600 to 1600 seeds.

The results show that correlations were close, and that mature seed content provided a reasonable indication of future quality. Of the causes of variation in quality that have a prestorage origin, variation in maturity was clearly an important one.

Records of Mature Seed Content

Methods. Mature seed content was determined for most commercial and experimental samples of green and Gatton panic that came to hand from 1971 onwards. The regression method was used for Gatton panic from 1974 and earlier, the direct method otherwise. Records were kept from 63 crops of green panic and 31 of Gatton panic from central and northern Queensland. These include complete records of all Gatton panic seed crops grown on an area of Kairi Research Station, north Queensland, under identical management since 1971. They consist of estimates made on seed harvested from each standing crop, plus values for fallen seed collected in traps below the canopy of six crops (see Hopkinson and English, 1982a for details).

Results. The overall average and standard deviation of mature seed content of seed of green panic was 59.9% $\pm$12.3. For Gatton panic it was 57.5% $\pm$11.0. The extremes were 31 to 90% and 31 to 86% respectively. Few consistent patterns could be detected that allowed mature seed content to be associated with particular conditions, though sometimes there were marked differences between years. For example, of the green panic crops grown in north Queensland, the 12 records for 1977 averaged 69% ranging from 61 to 82%, while the 8 records for 1980 averaged 48% with a range from 40 to 52%. Also, very low values were always derived from crops that had experienced stress, either as a result of drought, excessive rainfall, or low temperature through their being grown out of season.

The 27 Gatton panic records from Kairi averaged 59.5% $\pm$ 12.4 with a range from 31 to 86%, despite uniform management. The differences can only be attributed to the effects of varying seasonal conditions. Mature seed content changed little with time over the life of any one crop, except for tending to be low very early in the crop's life. Standard deviations of successive samplings averaged only 5.9% for the 9 crops sampled. Illustrated examples of sequences have already been published (Hopkinson and English, 1982a). Choice of harvest time is clearly not an important cause of variation in mature seed content, except perhaps in cases of extreme misjudgement.

Those records that included mature seed content of shed seed as well as from the standing crop are shown in Table 3. Shed seed always had a higher mature seed content than standing crop, but still contained significant and variable percentages of immature seed. On the occasion when the value for shed seed was relatively low, so also was the equivalent figure for standing seed. Obviously some seed undergoes abscission before it has completed its maturation, and the proportion of seed doing so is variable.

DISCUSSION

Immature seed is almost worthless, yet constitutes on average more than 40% of the pure seed present in green and Gatton panic seed samples. If standards of quality are based on the expectation that high quality seed should all be potentially useful, then immaturity is certainly an important cause of low quality in these grasses.

Variation in mature seed content is clearly a major cause of variation in quality. This was readily discernible over a range of maturities between 54 and 88% (Table 2). Over the recorded range of 30 to 90%, the differences in potential quality must be assumed to be massive.

The investigation was not designed to find out **why** mature seed content varies, but the question inevitably arises, and the records allow some reasons to be rejected while raising the possibility of others. Choice of harvest time, for example, which might seem to be an obvious reason for variation in maturity, has proved to be unimportant. Seasonal differences in weather, on the other hand, appear to be a major cause of variation. The association of high immature seed content with stress and the variable immature seed content of fallen seed suggest that a variable degree of premature shedding might be the cause of variation.

Table 3. Records of mature seed contents of standing and shed seed of Gatton panic. Values quoted are averages of successive samplings over the ripening period except for 1976-2 when only a single sample was taken at harvest ripeness.

Year and crop	Standing seed	Shed seed
	(%)	
1973	66.9	82.2
1974	55.6	65.6
1975-1	63.0	90.6
1975-2	75.7	92.3
1976-1	62.5	85.8
1976-2	70.5	87.0

If a high proportion of seed falls prematurely, the immature seed content of the standing crop must be high (e.g. 1974 crop, Table 3). Variation in the time taken for caryopsis to develop relative to the time taken for the abscission layer to form would affect the extent of premature shedding. Stressful conditions are likely to slow down caryopsis development, and if they did so without equally delaying abscission, premature shedding would occur, and lead to high proportions of immature seed in the standing crop.

Similarly, it is likely that conditions that favor retention will lead to high mature seed contents. It is often observed that in calm conditions seed remains loosely attached to the culm despite having a well-developed abscission layer. Such conditions have a reputation for producing good seed and prolonged retention probably raises the proportion of mature seed present. Both possibilities warrant experimental attention.

Although this account has been restricted to two cultivars of *Panicum maximum,* we have observed similar degrees of immaturity in other tropical pasture grass seeds, and believe that our conclusions apply in a general sense to any species that share similar habits of spikelet turn-over. We find the measurement of mature seed content widely useful, particularly where explanations of variation in quality or early warnings of low quality are needed.

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