Interactions Between Seed Moisture and Sheller Speed During Small-Scale Processing on the Subsequent Seed Quality of Maize (*Zea mays* L.)

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ABSTRACT

An evaluation of processing damage caused by a portable Burrows Amalco Cylinder sheller on F_2 seeds of a yellow dent maize hybrid, showed that seed moisture contents (SMC's) of just below 25% seem the most appropriate for this system which operates at relatively high cylinder speeds. This moisture content is sufficiently high to cushion the seed from major breakage and cracking damage but appears to avoid the type of bruising associated with severe internal disruption. This result contrasts with most large scale commercial practice where shelling SMC's are usually between 12 and 18%. Evidence is also presented of interactions between mechanical damage and both seed deterioration during storage and microfloral associations with the seed. These considerations should also be taken into account when establishing an appropriate processing protocol.

Additional index words: **processing damage, seed deterioration, seed microflora**

INTRODUCTION

Although it is standard commercial practice in the United States to shell maize for planting at seed moisture contents (SMC's) of between 12 and 14% (Jugenheimer, 1976; Thomson, 1979), commercial firms in New Zealand have been shelling at SMC's as high as 18% (Escasinas, 1986). In the literature there is considerable disagreement on the safe moisture contents for shelling maize. For example, Hall and Johnson (1970) suggest seed moisture contents should be in the range 17 - 24% while Jindal, Herum and Handy (1979) observed the lowest damage at about 25%. However, Waelti and Buchele (1969) and Pierce and Hanna (1985) found a rapid increase in kernel damage as moisture contents rose above 20%. These differences may be due to the exact mechanical configuration of the sheller used, genotypic variation in endosperm hardness or the strength of the seed coat, or, most importantly, on the way kernel damage was subsequently evaluated. The aim of this study was to undertake a detailed characterisation of the interactions between seed moisture and cylinder sheller speed for one cultivar of maize, with special reference to the nature of the damage incurred and the effect of those injuries on subsequent seed quality, particularly after storage.

MATERIALS AND METHODS

Cobs were hand-harvested from a stand of the late maturing yellow dent maize hybrid, cv. 3184 (from Pioneer Hi-Bred International Inc.) which had been left in the field until mid-August.

The crop had been sown on 15 November 1989 and kernels reached maximum dry weight around 24 April 1990 (Mashauri, unpublished results). Dehusked cobs were spread out in a glasshouse and allowed to air dry at a daily mean ambient temperature of 7 - 17°C and samples were shelled at intervals as kernel moisture contents decreased from an initial 29.4% down to 13%.

A portable Burrows Amalco STP cylinder sheller was used in this study. It is powered by a 1 H.P. electric motor driving an 0.075m radius peg drum cylinder. There is no protective rubber sheathing on the pegs. Cylinder speed is varied by changing the position of the drive belt on a pair of concentric pulleys. At its lowest speed, the sheller operates at 570 r.p.m. (determined directly using a digital tachometer coupled to the sheller drum shaft). For comparison, the sheller was also operated at 940 r.p.m. and 1524 r.p.m., while a fourth set of cobs were hand-shelled as controls. All shelled samples were subsequently dried down to 13% SMC. Seed moisture contents were evaluated by drawing sub-samples from the four replicates of each shelling run and drying two 10g replicates of the ground composite sample at 130°C for four hours (International Seed Testing Association, 1985).

Seed losses were estimated by determining the weight of the pure fraction of seed remaining after each shelling treatment and comparing this to the corresponding hand-shelled sample weight. Samples of fifty kernels were evaluated for mechanical damage by soaking the seed for 15 minutes in a 20% ferric chloride solution (S.Lankford, pers.comm.). Seeds were categorised into bruised (showing staining but without major cracking), cracked seed and broken kernels. X-ray analysis of samples was carried out as described by Escasinas (1986).

Seed germinability was assessed as per ISTA (1985) recommendations after seven days at 25°C. Mean root and shoot dry weights of normal seedlings were determined at the end of the germination test. For the storage studies seeds were placed in heat sealed moisture-proof aluminium foil laminate packages and held at either 5°C or 30°C for 51 and 90d respectively. Levels of fungal contamination were

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assessed on a percentage seeds infected basis by plating surface sterilised seeds on either malt agar (for field fungi) or malt salt agar (for storage fungi) and incubated at 25°C for five days.

Details of replication for each evaluation are explained in the figures and tables. Apart from the seed health tests shown in Table 2, all replicates were derived from separately shelled sub-samples.

RESULTS AND DISCUSSION

The effects of seed moisture content and increased cylinder speed in relation to seed losses due to breakage are quite clear (Figure 1). Losses at the highest cylinder speed were excessive and are not considered further. Many authors (*e.g.* Byg and Hall, 1968; Jugenheimer, 1976) have pointed out the importance of keeping cylinder speeds low during shelling for the seed, and even allowing for the small size of the cylinder, 1524 r.p.m. would be extreme compared to large scale commercial shellers. Nevertheless, at the two lower speeds, losses are high at low moisture contents as kernel brittleness is increased by drying, making them more prone to impact injury. The sheller used in this study is not the gentlest option for processing kernels for planting, the impacting force of the pegs on this cylinder being quite considerable, calculated at 64 Newtons at 570 r.p.m. and 82 Newtons at 954 r.p.m.

Seed losses must be balanced against damage incurred by the pure seed fraction. Figure 2 shows the different types of damage found after shelling at 570 and 954 r.p.m. Although levels of total damage to pure seed threshed at 570 r.p.m. were much lower in dry seeds (16% at 13.0% SMC, 32% at 29.4% SMC), this does not compensate for initial shelling losses. At kernel moisture contents of less than 17%, cracking damage predominates, but bruising damage is a much greater problem at SMC's of 21% and higher.

Table 1 : Percentage normal germination of samples of maize kernels after shelling at different seed moisture levels and cylinder speeds. Data are means of four replications.

SMC (% fresh weight)	Sheller Cylinder Speed (r.p.m.) 0	570	954
13.0	85[a]	74[b]	70[a]
16.8	85[a]	73[b]	70[a]
21.0	89[a]	77[a]	68[b]
24.8	81[a]	79[a]	66[b]
29.4	87[a]	79[a]	55[c]

Mean values within the same column followed by the same superscript are not significantly different at the $P<0.05$ level.

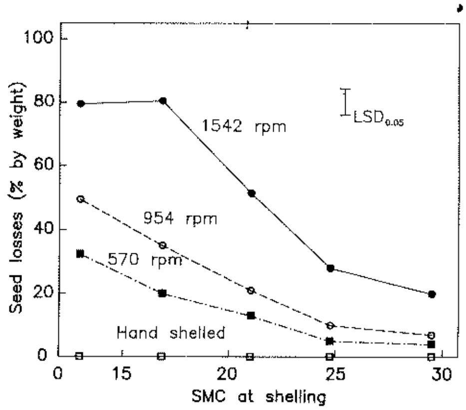

Figure 1.
Losses of broken seed after shelling maize at different seed moisture levels and cylinder speeds. Data are means of four replications.

Table 1 shows the immediate germinability of kernels after shelling under the different conditions used. Mechanical shelling causes some decrease in germination at all SMC's, but losses of germination in the remaining pure seed fraction at low moisture contents were less than might have been expected from the total damage incurred. This observation is in agreement with Escasinas (1986) who demonstrated that the extent of cracking damage *per se* bears little relation to loss of germinability. Rather, it is the position of the damage in relation to the embryo which is more important. Seeds shelled at 29.4% moisture and 954 r.p.m. had 44% bruising. This sub-lot showed a severe reduction in normal germination with a high level of dead seeds. Bruising causes collapse of tissues and release of hydrolytic enzymes which may subsequently do extensive damage (O'Brien, Singh and Garrett, 1984). X-ray analysis revealed that more than 30% of the seeds of this sub-lot had detectable internal injuries, although reducing the seed moisture to 24.8% before shelling reduced this type of damage by more than half.

After 51d storage at 5°C, 13% SMC, all samples threshed at 954 r.p.m. had similar low germination levels (43 - 50%). All except the samples shelled at 29.4% SMC showed considerably more deterioration than less damaged seeds. These results were generally expected, in that while damaged seed may show acceptable germination immediately after processing, they often store very poorly (*e.g.* Moore, 1972). Surprisingly, storage for longer periods (up to 90d) at the higher temperature of 30°C generally resulted in smaller losses of germinability (data not shown), although considerable losses of vigour (measured as seedling dry weights) were evident in seeds shelled at high SMC's prior to storage at this temperature (Figure 3). The reason for this discrepancy in storage behaviour at the two temperatures became clear when the fungal loading of each sample was investigated after storage. Due to late harvesting, the crop was severely contaminated with field fungi, especially *Fusarium* spp., which persisted during storage at 5°C (Table 2) and were responsible for reduced germinability once seeds were brought out of store. At 30°C, levels of field fungi decreased dramatically while only a few seeds were infected with storage fungi. This effect of high storage temperature in reducing the level of *Fusarium* spp. in maize has also been noted previously (Kabeere, pers.comm.)

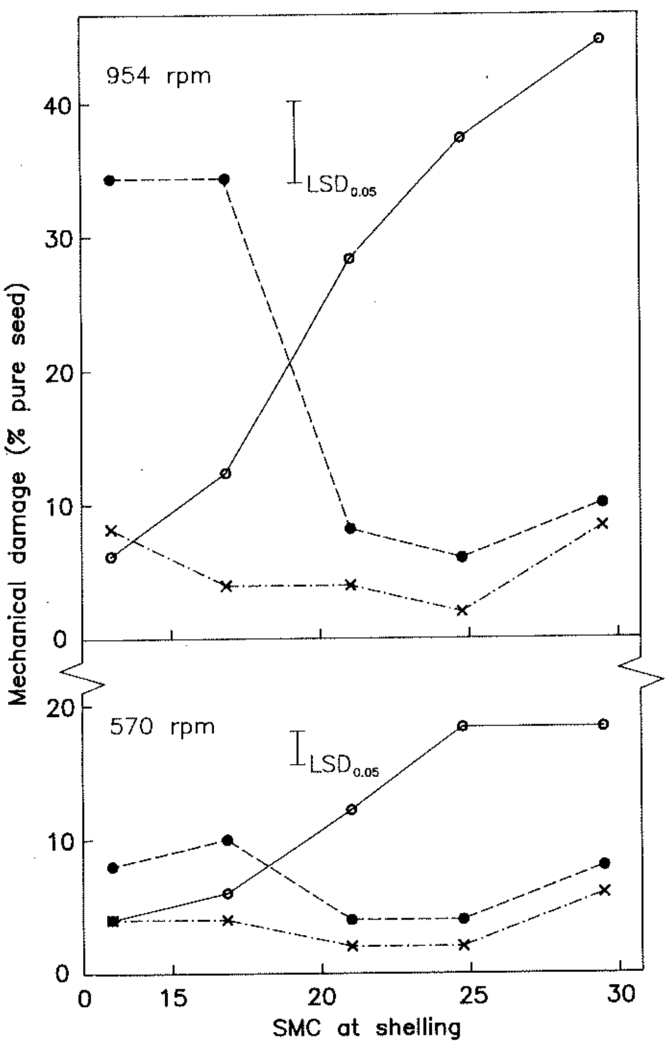

Figure 2.
Types of damage found in the pure seed fraction of maize kernels shelled mechanically at 570 or 954 r.p.m. at different seed moisture levels. Data are means of three replications. ●---- ●: cracking damage, O—O: bruising damage and X----X: broken seed. Hand shelled material showed just 2% damage.

Table 2: Percentage of seeds infected with field or storage fungi after storage at either 5°C for 51d or 30°C for 90d (SMC 13%). Data are means of five replications of 10 seeds, averaged over samples threshed at 29.4, 21.0 and 13.0% SMC and all shelling speeds.

	Percentage of seeds infected after storage	
	5°C, 51d	30°C, 90d
Field Fungi		
Fusarium spp.	80	12
Nigrospora spp.	10	2
Alternaria spp.	4	0
Storage fungi		
Aspergillus spp.	0	4
Penicillium spp.	0	2

CONCLUSIONS

This short, preliminary study demonstrates the complexities of determining the optimum processing conditions to preserve planting value in maize. From these results, SMC's just below 25% seem the most appropriate for mechanical shelling of seed for planting using the small scale Burrows machine. Although this moisture content is relatively high, it is necessary to cushion the seed from major breakage and cracking damage, but possibly because of the naturally soft endosperm of this cultivar, it appears to avoid the type of bruising associated with severe internal disruption found at still higher moisture contents. The speed of the cylinder should be as low as possible.

These results obviously need verification with a wider range of seed material of different endosperm types and preferably of higher quality. Tempering of the seed (*e.g.* Escasinas, 1986) may alleviate some of the damage observed here. Nevertheless, it is at least clear that standard practice for cob drying prior to large scale shelling cannot simply be extrapolated to smaller systems without prior investigation. Both genotype and pre-harvest history of the crop should be taken into consideration. This line of maize used in this study has a soft, starchy kernel and this softness is likely to be exacerbated by the prolonged period in the field after mass maturity. Equally important are the ways seed performance is subsequently evaluated since deleterious effects on seed quality may not be apparent from an initial germination test.

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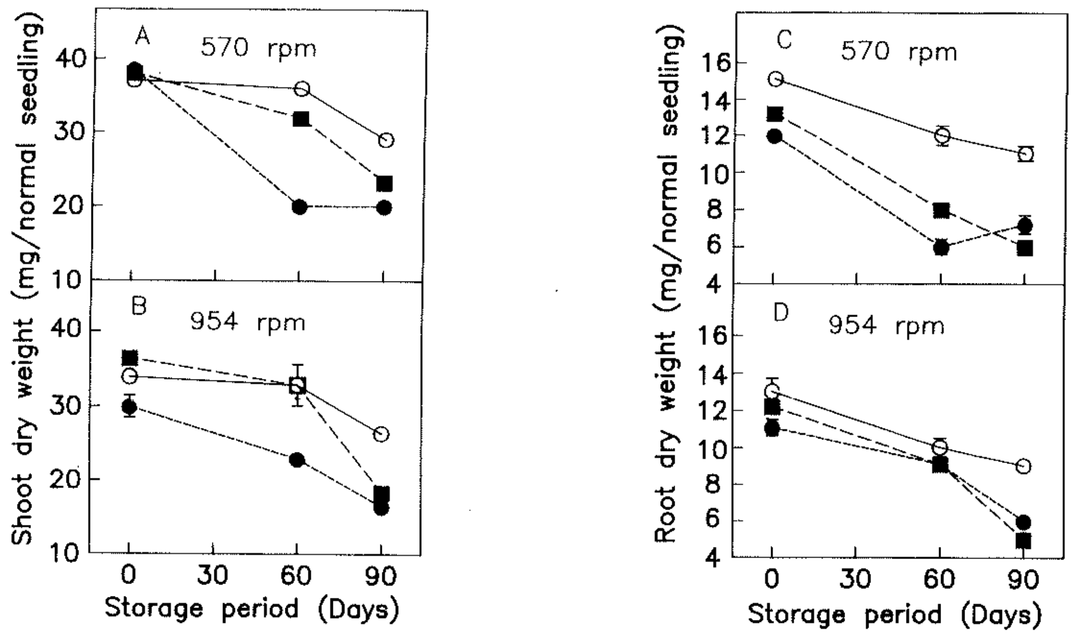

Figure 3.
Changes in shoot (A,B) and root (C,D) dry weight of normal seedlings of seeds shelled at different moisture contents at either 570 r.p.m. (A,C) or 954 r.p.m. (B,D) and subsequent storage at 30° C, 13% SMC. Seeds were shelled at 16.8% (O — O), 21.0% (■---■) or 29.4% (●-●) SMC, respectively. Individual standard errors are shown where larger than all symbols used. Data are means of four replications.

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