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Cone threshing of chaffy grass seeds to improve handling characteristics

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Abstract

Cone threshing was used to remove awns, sterile florets, and some surface hairs from the normal chaffy dispersal units of *Andropogon gayanus*, *Bothriochloa insculpta*, and *Bothriochloa pertusa*. This facilitated subsequent cleaning to increase analytical purity with little or no reduction in germination, even after storage for up to 20 months. Small scale commercial use of cone threshing to process 450 kg of *B. insculpta* seed was also monitored with similar results, although germination tests showed some evidence of more rapid deterioration in processed samples after storage for 25 months. About 50 to 60% of caryopses were removed from *Chloris gayana* seed by the same method, with little or no apparent reduction in germination when stored for up to 18 months.

Provided a seed lot does not contain an excessive amount of other seeds and is pre-cleaned to remove straw before cone threshing, subsequent cleaning can be largely restricted to aspiration. This sequence produces less bulky, higher quality seed that flows more readily. As a result, purity testing is faster and easier, storage and transport costs are reduced, and seed can be distributed more uniformly during sowing.

INTRODUCTION

A number of useful pasture grasses have chaffy seeds. The dispersal units are characterised in varying degrees by sterile florets, long awns, and short surface hairs. Collectively, these appendages result in handling problems which detract from the commercial usefulness of such grasses. Chaffy seeds *en masse* are relatively light and bulky and do not flow as freely as denser, smoother seeds because the individual units tend to become entangled. Seed cleaning and testing are slow and difficult; storage and transport are expensive; and a uniform distribution of individual dispersal units with conventional sowing equipment may prove impossible.

Over the past 40 to 50 years, attempts to improve the handling of chaffy grass seeds by physical modification have centred mainly on the use of conventional hammermills operated at reduced speeds (for example, Weber 1939; Hoover *et al.* 1947; Schwim 1952; Cooper *et al.* 1957; Grof 1957; Atkins and Smith 1967). Processing, however, is slow and reported effects on seed germination have varied. The degree of tolerance between the desired result and excessively damaged seed seems relatively small, while success depends largely on operator skill in regulating the rate of feed and in choosing an appropriate screen size and a suitable operating speed.

Dropping chaffy seeds through flames has also given variable results. In *Bothriochloa insculpta*, this reduced germination because of severe damage to caryopses (D. S. Loch, unpub. data), but had no such detrimental effect on *Cenchrus ciliaris* (Pogue 1983; R. J. Bateman, pers. comm.) where the chaffy seed units offer greater protection for the enclosed caryopses. Other promising techniques have included the use of debearders (Atkins and Smith 1967; Brown *et al.* 1983) and the so-called high air velocity impact method of Dewald *et al.* (1983).

Although not previously used for this purpose, a cone thresher offers a further possibility for processing chaffy grass seeds. Essentially, this technique involves the use of a resilient rotor surface to rub seed passing through the machine against the resilient surface of the surrounding stator (Figure 1). This paper reports on the effects of cone threshing on chaffy seeds of eight warm climate pasture grasses.

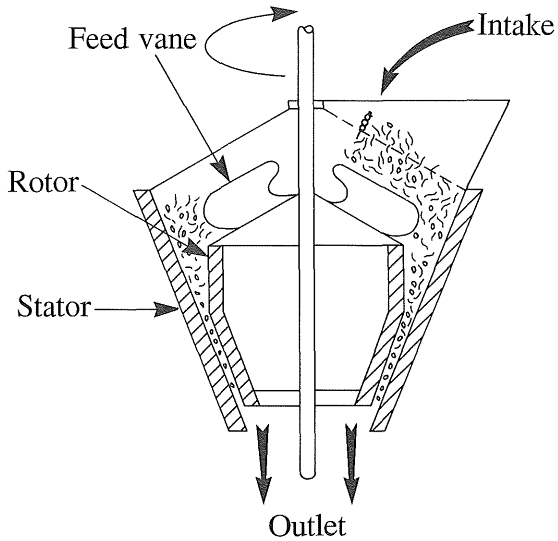

Figure 1. Cone thresher in section.

EXPERIMENTAL

Methods

Between November 1980 and June 1982, the cone threshing components on commercially available machines (Mark I and Mark II models of the Hannaford Seedmaster Resilient Tapered Thresher — about 300 mm maximum cone diameter) were used to process the following seed lots:

Andropogon gayanus (gamba grass) cv. Kent — 8 seed lots;

Bothriochloa insculpta (creeping bluegrass) cv. Hatch — 14 seed lots;

Bothriochloa pertusa (Indian bluegrass), naturalised strains from Bowen, Biloela, and Emerald Downs — 14 seed lots;

Chloris gayana (Rhodes grass) cvv. Callide, Samford, Pioneer — 14 seed lots;

Cenchrus ciliaris (buffel grass) cvv. American, Biloela, Gayndah — 3 seed lots;

Hyparrhenia hirta — 1 seed lot;

Hyparrhenia rufa — 2 seed lots; and

Pennisetum polystachion — 1 seed lot.

On these machines, the gap between rotor and stator was varied by trial and error. A soft rotor lining (40 Shore 'A' compared with 60 Shore 'A' for the standard lining) was tested with some seed lots. Processed seed was cleaned on separate equipment by conventional screening and winnowing. Except for a few small seed lots, samples were taken before processing (control) and after final cleaning. Measurements were made of caryopsis content, purity, and germination using standard laboratory procedures; percentages of naked caryopses showing macroscopic damage were also determined. For all data presented, each pure seed unit is defined as containing a caryopsis.

Results

Chloris gayana

At near optimal settings and processing rates of around 15 to 25 kg/h, cone threshing of six *C. gayana* seed lots extracted 53% of caryopses by weight (range: 35 to 75%), but only 37% by number (range: 26 to 51%). Larger, heavier caryopses were preferentially removed, increasing the mean individual weight by an average of 44% (range: 29 to 69%) from 0.17 mg for caryopses within spikelets in the control samples to 0.24 mg for processed naked caryopses. This was accompanied by a smaller 25% relative increase in germination to an average of 61% in naked caryopses after processing. Physical damage during processing was minimal, with only 3% of these naked caryopses showing macroscopic damage. The different forms of *C. gayana* seed before and after cone threshing and cleaning are shown in Plate 1.

Extraction of caryopses and the degree of damage were increased by use of the softer rotor lining and/or a reduced gap between stator and rotor (Figure 2). This was accompanied by reduced germination and slower processing rates (data not presented).

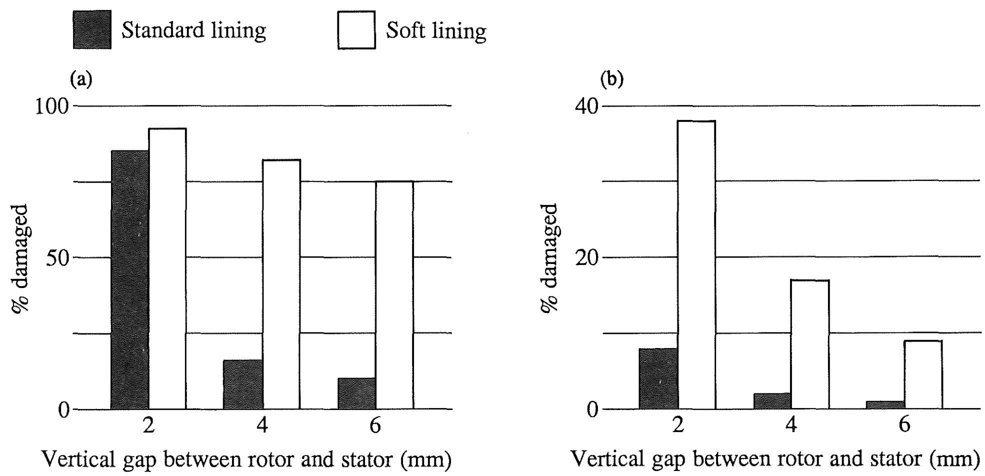

Figure 2. Effects of different rotor-stator openings and different linings on the removal of caryopses from seed of *Chloris gayana* cv. Callide, a) extraction of caryopses by weight; b) Caryopsis damage.

Andropogon gayanus, Bothriochloa spp.

By comparison with *C. gayana*, caryopses in *A. gayanus* and the *Bothriochloa* species are held more tightly within the chaffy seed units. The main effect of cone threshing was to trim these chaffy seed units. Few caryopses were completely removed (4% by weight in *A. gayanus*; insufficient quantities to treat as a separate fraction in *Bothriochloa* spp.), though more were extracted by the soft rotor and by increased abrasion from excessive straw. Damage to naked caryopses was greater than in *C. gayana* (means of 23% and 32% macroscopic damage in *B. insculpta* and *A. gayanus* respectively with the standard rotor lining) and germination of these fractions was considerably reduced (by 79% and 52% of control values in *B. insculpta* and *A. gayanus* respectively). Observations on these species and on other grasses (see next sub-section) suggested that longer, narrower caryopses are more prone to such damage than shorter caryopses with less exposed embryos.

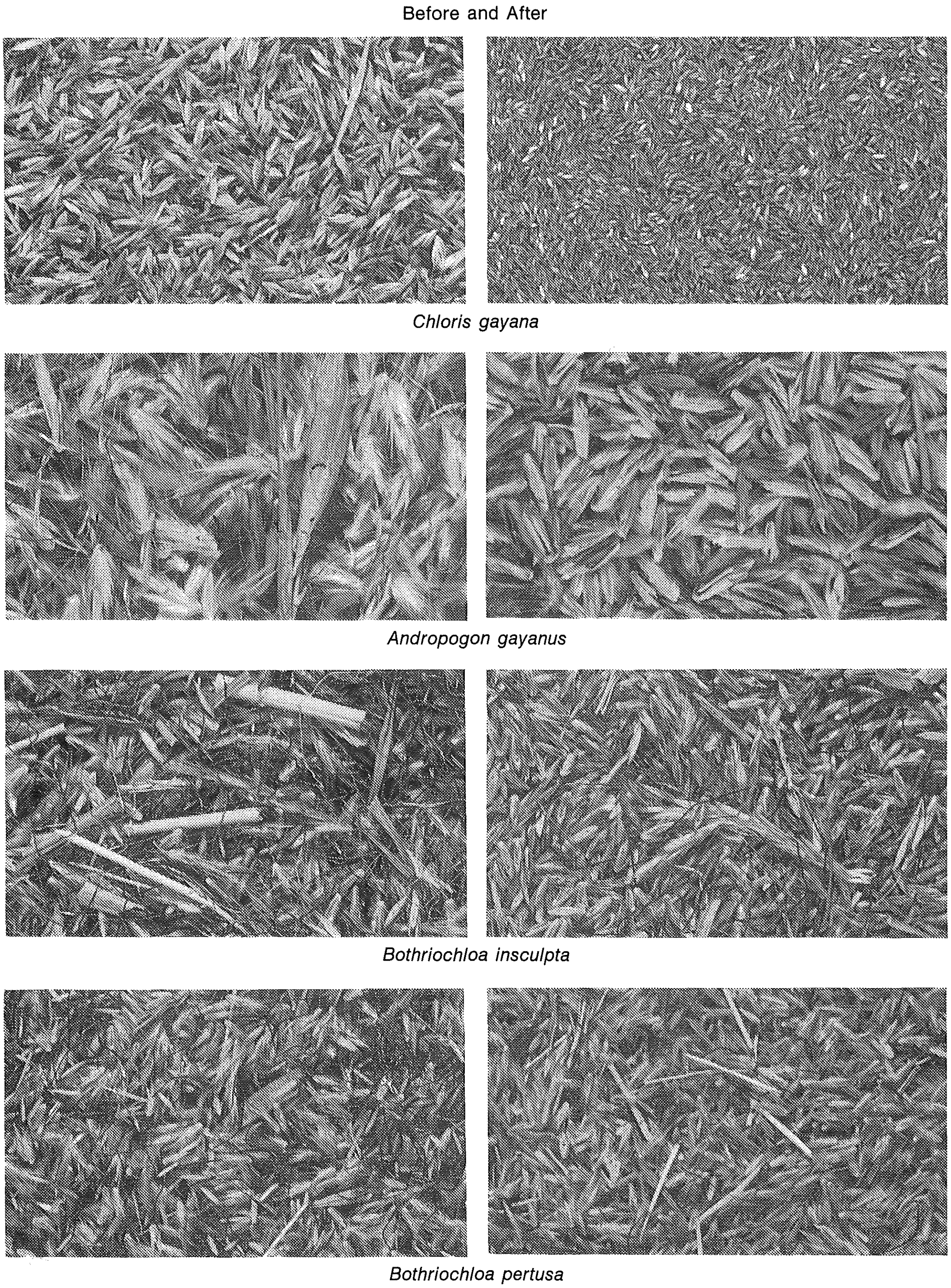

Plate 1. Chaffy grass seeds before and after cone threshing and cleaning.

The rubbing action of cone threshing removed awns and sterile florets from the original dispersal units, leaving fertile florets with fewer surface hairs as 'modified' seed units (Plate 1). Processed seed flowed more freely, especially that of *A. gayanus* and *B. insculpta* where the original seeds had fewer surface hairs than *B. pertusa* though there were minor differences between naturalised ecotypes of the last-mentioned species. After processing, about 40 to 60% of the original weight was cleaned from the *Bothriochloa* species (Table 1), reducing the original volume by 75% or more. Loss of weight was higher with *A. gayanus* (usually more than 80%) because of short-chopped straws in most seed lots. This was much lower (36%) in hand-harvested *A. gayanus* without straw, and was less than 50% in the cleanest seed lots of *B. insculpta.*

Table 1. Effects of cone threshing on seed characteristics expressed as percentages of comparable values for unprocessed seed (control = 100%), together with standard errors of the mean. All data refer to seed lots processed with rotor lining of 60 Shore 'A' hardness

Grass	Relative values for processed seed (%)				
	Seed lot weight	Purity	Unit pure seed weight	Germination*	Caryopsis content
Andropogon gayanus	23±10	306±50	96±2	100±6	128±11
Bothriochloa insculpta	39±2	202±13	93±1	111±9	136±5
Bothriochloa pertusa	56±2	142±5	87±2	97±4	116±3

* Excluding naked caryopses.

With unprocessed seed of *A. gayanus* and the *Bothriochloa* spp., cleaning is difficult and restricted mainly to the removal of long straws. Cleaning was easier after cone threshing and increased analytical purity considerably, largely through removal of inert material including chaffy seed appendages (Table 1). After processing and cleaning, this gave average purities of 40, 71, and 75% in *A. gayanus, B. insculpta*, and *B. pertusa* respectively. There were also smaller increases in caryopsis content. These changes were offset by minor reductions in the mean weight of pure seed units. There was little or no apparent effect on germination (Table 1), even after storage for up to 20 months after processing (data not presented). Increases in pure live seed content of processed seed therefore reflected higher purity levels.

Processing rates of 10 to 25 kg/h were achieved with the standard rotor lining provided the rotor-stator gap was increased periodically for a second or two to avoid excessive build-up of light threshed material (mainly awns) which restricted flow through the threshing cone. Higher rates (25 to 40 kg/h) were recorded for some seed lots with high proportions of free-flowing weed seeds (*B. insculpta*) or straw (*A. gayanus*). By comparison, processing rates achieved with the softer lining were generally less than 10 kg/h.

Other grasses

Results with the *Hyparrhenia* species were similar to those with *A. gayanus* and the *Bothriochloa* species. There appeared to be some scope for shortening or removing the stiff bristles on involucres (= dispersal units) of *C. ciliaris* with cone threshing, though seed units were modified less than in *A. gayanus*, the *Bothriochloa* species, and the *Hyparrhenia* species. In contrast, caryopses together with their surrounding lemma and palea were easily and almost completely removed from the original involucres of *Pennisetum polystachion*, giving a dense, free-flowing sample of processed seed.

SMALL SCALE COMMERCIAL USE—A CASE HISTORY

In July 1982, 450 kg of *B. insculpta* cv. Hatch seed was processed by a commercial seed grower at about 15 to 20 kg/h using a Hannaford Seedmaster Resilient Tapered Thresher Mark II. Seed was harvested by direct-heading, and had been dried but not pre-cleaned before processing. Processed seed was subsequently cleaned through a large screen–air cleaner followed by two different indent cylinders in series on a length separator. The cleaning action was achieved largely through aspiration, with screens and indent cylinders mainly removing short straws broken during processing. Screening capacity was 35 to 40 kg/h with a slightly lower maximum for efficient cylinder operation. Some difficulties were also experienced from blockages in connecting ducts.

A total of 260 kg of cleaned seed was produced, giving a recovery rate of 46% of the original weight. Samples from each of the nine bags in the lot showed this to be of high quality with only a 17% decline in germination (cf. an 8% decline in control samples) after 25 months storage at an average of about 22°C (Table 2). Comparable control and processed samples again showed that improvement in seed quality was mainly in terms of analytical purity (60% relative increase) through removal of inert matter (45% increase) and increased caryopsis content (10% by weight). By comparison, processed samples showed only a 7% reduction in germination compared with the controls, indicating little or no effect on this attribute.

Table 2. Quality measurements (± standard errors of the mean) on cleaned commercial *Bothriochloa insculpta* cv. Hatch seed after processing in July 1982

% purity	% other seeds	% caryopses	% tetrazolium viability	% germination	
				Sept. 1982 (+0.2% KNO_3)	Aug. 1984
78.4 ±1.4	0.4 ±0.1	79 ±1	52 ±1	53 ±2	44 ±2

DISCUSSION

As observed with hammermilling (Hoover *et al.* 1947; Cooper *et al.* 1957), varying degrees of processing are possible by cone threshing chaffy grass seeds. These range from trimming the original dispersal units in *A. gayanus* and the *Bothriochloa* species to extraction of naked caryopses which was partially achieved with *C. gayana* (see Plate 1).

In principle, cone threshing was an effective means of processing chaffy grass seeds and, due to the cushioning effect of resilient linings, there was a reasonable degree of tolerance between the desired result and excessive seed damage. At optimum settings, there was little or no immediate reduction in viability after cone threshing, though there was evidence of slightly more rapid deterioration after storage of processed *B. insculpta* seed for about two years. In earlier work with *C. ciliaris*, Grof (1957) also noted a more rapid decline in germination of hammermilled seed in storage, probably from physical damage during processing.

In practice, processing rates possible with existing cone threshing machinery need to be increased at least 3 to 4 times before this technique could be used on a large commercial scale. The main problems revolve around size of existing cones and length of time spent in these by material being processed. Larger cones and/or a number in parallel are obvious solutions to cone size. Time spent in the cone, however, is a more complex problem which depends to some extent on the condition of unprocessed material and on operator skill. For example, processing rate can be increased by a slight widening of the gap between stator and rotor without obvious reduction in effectiveness provided rate of feed is regulated to keep the threshing cone well packed with unprocessed seed; the regular release of processed material caught within the cone also helps. A further possibility, particularly with *A. gayanus* and the *Bothriochloa* species, is to design a shorter rotor to reduce time spent in the threshing cone since this currently appears to be longer than necessary.

Cone threshing should follow pre-cleaning to remove large straws. Aspiration (for example, through part of a standard combine harvester to avoid additional on-farm investment) could then be used for the rapid removal of light trash from processed seed. Screens and indent cylinders are largely unnecessary during cleaning provided the amount of other seeds is not excessive and straw is removed before being broken into fine fragments by cone threshing.

As with hammermilling (Atkins and Smith 1967), the benefits of cone threshing stem from the production of less bulky, higher quality seed that flows more readily. Cone threshing of chaffy grass seeds could be used to increase quality and to reduce overall variation in quality on seed markets by facilitating the removal of empty seed units. However, price per kilogram would be increased by the accompanying reduction in weight (about 40 to 60% in pre-cleaned seed lots without excessive straw or weed seeds), necessitating market development to ensure that consumers recognise the compensating effect of lower seeding rates and the added advantage of more uniform sowing. Because of the removal of sterile florets and other inert material during processing and cleaning, purity testing is both faster and easier, although the improvement is not sufficient for processed seed of *A. gayanus* and the *Bothriochloa* species to be blown satisfactorily in a standard laboratory blower. The reduced weight and volume of processed seed have obvious benefits for storage and transport, especially in international trade. This is particularly so for *C. gayana* caryopses which constitute a very concentrated product with very little bulk, and could be transported cheaply by air or in refrigerated sealed containers.

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