An evaluation of harvesting losses and low cost storage systems for high moisture barley

E.Z. JAN1, D. McCARTNEY2, Z. MIR3, L. HILL4, B. BERKENKAMP2 and T. WRIGHT2

Agriculture and Agri-food Canada Research Centres, 1P.O. Box 1030, Swift Current, SK, Canada S9H 3X2; 2P.O. Box 1240, Melfort, SK, Canada S0E 1A0; 3P.O. Box 3000 Main, Lethbridge, AB, Canada T1J 4B1; and 4 Prairie Agricultural Machinery Institute, Humboldt, SK, Canada S0K 2A0. Received 31 March 1992; accepted 24 October 1994.
window fell through the stubble, than in good growing conditions (Dodds 1974). Direct combining is an effective means of eliminating pick-up loss. Pratt et al. (1961) reported an increase in harvested grain at KMC ranging from 20 to 48%.

The main disadvantage of harvesting HMB is the storage problem. Spoilage will occur in the presence of oxygen (Rode et al. 1986). Ensiling of HMB has been shown to be a satisfactory method of storage; however, the cost will vary depending on whether a pit, bunker, concrete stave, or oxygen limiting silo is used (Kennelly et al. 1988). Alternatively, anhydrous ammonia and urea may be used to successfully preserve high moisture grain (Robinson et al. 1988; Rode et al. 1986; Mowat et al. 1981).

The objectives of this study were to determine if there is a difference in losses between HMB and DB in the harvesting system and to evaluate various temporary low cost storage systems that could be used for tough grain or high moisture grain.

MATERIALS AND METHODS

A field was swathed alternatively with a 3.66 m (Versatile 400) and a 6.4 m (New Holland 1090) swather to make windrows with two densities. Harvesting losses were determined by measuring cutter bar loss and pick-up and combining loss when harvested at various KMC stages in 1989 and 1990. Cutter bar loss was measured by taking square meter samples immediately after swathing and pick-up loss after combining at various KMC. The combined pick-up and cutter head loss samples were taken from where the windrows were laid and an effort was made to collect only the missed heads and exclude the threshed grain kernels from the combine discharge. Loss percentages were then calculated from data from square metre samples and overall yield. The pick-up loss was derived from subtracting average cutter bar loss from the combined loss calculated.

The combine loss study to determine the losses at high and low moisture contents was conducted in 1989. A JD 7720 Titan II Combine equipped with grain loss monitors and catching apparatus in accordance with ASAE standard S396.1 (ASAE 1988) and Prairie Agricultural Machinery Institute's test procedure for self-propelled combines was used (PAMI 1987). The barley field was swathed at 30% grain moisture. High moisture barley was combined immediately after swathing and dry grain was combined when the moisture of grain in the windrow reached 15% moisture.

Hartland, a two row barley, was windrowed on August 29, 1988. Two of the 6 ha plots were harvested directly behind the swather as HMB at a targeted 25% moisture. The remaining two plots were harvested as field dried barley. The HMB barley was stored using four different storage treatments and compared to field-dried grain stored in a commercial metal grain bin. The HMB storage treatments were:

- Ammoniation: Approximately 13 t of HMB were piled on a sheet of 0.15 mm black polyethylene. The grain was covered with polyethylene and the edges of the sheets were rolled together, top over bottom, and covered with sand so that the rain would not penetrate the fold. A 50.8 mm diameter perforated metal pipe with 3.2 mm holes drilled at 406 mm centres was used to apply the anhydrous ammonia. The pipe had a sharpened tip at one end and a valve and anhydrous hose coupling at the other. The pipe was pushed into the centre of the grain pile approximately 460 mm from the bottom. Anhydrous ammonia was then added at a rate of 1.5% on a dry matter basis (Kernan and Knipfel 1981).

- Urea addition: Approximately 13 t of HMB was piled on the polyethylene sheet and covered similar to the ammoniation treatment. Feed grade urea was added at a rate of 3% on a dry matter basis as the grain was augered into the pile.

- Vacuum storage: Approximately 13 t of HMB was piled on 0.15 mm black polyethylene sheet and covered similar to the ammoniation treatment. A 25.4 mm semi-flexible PVC pipe with 3.2 mm holes drilled every 150 mm was placed around the circumference approximately 300 mm from the bottom and 300 mm into the grain pile. One end of the hose was brought through the polyethylene cover and attached to a portable shop vacuum cleaner. The air was removed from the grain pile until the polyethylene sheeting compressed against the pile (11.5 kPa pressure differential). The plastic pipe was then sealed with a rubber plug.

- Silo bag: Approximately 22 t of HMB was stored with a silage bagger in a test section of a 2.7 m diameter x 60 m long white polyethylene silage bag of 0.22 mm thickness (Alberta Ag Industries, Westlock, AB). An approximately 5.5 m test section was stored with non-test HMB in a tube and clearly marked on the plastic for identification.

Three thermocouple temperature probes were inserted into each grain pile. For conical grain piles, the probes were placed at levels of 300, 600, and 900 mm from the bottom at the circular centres. For the cylindrical silo bag, the probes were inserted at the centre and 450 and 900 mm from it (Fig. 1). The temperatures were automatically recorded during the storage phase of the study. Detailed nutritional analyses were done and are described in McCartney et al. (1990).

RESULTS AND DISCUSSION

The cutter bar loss was found to be 0.5% of the yield potential (2.67 t/ha) when swathed at 30% KMC. This included the damage by rain, wind, and hail which took place before swathing in 1989. The pick-up loss from the windrows made from 3.66 m swaths was negligible and not affected by the KMC. However, for the windrows made from the 6.4 m swaths, the pick-up loss increased as the KMC decreased. This was probably due to the fact that the longer the windrow is left in the field to dry, the more it settles below the stubble making it more difficult to pick up. For the same width windrow, the swath settlement would have more effect on the

Fig. 1. Location of the temperature probes.
The trend is shown in Fig. 2. Rain on the windrow probably contributed to the settlement of the swath; there were two rain showers before the windrow reached 15% KMC. Two different swather-windrowers were used in this study and the machine factor is assumed negligible.

The combine losses, measured as percent of grain input versus the material other than grain (MOG) feedrate, are shown in Fig. 3. The grain loss for combining dry grain (14% KMC) is about 0.25% higher than HMB at the practical combine loss range of 2-3%.

![Fig. 2. Pick-up loss of 6.4 m swath at various kernel moisture contents.](image)

In Saskatchewan, windrowing at 35% KMC and combining at KMC 15% and under for DB is a common grain harvesting practice. Under this system, there was a trend of lower loss (1%) by harvesting as HMB as compared to dry grain. Large yield differences previously reported in Montana (Kraus 1979), Alberta (Kennelly et al. 1987) and Minnesota (Windels 1972) were probably due to one or more of the following reasons: (1) more natural loss occurred when the crop was left standing to mature before swathing-combining, (2) shorter straw was cut in direct combining HMB which improved combine efficiency, (3) harvesting a considerable amount of wild oats and other weeds and quantity of thin kernels in the HMB. This latter material would have threshed out before combining as dry grain. In today's farming practice, wild oats and other weeds are controlled effectively with herbicide treatment and not expected to be present in the HMB.

Due to dry weather in 1988, the HMB was harvested at 21.6% moisture rather than the desired 25-28% range. There was no grain spoilage from any grain storage treatment during the early fall and winter period. No freezing problems occurred during the trial period. However, after the trial was completed, severe mould damage occurred in the remaining vacuum storage grain during the hot weather of the following summer. The anhydrous and urea treated grain remained satisfactory when exposed to atmosphere during the hot weather period. Grain from the silo bags did not spoil as long as the bags remained closed; however, spoilage did occur in hot weather after being exposed to the atmosphere for several days.

Temperatures in all treatments, except ammoniation, remained under 40°C and gradually cooled through the storage period. In ammoniated grain, the temperature at level 3 (900 mm above the ground) rose to 101°C in 3 h and fell below 40°C after 10 h. At level 2 (600 mm from the ground) the temperature reached 96°C in 3 h and fell gradually to 40°C after 30 h. The heat was due to the exothermic reaction between ammonia and moisture in the grain. Level 3 cooling down faster because it was closer to the surface. The chemical analysis (McCartney et al. 1990) indicated that heat damage did not occur. The temperatures at level 3 in the grain piles and the centre of silo bag are presented in Fig. 4. No major nutritional differences from any of the storage systems were observed (McCartney et al. 1990).

A complete economic study is beyond the scope of this paper. Based on the optimal size of operation in which the polyethylene is fully utilized, the material cost of each system was calculated using 1994 costs at Melfort, Saskatchewan as shown in Table I.

The vacuum storage system appears to be the lowest cost in material and requires only equipment which is normally available on farms. Since the system is only good for short term storage in fall and winter, it is only ideal for an operation which can use up the stored grain in the winter. The silo bag system can provide the ability to maintain the grain quality through the summer but its cost depends on the scale of operation to justify the cost of the bag filler other than the higher cost of silage bags. With an additional cost, ammoniation and urea treatment improve the reliability as compared to the vacuum storage system. Ammoniation is less costly than the urea treatment but more troublesome in applying anhydrous ammonia. Systems which require handling large sheets of polyethylene need a minimum of three persons at the preparation and finishing stages. It can be difficult if the wind is strong. The silo bag system only requires two persons at the time of tying the tubes. During the course of filling, the truck operator usually can handle the work.
Fig. 4. Temperature of high moisture barley stored in four systems.

Table I. Costs and machinery requirements of the high moisture barley systems

<table>
<thead>
<tr>
<th>System</th>
<th>Consumable cost</th>
<th>Equipment required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammoniation</td>
<td>polyethylene sheet $2.48/t DM, anhydrous ammonia $7.10/t DM</td>
<td>front end loader auger ammonia injector</td>
</tr>
<tr>
<td>Urea treatment</td>
<td>polyethylene sheet $2.48/t DM, urea $13.2/t DM</td>
<td>front end loader auger</td>
</tr>
<tr>
<td>Vacuum storage</td>
<td>polyethylene sheet $2.48/t DM</td>
<td>front end loader auger vacuum cleaner</td>
</tr>
<tr>
<td>Silo bag</td>
<td>silage bag $4.21/t DM</td>
<td>tractor 52.5 kW bag filler</td>
</tr>
</tbody>
</table>

CONCLUSIONS

1. Barley harvesting loss including cutting loss, pick-up loss, and combine loss was 1% less for HMB than DB when the barley was windrowed at 30% KMC with a 6.4 m swather.

2. HMB can be preserved for short term over the winter by one of the four treatments: (a) ammoniation, (b) urea addition, (c) vacuum storage, and (d) silo bag. Temperatures of all treatments remained under 40 °C except a short rise of 101 °C was found with ammoniation treatment.

ACKNOWLEDGMENTS

The authors acknowledge the financial assistance of the Saskatchewan Agriculture Development Fund and the cooperation of Gary and Danny Stevenson, Ethelton, SK. Appreciation is extended to Larry Falk, Tom Harrison, Brenda Sorensen, Al Shaner, Daryl Pshyk, Paul Dmytrov, and the livestock crew of Melfort Research Centre.

REFERENCES


Krall, J.L. 1979. High moisture barley. Technical Bulletin No. 625. Montana Agricultural Experimental Station, Montana State University, Bozeman, MT.


