POST-MATURATION

DRY-DOWN

OF

CORN (*ZEA MAYS* L.) HYBRIDS

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ABSTRACT

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POST-MATURATION DRY-DOWN OF CORN (ZEA MAYS L.) HYBRIDS.

Major Professor: Dr. E. N. Larter.

Eleven corn hybrids of Canadian (dents), European (flints), and European/ Canadian (flint/dents) parentage were studied with the following objectives: (1) to determine the differences in rates of dry-down, and (2) to establish which morphological features, if any, account for differences in moisture loss found between hybrids.

European flint hybrids reached physiological maturity at 5.5% higher kernel percent moisture than the Canadian dents, and 4.2% higher moisture than the flint/dents. Rates of moisture loss were significantly different between individual hybrids, but not significantly different between the three hybrid groups.

All groups reached 50% silking simultaneously. However, after this stage of maturity transition between the hybrid groups began to occur. The dent group reached physiological maturity almost seven days earlier than did the flints and four days earlier than the flint/dents.

Grain filling duration was positively associated with the percent kernel moisture at black layer maturity (BLM).

Husk characteristics which most influenced the rate of dry-down after BLM were: number of husks, husk density, and tendency for husks to loosen naturally. Treatments whereby husks were manually opened to reduce the resistance to moisture loss were highly significant in increasing the rate of moisture loss for all groups of hybrids. Conversely, by closing the husks, the rate of moisture loss was effectively reduced.

Pericarp thickness was significantly different between hybrids, but could not be associated with either percent kernel moisture at harvest or rate of moisture loss.

These results suggest that the period of dry matter accumulation between the stages of silking and BLM is crucial in determining the percent kernel moisture at physiological maturity, after which moisture loss is regulated by resistance factors such as husk characteristics and perhaps pericarp thickness.

1. INTRODUCTION

During the past 10 to 15 years there has been a considerable increase in the amount of corn (Zea mays L.) grown in the short-season areas of Europe and North America. In the period from 1974 to 1984, the area of corn production has nearly doubled in Canada, and increased from 2,000 ha to 67,000 ha in Manitoba alone. As earlier maturing hybrids become available it can be expected that corn will be grown in even shorter-season areas than those currently under cultivation.

The growth and development of corn in short-season areas is characterized by a production system that attempts to utilize as much of the growing season as possible. This is accomplished by growing hybrids that utilize a greater proportion of the effective heat available for corn growth and development prior to reaching maturity. The average frost-free season in Manitoba is completely utilized by the currently available corn hybrids, and even with the earliest hybrids there is a danger of encountering a killing frost prior to maturity, especially if planting is delayed past mid-May.

The difference between long and short-season areas is well defined in the province of Ontario. A corn hybrid adapted to the long season is one which, when planted at the beginning of the growing season, will have reached 28% kernel moisture by the average date at which a 10% chance of 0°C temperature occurs (Brown, 1975). A hybrid adapted to the short-season areas of that province will reach 40% moisture by that date. This means that in this same time period, the adapted hybrid in the long season area will generally be ready to harvest, whereas in the short-season areas the grain must still dry down to a low enough moisture level for efficient harvesting. Thus, if corn is to be successfully grown in the shorter-season areas there is a need for hybrids which will field-dry rapidly after they have reached physiological maturity.

Corn breeders in Europe and in North America have a mutual interest in early maturing corn germplasm. Flint endosperm germplasm represents a source of early maturing material that is used extensively in the development of short-season inbreds and hybrids in Europe. Because the early European germplasm has been subjected to different climatic pressures and agronomic preferences, it is phenotypically and genotypically different than the early Canadian material. Corn hybrids which are cold tolerant and disease resistant are required for the cold, wet spring of the northern European climate (Derieux, 1978). The European flints have superior early seedling and vegetative vigour, they silk earlier, and exhibit a greater degree of population tolerance when compared to Canadian hybrids

(Baron, 1982). These are desirable qualities from the Canadian point of view.

On the negative side, however, the European hybrids contained 4% more kernel moisture than Canadian hybrids at the date of final harvest. It has therefore been suggested that European hybrids are agronomically suited for grain production in short-season areas of Canada, except for the problem of slow grain dry-down (Baron, 1982).

Corn breeders today do not yet have the techniques to select genotypes with rapid dry-down capabilities. The main reason for the lack of techniques is that the process of kernel drying is not yet fully understood (Zuber, 1982). Differences in husk and pericarp characteristics among hybrids have been associated with differences in percent kernel moisture after grain maturity (Baron, 1982).

The purpose of this study was to measure the rate of drying of a group of European flint hybrids , Canadian dent hybrids, and European flint X Canadian dent hybrids following physiological maturity; and to determine which morphological traits, if any, account for differences in moisture loss found between hybrids.

2. LITERATURE REVIEW

For most corn breeding programs in short-season areas the primary goals are a combination of high yield and early maturity. There are three measures of maturity in corn that are commonly used. These include the date of silking, physiological maturity (when all or most of the dry matter of the kernels has been deposited), and ear moisture at harvest. In areas where high moisture may cause storage problems or high costs for artificial drying, kernel moisture at harvest is the most important maturity consideration. Reduced moisture content at harvest can be obtained either by breeding for a fast rate of dry-down after maturity or by extending the time available for drying by breeding for earlier maturity. The first approach is more desirable, since breeding for early maturity is likely to result in decreased yields.

2.1 ESTABLISHING DATE OF PHYSIOLOGICAL MATURITY

Physiological maturity is defined as the time of maximum dry weight (Shaw and Loomis, 1950), and the interval between pollination and physiological maturity establishes the length of the grain filling period. Water and dry matter enter grain kernels after anthesis until maximum kernel weight is achieved (Sofield et al.,1977). Because maximum dry weight is difficult to determine, Daynard and Duncan (1969) proposed the use of the black layer formation as an indicator of physiological maturity. The black layer develops in a region of cells several layers thick which are formed between the basal endosperm of the kernel and the vascular area of the pedicel early in seed development. As the time of maximum dry weight approaches, these cells shrink and become compressed into a dense layer which appears black to the naked eye. Almost simultaneously, the basal conducting cells of the endosperm become disorganized and are crushed so that their translocation functions most probably cease. At maturity the black layer connects with the pericarp and the testa to form a suberized layer around the seed (Kiesselbach and Walker, 1952). Rench and Shaw (1971) confirmed the suggestion that the completed black layer development defined physiological maturity better than the previous methods of maximum dry weight (Shaw and Thom, 1951) or kernel moisture (Neal, 1968).

However, there were problems with the use of the black layer formation as an indicator of maturity, including variability in appearance (Carter and Poneleit, 1973) and difficulty in detecting its presence (Afuakwa and Crookston, 1984). In conditions of environmental stress, black layer formation can be induced prematurely (Daynard, 1972; Afuakwa et al., 1984). Afuakwa and Crookston (1984) suggested the use of the kernel milk line as a means of monitoring kernel maturity. The milk line is a transitional boundary between the solid and liquid matrices of the maturing endosperm. The disappearance of the kernel milk is coincident with black layer development and the cessation of kernel dry weight increase. It is easier to determine the day on which milk is no longer present in kernels than to determine when the placental region is black. Afuakwa and Crookston (1984) recommended using both the development of the black layer and milk disappearance as indicators of physiological maturity in maize. In this thesis the occurrence of silking, first glazing, and half-milk stages as well as black layer stage will all be used as maturity indicators. The term "black layer maturity" will be used synonomously with physiological maturity.

2.2 WEATHER INFLUENCE ON DRYDOWN AFTER MATURITY

Several studies have been made to determine factors associated with differences in rates of maturing and drying. Hallauer and Russel (1961) conducted a study to estimate the rate of grain moisture reduction from 40 days after silking to approximate physiological maturity and to determine the effects of six selected weather factors on grain moisture reduction. They found that degree days showed a consistent association with grain moisture loss but concluded that the use of any one of the six weather factors for estimating grain moisture reduction was unreliable. Although these conclusions may be reasonable when examining the grain filling period, they should not be extrapolated to include the period after maturity when we might expect drying to be more responsive to weather factors. Schmidt and Hallauer (1966) related a series of weather factors to the decline in percent moisture from silking until after grain maturity; a range from 88% to 20% kernel moisture. Above 30% kernel moisture content the rate of moisture reduction was significantly correlated to the temperature of the air. Below 30% kernel moisture the reduction rate was significantly correlated to the humidity of the air.

2.3 DIFFERENTIAL RATES OF DRYING

Gunn and Christensen (1956) examined moisture loss regressions over the period from 30 to 100 days after silking in 49 hybrids of a wide range of maturities. Early hybrids had lower moisture content than late hybrids throughout the period examined, but no significant difference in drying rate was found among the hybrids in this test. In contrast, however, Hillson and Penny (1965) found highly significant differences in moisture loss regressions from 51 to 75 days after silking in a group of 15 single cross hybrids. The inbred parents differed in their effects on the drying rates of their hybrid progeny.

European and Canadian hybrids have been compared with respect to grain percent moisture at harvest (Bunting, 1972; Beil, 1975; Baron, 1982). In England, Bunting (1972) showed that although the corn hybrids INRA 200 (a flint x dent European) and OX 302 (a Canadian hybrid) silked at similar times, INRA 200 produced grain of higher moisture content at harvest. These results agreed with those of Beil (1975) who tested various crosses of American or Canadian inbreds and European flints. Single cross hybrids containing one European inbred were comparable to hybrids containing only American inbreds for grain yield, but were higher in percent grain moisture at harvest (Beil, 1975). Baron (1982) found similar results when comparing commercial European hybrids to Canadian hybrids. Kernel moistures at 30 days post-silking of Canadian hybrids were greater than for European hybrids, but moisture levels measured 40 to 60 days later were lower in Canadian hybrids.

2.4 MORPHOLOGICAL FACTORS INFLUENCING DRY DOWN

Using a forced air dryer, Crane et al. (1959) measured the rate of moisture loss from hybrids with differential drying rates. Several factors were examined in order to learn if they were associated with differential drying rates. Husk and shank characteristics and shape or size of ear were not found to be major factors associated with differing rates of drying. However, differences in osmotic diffusion pressure of kernels and in pericarp permeability were found between a fast and a slow drying hybrid. Kernels of lower osmotic diffusion and with more permeable pericarps exhibited a more rapid drying rate. On the other hand, Purdy and Crane (1967b) found that fast drying hybrids had a kernel of greater osmotic pressure. Both studies involved a fast and a slow drying hybrid. Another study (Nass and Crane 1970), using endosperm mutants with various drying rates, indicated that there was no relationship between fast or slow drying rates and kernel osmotic pressure.

Purdy and Crane (1967a) studied oven drying rates in a diallel involving three fast and three slow drying inbreds. Correlations indicated that selection for faster drying rates would most likely result in smaller ears, later silking date, and lower moisture content at 60 days after silking. Phenotypic and genotypic correlations were moderately high and similar. Diallel analysis indicated significant differences for general and specific combining ability effects with the additive component more important than the nonadditive. Drying rate therefore, would seem fixable. Since husked ears were used in this study, no effect of the husks was taken into account.

Troyer and Ambrose (1971) imposed a set of husk and leaf treatments on five hybrids of varying drying rates. Results indicated that rate of drying is relatively independant of number of leaves or amount of green leaf area (including husks) available for transpiration. Husks limited air movement around the grain so that loose short husks of a low number were most condusive to fast drying. Premature death was found to speed the rate of drying.

Husks of European hybrids were found to senesce later, have heavier dry weights, and have a higher water percentage on a given date when compared with hybrids of Canadian origin (Baron, 1982). These traits were shown to be important in influencing dry-down rate through a husk modification experiment (Baron, 1982). As was indicated previously, the European hybrids were found to be higher in percent kernel moisture than Canadian hybrids. Following artificial husk loosening or husk removal treatments, the harvest kernel moisture percent of the European hybrid was reduced so that this hybrid was similar in grain moisture to that of the two Canadian hybrids studied. The husk loosening or husk removal treatments were much less effective in accelerating the dry-down rate of the Canadian hybrids. The husks were apparently already sufficiently loose in plants of these hybrids.

Hicks et al. (1976) simulated the effect of frost on drying rate by removing ears from maturing corn and subjecting them to freezing temperatures. The ears were then reattached to the stalks in the normal ear position for field drying. The drying rate of the treated ears was not significantly different from the drying rate of normally maturing ears.

Defoliation treatments (Tollenaar and Daynard, 1978), had a major influence on grain moisture percentage and date of black layer formation. The black layer formation occurred earlier in most defoliation treatments; the reason probably being an exhaustion of assimilate supplies. High kernel moisture occurred in a treatment of complete defoliation at 1 week after mid-silking. This would indicate that the lower grain moisture was not due to an increased rate of drying, but rather a result of a reduction in assimilate supply relative to kernel sink demand. Defoliation at 6 weeks after mid-silking did not accelerate drying significantly. This is in accordance with the reported effects of chemical defoliate treatments at a similar physiological stage (Mortimore, 1959; Jenkinson, 1973).

Anderson (1980) studied the interrelationships among various variables and harvest moisture content in a group of early maturing corn inbreds and derived single cross hybrids. Moisture content of the grain at harvest was found to be positively correlated to kernel weight and percentage moisture at the time of black layer formation. Harvest moisture was negatively correlated with kernel number.

Several studies have indicated that duration of the grain filling period is positively correlated with final grain moisture percentage (Cross, 1975; Anderson, 1980; Baron, 1982). Baron (1982) suggested that this extended duration of grain filling might allow water to accumulate in kernels for a longer period of time. Further, the access of water to the kernel from the plant for relatively extended periods of time might minimize the effect of the rate of replacement of water by dry matter in filling kernels via a dilution phenomenon as described for wheat by Meredith and Jenkins (1975). In that study it was concluded that loss of kernel moisture after physiological maturity was a metabolically active process. They found that ears continued to lose kernel moisture during several days of rain when evaporative loss would not have occurred. They further supposed that the metabolic water was being pumped back into the plant rather than being lost by evaporation from the grain surface (Meredith and Jenkins, 1975).

Hunter et al. (1979) compared the field drying rate of flint and dent endosperm material of similar genetic backgrounds. The flint material used was very similar to the dent material with respect to plant maturity and plant morphology. Pericarp thickness of the two classes was measured and found not to differ significantly. The results indicated that there were no major differences in field drying rate between flint and dent endosperm types. They suggested that flint endosperm type is not responsible for slow dry-down in the field. In contrast, Nass and Crane (1970) studied mutant endosperm control on drying rate and found implications that the endosperm is indeed involved in regulating moisture loss. These authors propose that the drying rate is regulated in part by hydrophylic compounds in the endosperm such as sugars, proteins, and carbohydrates. The amount and type of hydrophylic compounds present would then determine the amount of water held and the rate of its release from the endosperm.

2.5 PERICARP THICKNESS

The pericarp is the outer protective tissue enveloping the mature corn kernel, and is of maternal origin. As well as serving a protective role in preventing physical damage to the embryo axis and excluding pathogenic organisms, it also appears to function in water movement.

Using fast and slow drying corn, Purdy and Crane (1967b) found that by removing the pericarp from the kernels, the hybrids displayed almost identical rates of moisture uptake or loss. Treatment of kernels with a potassium cyanide "killing" solution resulted in no change in rate of water loss, suggesting that differential rates of loss were due to the physical structure of the pericarp rather than metabolic processes within the kernel. The faster drying rates were associated with thinner pericarps and greater permeability.

Variability among early corn genotypes for pericarp thickness was measured by Ho et al. (1975). A wide range of thickness was noted (25 to 126 μ) and pericarp thinness was found to be partially dominant. Wolf et al. (1952) studied the structure of the mature corn kernel and found the cell number in dent corn pericarp was very constant. This indicated that differential thickness was a function of cell wall thickness rather than an increase in cell number.

European hybrids are reported to have thicker pericarps than North American hybrids (Derieux, 1978; Baron, 1982). Baron (1982) indicated that it is possible to breed hybrids of a European phenotype but with thin pericarps in order to achieve a faster dry-down rate. Derieux (1978) indicated, however, that such selection may have negative side effects in increasing the vulnerability of kernels to mechanical damage when harvested at moisture content above 30%.

The literature on corn dry-down seems rather contradictory, probably due to the wide range of materials used by various researchers. In the present study, attempts were made to evaluate several factors which may have the potential to affect corn dry-down rate using a group of corn hybrids of diverse parentage.

3. MATERIALS AND METHODS

3.1 MATERIALS

Eleven hybrids of corn (*Zea mays* L.) were chosen for this study on the basis of their heritage. The hybrids can be divided into three groups: European heritage, North American heritage, and European/North American heritage. The European hybrids are of the flint type, the North American hybrids are of the dent type, and the European/North American hybrids are of mixed flint and dent type.

The list of hybrids used in the study is as follows:

FLINTS:	F7 X F2
	CO255 X F2
	CM451 X CO255
DENTS:	CM174 X CM220
	CM385 X CM387
	Q177 X CM49
	CM327 X M38A
FLINT/DENTS:	CM370 X CM651
	CM457 X CM182
	EP1 X CM49
	CM370 X CO264

3.2 METHODS

3.2.1 MANAGEMENT AND DATA COLLECTION

The hybrids were planted in 1984 on May 10 at Morden, Manitoba, and on May 14 at Winnipeg. Morden is located approximately 125 km southwest of Winnipeg. The experimental design was a split-split randomized complete block with four replications at each location. Each plot consisted of a single row containing 32 plants. Rows were 9 m long and spaced 76 cm apart. Plots in Morden were machine-seeded, whereas those in Winnipeg were hand-seeded. Fertilizer was sidebanded at a rate in excess of soil test recommendations on the date of emergence (June 15) at Winnipeg and on the date of planting (May 10) at Morden.

Weeds were controlled by a pre-seeding application of commercial herbicides at both the Winnipeg and Morden sites. In addition hand weeding was used when necessary. Plots were also sprayed twice with commercial insecticide for the control of the European corn borer (*Ostrinia nubilalis* H.) on July 13 and July 18 at Morden and on July 16 and July 23 at Winnipeg. Rates of application of the pesticides were in accordance with those recommended. Since pest control was not 100%, any plants which showed signs of stem weakening due to insect infestation were mechanically supported in order that they would not be adversely affected in their growth and development.

Date of 50% silking was recorded on the day at which at least 50% of the plants in the plot displayed silk emergence from the primary ear shoots. Observations of the first glazing stage, the 50% half-milk stage, and the black layer stage were made on the kernels from the centre of six cobs taken from each plot. The end plants of each plot were excluded from observations. First glazing dates were recorded when five out of ten kernels showed initial indications of the milk line formation (generally called glazing). The date of 50% half-milk stage was recorded when five out of ten kernels had a milk line positioned mid-way down the kernel's endosperm face. Similarily, the date of black layer was noted when five out of ten kernels showed a milk line which had reached the base of the kernel and a definite black layer formation was evident.

3.2.2 TREATMENT APPLICATION

At the time of kernel milk disappearance and simultaneous black layer development, plants were assumed to have reached physiological maturity (Zuber, 1982). Subplots were established by dividing the twenty centre plants within each row (plot) into five groups of four. This represented the first split in the split-split randomized complete block experimental design. Each plant within a group of four was subjected to one of the following treatments and randomized within each of the five subplots. The four treatments included husk modifications: (1) physically opening up of the husk; (2) maintaining a closed husk by wrapping an elastic band around the ear; (3) breaking the ear from the stalk at the shank and tying it to the stalk in its former position; (4) leaving the ear and husk in its unaltered state to serve as a control. (The four treatments represented the second split in the experimental design.) Each plant was labelled with a colored tag to indicate the treatment which it recieved. Prior to applying the treatment, cob moisture was measured using an electronic moisture meter (Model DC1Ø, manufactured by Moisture Register Co., North Hollywood, Calif.). The accuracy of this instrument has been documented (Kang et al., 1978) and the reading obtained at this stage of development was considered to be the kernel moisture percentage at physiological maturity.

Three subsequent moisture readings were made on the same cobs at four day intervals. After the final moisture reading was taken the five control treatment ears per plot were harvested with husks and shank intact, and dried for five days in a sample drying chamber at a temperature of 4ØØC.

3.2.3 PARAMETER EVALUATION

3.2.3.1 HUSK MEASUREMENTS OF TREATMENT PLOTS

The length of husks was measured from the point at the butt of the cob to the point of the tip of the longest husk. Length of cob was the measurement from the butt of the cob to the uppermost point of the cob. Husk density measurements were made by driving a 20mm cork borer through the layers of dry husks at the approximate centre of one side of the cob and obtaining a sample of husk discs which were subsequently weighed. The total number of husks per ear was counted. A measurement of the tendency of husks to open up was made at harvest using a visual scale from 1-5; a value 1 indicating tight husks, and 5, very loose husks.

3.2.3.2 PERICARP MEASUREMENTS

Pericarp thickness was measured using a modified form of the procedure described by Helm and Zuber (1972). The five ears harvested per plot were sampled in a uniform manner: Ten kernels were removed from the centre of each ear and bulked. From the fifty-kernel bulk, ten kernels were randomly sampled and soaked in distilled water for six to eight hours. The crown and tip cap portions of each kernel were removed with a scalpel. The pericarp was slit along the edge of the kernel and the pericarp excised. The excised pericarps were placed in a 1:3 water:glycerol (by volume) solution and evacuated in a vacuum desiccator. After evacuation they were allowed to stand for twenty hours. The pericarps were blotted dry and placed in a controlled environment for twenty-four hours. The equilibration environment was 20°C and 50% relative humidity. The relative humidity level was maintained by suspending the material over a saturated solution of calcium nitrate. Six pericarp measurements were made on each of the ten kernels; three on the germinal side and three on the abgerminal side. The measurements were made using a plunger micrometer and were recorded in microns.

3.3 ANALYSIS OF DATA

Data combined over the two locations were analysed according to the procedures recommended by Steel and Torrie (1980) and McIntosh (1983).

Vandalism of the Winnipeg plots occurred on August 18th which resulted in the loss of two plots from one replicate as well as several guard rows. Missing value estimates were made in the analyses of the following data: days to 50% silking, glazing, half-milk and BLM; length of husks, length of cobs, number of husks, tendency for husks to loosen, husk density and kernel test weight. Missing value estimates were not used for either the moisture readings at BLM and four, eight and twelve days after BLM, or for pericarp thickness. These parameters involved such large numbers of missing values that estimates would not have been accurate. Therefore, the data were first analyzed by omitting the damaged replicate, then re-analysed including the replicate in question but deleting the hybrids of the two missing plots. This allowed the most complete use of the information from the damaged replicate without the use of missing value estimates.

Comparisons among the means of the three groups was accomplished using the Bonferroni Procedure for pre-selected contrasts (Chew, 1977).

3.4 METEOROLOGICAL INFORMATION

Temperature and precipitation records (Table 1) were obtained from the closest official weather station operated under established standards and with instruments provided by Environment Canada. Mean temperatures for the two locations were similar for the months of May to November. However, Winnipeg received almost 110 mm more total precipitation than that received by Morden during this same period. The largest precipitation differences between the locations occurred during the months of June and September.

TABLE 1. Meteorological information obtained by Environment Canada for the months May to November of 1984 at Morden and Winnipeg.

Month	Total precipitation (mm)		Mean temperature (oC)	
	Morden	Winnipeg	Morden	Winnipeg
May	37.0	29.8	11.3	10.1
June	120.4	227.9	16.5	17.0
July	38.4	38.3	20.3	19.6
August	25.8	21.6	22.3	21.0
September	33.4	62.0	11.3	10.6
October	117.6	99.0	6.6	6.4
November	23.0	26.6	-4.6	-4.9
Total	395.6	505.2	12.0	11.4

4. RESULTS AND DISCUSSION

4.1 GRAIN MATURATION AND DRY-DOWN

Results indicated that there were large differences in percent moisture at black layer maturity (BLM) between the flint, the dent, and the flint/dent hybrids used in this study (Table 2). The flint group reached maturity at 5.5% higher moisture than the dents and 4.2% higher than the flint/dent types. These differences remained true for the four moisture readings after BLM.

These results differ from those of Baron (1982). Using the same three kernel type classes as tested in the present study, he found that although the European hybrids were highest in moisture, the European/North American hybrids was the class with the lowest moisture at all stages of maturation. This difference could reflect the different parental background of the two sources of hybrids used. Another possible reason for variable results is the difference in classification of hybrids between the two studies. Baron (1982) used commercial hybrids of European and North American origin, but the parental inbreds were not necessarily of the origin implied by their classification (Giesbrecht, personal communication).

Rates of moisture loss subsequent to physiological

TABLE 2. Mean ear percent moisture measured during and after BLM in three classes of corn hybrids grown at two locations.

Hybrids	BLM	Post-BLM		
		4 days	8 days	12 days
Flints:				
F7 X F2	46.82	40.37	36.05	31.03
CO255 X F2	45.38	41.58	38.58	34.70
CM451 X CO255	46.27	39.03	35.73	31.43
Means	46.16	40.33	36.79	32.39
Dents:				
CM174 X CM220	39.60	35.60	31.88	25.47
CM385 X CM387	37.08	33.80	32.08	28.62
Q177 X CM49	42.77	33.13	29.30	24.35
CM327 X M38A	43.00	36.20	34.15	30.47
Means	40.61	34.68	31.85	27.23
Flint/Dents:				
CM370 X CM651	40.72	36.63	31.25	27.38
CM457 X CM182	38.35	34.25	30.90	25.92
EP1 X CM49	44.87	42.18	38.43	35.00
CM370 X CO264	44.03	38.33	34.10	28.27
Means	41.99	37.85	33.67	29.14

maturity were significantly different between individual hybrids within groups (P=<0.001). However, mean differences between the three hybrid groups (Table 3) were non significant according to the Bonferroni method (Chew, 1977). Each post-BLM value was analysed as a function of the moisture at physiological maturity, which eliminated the factor of initial moisture differences. Throughout the 12-day period of dry-down the dent group maintained a slightly higher rate of moisture loss relative to the other two groups. This difference, however, was not significant.

The maturity parameter observations (Figure 1) indicate that the three hybrid groups were similar in their initial stages of maturation. Although the flint and flint/dent groups reached 50% silking slightly sooner than the dent group, by the time of 50% first glazing the dents were slightly ahead of the other two groups in maturity. The flint and flint/dent groups reached these stages of maturity in a comparable time span.

By the time of the 50% half-milk stage, both the flint/dent class and dent class were similar in their maturity pattern. In contrast, the hybrids of the dent class were 4 days earlier than the flint class at this time and reached physiological maturity almost 7 days sooner than the flint class. The flint/ dent class matured 4 days later than the dent class, but almost 3 days sooner than

TABLE 3. Kernel moisture of three groups of corn hybrids at four, eight. and twelve days following black layer maturity. Moisture readings given as a percent of moisture at BLM.

Hybrids	Four days post-BLM	Eight days post-BLM	Twelve days post-BLM
Flints:			
F7 X F2	86.1	77.0	67.0
CO255 X F2	92.5	85.8	77.9
CM451 X CO255	84.6	77.8	68.1
Means	87.7	80.2	71.0
Dents:			
CM174 X CM220	90.9	80.9	64.5
CM385 X CM387	91.5	87.1	77.5
Q177 X CM49	77.0	68.2	56.5
CM327 X M38A	84.9	79.9	71.0
Means	86.1	79.0	67.4
Flint/Dents:			
CM370 X CM651	90.3	77.2	67.4
CM457 X CM182	89.4	80.5	67.5
EP1 X CM49	94.1	85.6	77.6
CM370 X CO264	87.1	77.4	64.4
Means	90.2	80.2	69.2

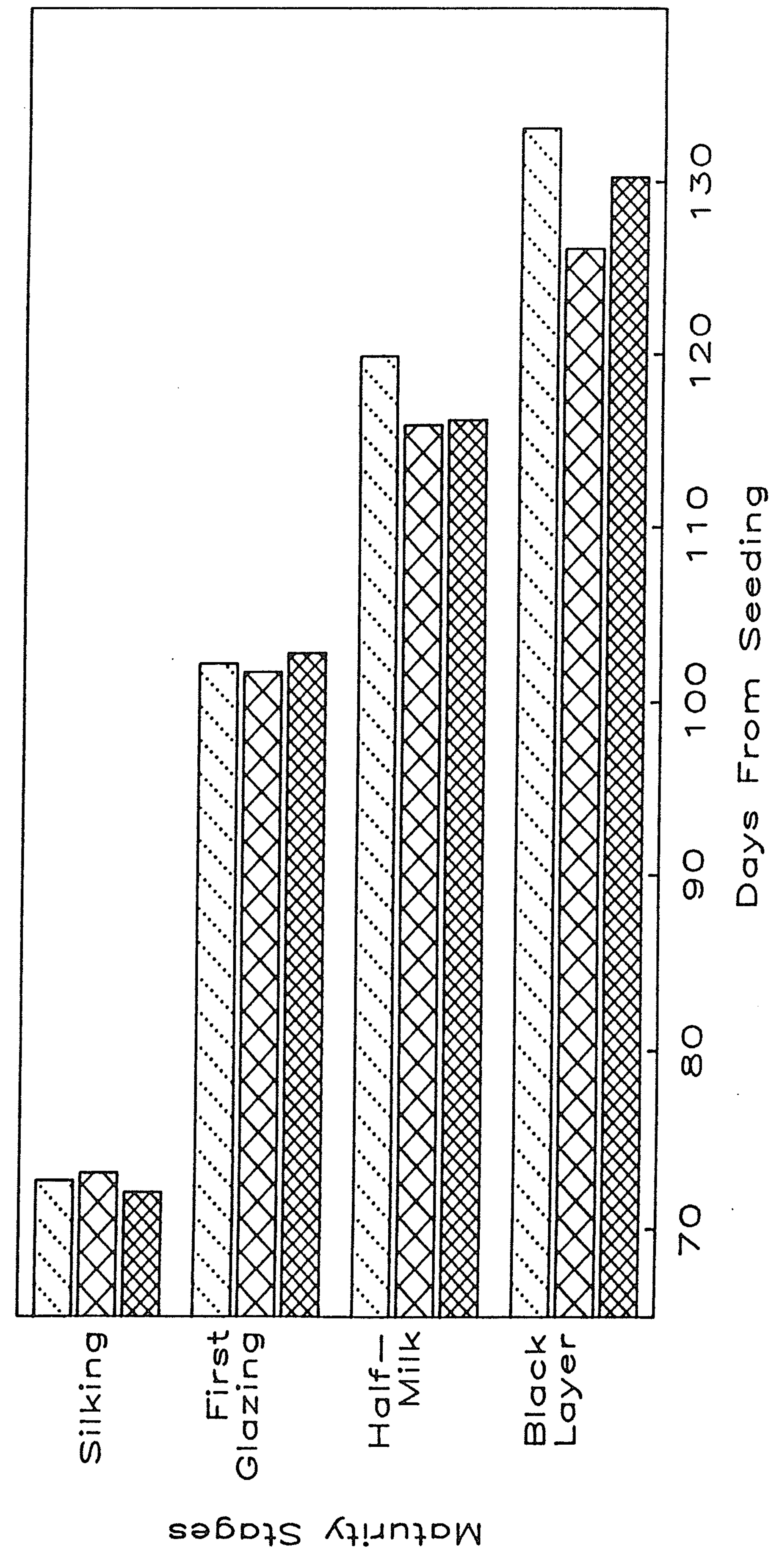
Figure 1. Number of days required for three groups of corn hybrids, grown at Morden and Winnipeg, to reach 50% silking, 50% glazing, 50% half-milk, and 50% BLM.

Legend: Hybrid group

Flint

Dent

Flint/Dent



Maturity Stages
Silking
First Glazing
Half—Milk
Black Layer
70
80
90
100
110
120
130
Days From Seeding

the hybrids of the flint class.

In the early stages of the maturation process (days to 50% silk and first glazing) location effects were non-significant. However, at the time of 50% half-milk and 50% black layer development there was a significant difference between locations (P=0.00 and P=0.04 respectively). Plants at the Morden location reached these levels of maturity earlier than the plants of the Winnipeg location. The lower precipitation experienced at the Morden site might have provided sufficient environmental stress to induce premature maturity. These latter stages of maturity (days to 50% half-milk and BLM) developed in the month of September, by which time the Morden site had received a total of 124.6mm less precipitation than the Winnipeg site. In the month of September, the Winnipeg site received approximately twice the amount of precipitation received by the Morden site.

These maturity parameter results correspond closely with the findings of Baron (1982) in which the rate of kernel percent moisture loss after black layer maturity was similar for all hybrid groups. Baron (1982) found that differences among hybrids in their relative loss of kernel moisture percentage occurred previous to black layer development. Percent kernel moisture of Canadian hybrids at 20 to 30 days post silking, (approximately the time of first glazing), was equal or higher than that of the

European hybrids. At 40 to 60 days post silking, or approximately BLM, the percent kernel moisture of Canadian hybrids was at least 3% lower than that of the European hybrids. It would appear that it is during the period between silking and BLM that differential moisture levels between hybrids occurs. After BLM the drying rates are similar for all groups of hybrids in the present study, similarily those studied by Baron (1982).

The fact that there are differences in moisture loss prior to BLM, but not afterwards implies that metabolic activities may be involved up until the black layer development. According to the findings of Schmidt and Hallauer (1966), rate of moisture reduction during the dry-down period is significantly correlated to the temperature of air when kernel moisture is above 30%. A metabolically active process would also be correlated to ambient temperatures. Below 30% kernel moisture content, reduction in moisture is a function of relative humidity, implying a more passive loss of moisture and related more to evaporative factors.

Meredith and Jenkins (1975) suggested that there was a common physical and physiological mechanism for "apparent" drying of developing and ripening cereal grains. The cereal grains used in their study were wheat, oats and barley. The filling process of kernel cells involves synthesis and deposition of starch granules and protein bodies. Once the required tissues in the kernel had been formed, the filling process of the cells followed similar pathways and therefore required similar water activity regardless of the cereal species they studied. Thus similarities in "apparent" drying rates were actually found to indicate similarity of rates of synthesis and deposition of storage metabolites. One could extrapolate this to suggest that differences in drying rates such as those exhibited by the corn hybrids in the present study might actually indicate different rates of synthesis and deposition of storage metabolites. This theory also corresponds well to the proposal by Nass and Crane (1970) that drying rate is in part regulated by hydrophylic compounds in the endosperm such as sugars, proteins, and carbohydrates. Different rates of synthesis would also help to explain the differences in number of days required to reach the various maturation stages exhibited by the flint versus dent hybrid groups.

Further studies would be required before confirming these hypotheses, especially since different plant species are being compared to corn in the two seperate studies.

As was found in previous investigations (Cross, 1975; Anderson, 1980; Baron, 1982) the percent moisture at BLM is positively associated with the grain filling period (Table 4). However, grain filling duration is also positively associated with kernel test weight. This is unfortunate

TABLE 4. Comparison of mean kernel percent moisture at BLM, grain filling period and grain test weight of three classes of corn hybrids grown at Morden and Winnipeg.

Hybrids	Kernel % moisture at BLM (%)	Grain filling period (days)	Grain test weight (kg/hl)
Flints:			
F7 X F2	46.82	60.8	77.31
CO255 X F2	45.38	60.4	79.90
CM451 X CO255	46.27	59.5	77.65
Means	46.16	60.2	78.29
Dents:			
CM174 X CM220	39.60	52.9	75.13
CM385 X CM387	37.08	50.1	69.54
Q177 X CM49	42.77	54.9	76.72
CM327 X M38A	43.00	53.7	73.01
Means	40.61	52.9	73.60
Flint/Dents:			
CM370 X CM651	40.72	57.9	76.50
CM457 X CM182	38.35	60.8	76.33
EP1 X CM49	44.87	58.5	76.70
CM370 X CO264	44.03	55.2	77.23
Means	41.99	58.1	76.69

from a plant breeding standpoint in that selecting for a shorter grain filling period in order to decrease harvest moisture, would have the negative effect of also decreasing test weight and possibly yield.

4.2 HUSK CHARACTERISTICS

Husk characteristics proved to be variable in their effect on moisture percentage of kernels at the time of harvest (Table 5). As found by previous workers (Troyer and Ambrose, 1971), a low number of husks, a low husk density, and the tendency for husks to open naturally, all contributed to a reduced kernel moisture at maturity. The husk length-cob length ratio was not associated with kernel percent moisture. Presumably, if a hybrid exhibits numerous husks of high density which have the natural tendency to remain tightly wrapped around the ears, the length of husks had little or no effect on the moisture loss resistance from the kernels. On the other hand, if husks were naturally very loose one would also not expect husk length to have an effect on dry-down.

The analysis of variance for tendency of husks to open reveals a highly significant location effect as well as a highly significant hybrid effect ($P=<0.001$ and $P=<0.001$ respectively). This implies that the natural looseness of the husks may in part be dictated by the

TABLE 5. Summarized means of four morphological traits of three classes of corn hybrids at Morden and Winnipeg.

Hybrids	Husk length vs. cob length	Total no. of husks	Husk looseness*	Husk density (grams)
Flint:				
F7 X F2	1.17	14.1	1.72	0.15
CO255 X F2	1.06	14.4	1.95	0.15
CM451 X CO255	1.08	15.2	2.42	0.13
Means	1.10	14.6	2.03	0.14
Dent:				
CM174 X CM220	1.11	13.6	3.70	0.13
CM385 X CM387	1.38	9.2	2.53	0.10
Q177 X CM49	1.20	12.5	3.03	0.11
CM327 X M38A	1.14	12.0	3.48	0.13
Means	1.21	11.8	3.18	0.12
Flint/Dent:				
CM370 X CM651	1.19	11.6	2.75	0.12
CM457 X CM182	1.25	14.7	2.73	0.14
EP1 X CM49	1.30	18.9	3.73	0.12
CM370 X CO264	1.36	11.1	2.68	0.11
Means	1.28	14.1	2.97	0.12

* based on visual ratings from very tight husks (1) to very loose husks (5).

plants exposure to certain enviromental conditions. The husks from the hybrids grown at the Winnipeg site were significantly more loose than those hybrids grown at the Morden site. Which weather factors effect this loosening tendency are as yet unknown and this is an area which would require further study.

The length of ears also showed a significant location effect (P=0.01). The average ear length from the Winnipeg location was greater than that from the Morden trial.

4.3 HUSK TREATMENTS

The husk modification treatments proved to markedly influence the rates of kernel moisture decline (Figure 2). The rate of moisture decline of the control treatments averaged across the three groups of hybrids was 1.11% per day. Physically opening the husks had the effect of decreasing the resistance to moisture loss and therefore increasing the rate of moisture decline to 1.66% per day. In contrast, closing the husks caused a decrease in the rate to 0.98% moisture loss per day. Moisture declined at a rate of 1.18% per day for the broken shank treatment, which is a similar rate to that of the control moisture decline. It would appear that moisture was no longer moving into the ears through the shank at the time of physiological maturity and so breaking the shank had very little effect

Figure 2. Mean percent moisture over a twelve day period following physiological maturity of three groups of corn hybrids grown at Morden and Winnipeg. Illustrated are four husk modification treatments: (a) control, (b) broken shank, (c) loosened husks, and (d) closed husks.

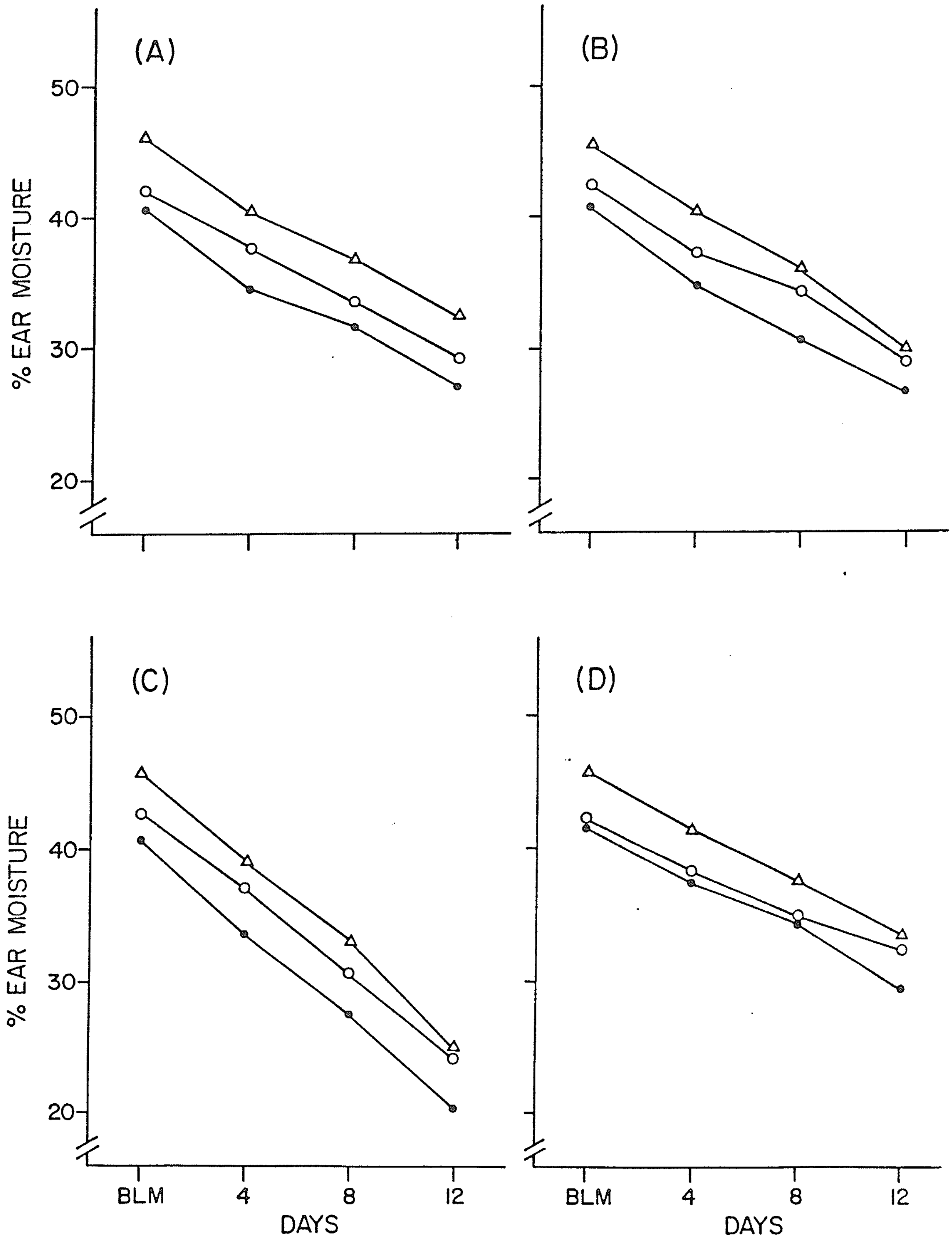
Legend:

Hybrid group

Flint △

Dent ●

Flint/Dent ○


(A)
(B)
(C)
(D)
% EAR MOISTURE
50
40
30
20
BLM
4
8
12
DAYS

on moisture loss. At twelve days after maturity the mean moisture percentage of the loosened husk treatments was 6.6% lower than that of the control (Table 6). In contrast, closing the husks resulted in an increase of 2% moisture. The difference between the broken shank mean percent moisture and the control moisture was less than 1% at this time.

An important factor to note is that the treatments affected the moisture loss of the three hybrid groups similarily (Figure 2). However, significant differences between the individual hybrids were found (Table 7). The mean moisture loss due to open husks relative to the controls are greatest for the dent hybrid CM174 x CM220 and the least for the dent hybrid Q177 x CM49 (Table 6). Perhaps if there had been a greater range in the degree of husk looseness between parental material, there might have been an even larger difference between hybrids in response to treatments of opening and closing of husks. Although there were significant differences between hybrids of the present study, they did not exhibit the extreme differences in natural loosening and tightness that have been witnessed in some other hybrids (Geisbrecht, personal communication).

TABLE 6. Mean moisture percentages of three groups of corn hybrids grown at Morden and Winnipeg, twelve days after physiological maturity for four husk modification treatments.

Hybrids	Treatments				Mean
	Broken shank	Closed husks	Open husks	Control	
Flint:					
F7 X F2	29.30	31.98	22.95	31.03	28.82
CO255 X F2	30.80	36.40	24.68	34.70	31.65
CM451 X CO255	29.73	32.33	27.22	31.43	30.18
Mean	29.94	33.57	24.95	32.39	
Dent:					
CM174 X CM220	23.15	27.80	16.23	25.47	23.16
CM385 X CM387	28.33	30.57	22.22	28.62	27.43
Q177 X CM49	27.40	29.10	21.92	24.35	25.69
CM327 X M38A	28.77	31.28	21.02	30.47	27.88
Mean	26.91	29.69	20.35	27.23	
Flint/Dent:					
CM370 X CM651	28.17	28.97	21.98	27.38	26.63
CM457 X CM182	27.33	27.93	20.97	25.92	25.54
EP1 X CM49	32.85	36.90	30.27	35.00	33.75
CM370 X CO264	28.52	31.27	23.85	28.27	27.98
Mean	29.22	31.27	24.27	29.14	
Total mean	28.58	31.32	23.03	29.33	

TABLE 7. Analysis of variance of percent ear moisture twelve days after physiological maturity relative to percent ear moisture at physiological maturity for eleven corn hybrids grown at Morden and Winnipeg.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
Location (L)	1	0.314300	0.314300	2.34	0.110
Rep/L	4	0.536338	0.134084		
Hybrid (H)	10	3.689730	0.368972	5.369	0.000**
H*L	10	1.403793	0.140379	2.046	0.054*
Error H	40	2.744667	0.068617		
Treatment (T)	3	7.346479	2.448826	118.582	0.000**
T*L	3	0.121206	0.040402	1.956	0.124
H*T	30	0.824886	0.027496	1.331	0.139
H*T*L	30	0.388571	0.012952	0.672	0.931
Error T	132	2.725919	0.020651		
Sub-error	1056	15.044660	0.014268		
Total	1319	35.140549			

Mean = 0.65833
Minimum = 0.23288
Maximum = 1.45000

*,** Significant at the 5% and 1% levels of significance, respectively.

4.4 PERICARP THICKNESS

Pericarp measurements indicated that there was a difference in pericarp thickness between the three hybrid groups (Table 8). In general, the flints had a thicker pericarp, followed by the dents, and flint/dent groups in order of decreasing thickness. On the assumption that increased pericarp thickness decreases the rate of moisture loss by imposing a greater resistance factor, one would expect the flints to have the thickest pericarp tissue, followed by the flint/dents, and dents in that order. The flint group exhibited the thickest pericarp as well as the highest kernel moisture percentage of the three groups studied, and therefore lends some credibility to the previous assumption. The dent group, however, exhibited the lowest kernel percent moisture but did not display the thinnest pericarp. The flint/dent group exhibited a kernel percent moisture which was intermediate to the other groups, and yet showed the thinnest pericarps of the groups studied. The dent and flint/dent groups, therefore, contradict the assumption that a decreased pericarp thickness increases moisture loss.

Further contradictions to this assumption arise when one examines the hybrids on an individual basis (Figure 3). An exceptional example is the flint/dent hybrid, EP1 x CM49, which has a very thin pericarp and exhibited the highest moisture percent at harvest of all hybrids tested.

TABLE 8. Mean pericarp thickness (μ) of three groups of corn hybrids grown at Morden and Winnipeg.

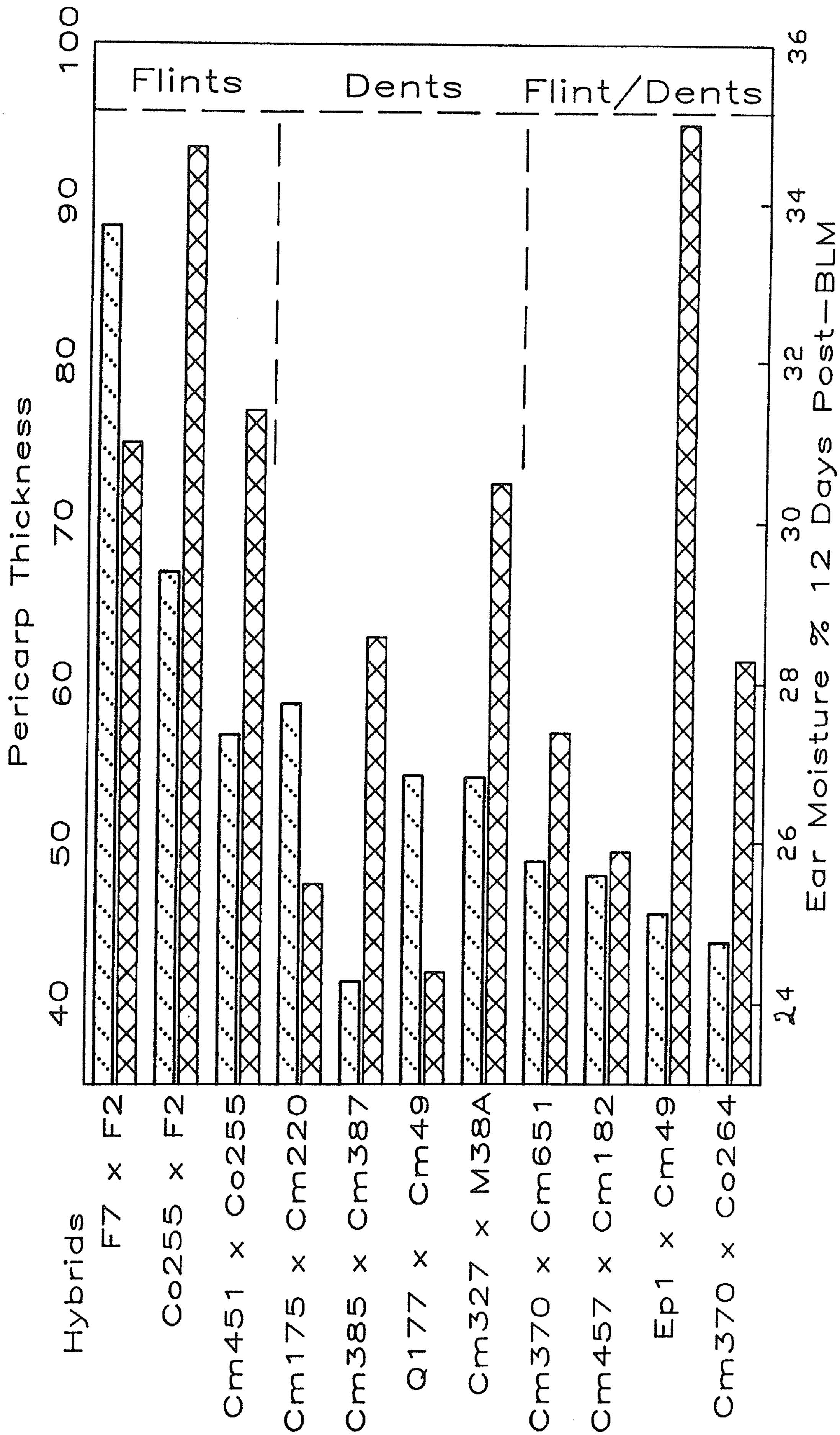
Hybrids	Pericarp thickness (μ)
Flints:	
F7 X F2	88.53
CO255 X F2	66.95
CM 451 X CO255	56.85
Mean	70.78
Dents:	
CM174 X CM220	58.75
CM385 X CM387	41.41
Q177 X CM49	54.30
CM327 X M38A	54.24
Mean	52.18
Flint/Dents:	
CM370 X CM651	48.92
CM457 X CM182	47.99
EP1 X CM49	45.55
CM370 X CO264	43.83
Mean	46.57

Figure 3. Pericarp thickness and percent ear moisture of three groups of corn hybrids, twelve days after physiological maturity.

Legend:

Pericarp thickness

% ear moisture



Pericarp Thickness
40
50
60
70
80
90
100
Ear Moisture % 12 Days Post-BLM
24
26
28
30
32
34
36
Flints
Dents
Flint/Dents
Hybrids
F7 x F2
Co255 x F2
Cm451 x Co255
Cm175 x Cm220
Cm385 x Cm387
Q177 x Cm49
Cm327 x M38A
Cm370 x Cm651
Cm457 x Cm182
Ep1 x Cm49
Cm370 x Co264

Wolf et al. (1952) reported the pericarp covering the abgerminal side of the kernel to be thicker than that on germinal side. In the present study it was hypothesized that overall pericarp thickness might not be the overriding factor in moisture loss resistance; perhaps one side of the pericarp could be correlated to drydown, regardless of overall pericarp thickness. The six measurements of each pericarp were analyzed in two groups of three measurements for each side (Table 9). The abgerminal side was found to be consistently thicker than the germinal side for all hybrids (Figure 4). However, thickness of pericarp sides also did not correspond to moisture percentage at harvest. Considering the difference in thickness of the sides, it would be interesting to measure the thickness of the pericarp crown for hybrids of various dry-down rates. The crown of the kernel would appear to be a logical area with maximum evaporative potential, and varying thickness in this area may be a function of dry-down rate. Richardson (1960) found that although the thickness of popcorn crown pericarp tissue was minimal when the kernel reached physiological maturity, after drying to storage moisture levels, this tissue had thickened. No such changes in thickness were found when studying the sides of pericarp tissue from mature dent corn (Helm and Zuber, 1970). Unfortunately, there are difficulties associated with measurements of the crown area of dent pericarp tissue, as was discussed by these workers.

TABLE 9. Analysis of variance of pericarp thickness measurements of the germinal and abgerminal sides of eleven corn hybrids, at Morden and Winnipeg.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
Location (L)	1	39.241	39.241	2.93	0.162
Error L	4	53.604	13.401		
Hybrid (H)	10	6372.177	637.218	88.00	0.000**
H*L	10	66.174	6.617	0.91	0.530
Error H	40	289.637	7.241		
K/H*R/L	594	918.727	1.547		
Side (S)	1	1179.928	1179.928	1535.75	0.000**
S*H	10	656.841	65.684	85.49	0.000**
S*L	1	1.600	1.600	2.08	0.150
S*H*L	10	28.058	2.806	3.65	0.000**
Error S	638	462.980	0.726		
Measure error	2640	2571.400	0.974		
Total	3959	12640.367			

Mean = 5.52
Minimum = 1.70
Maximum = 16.20

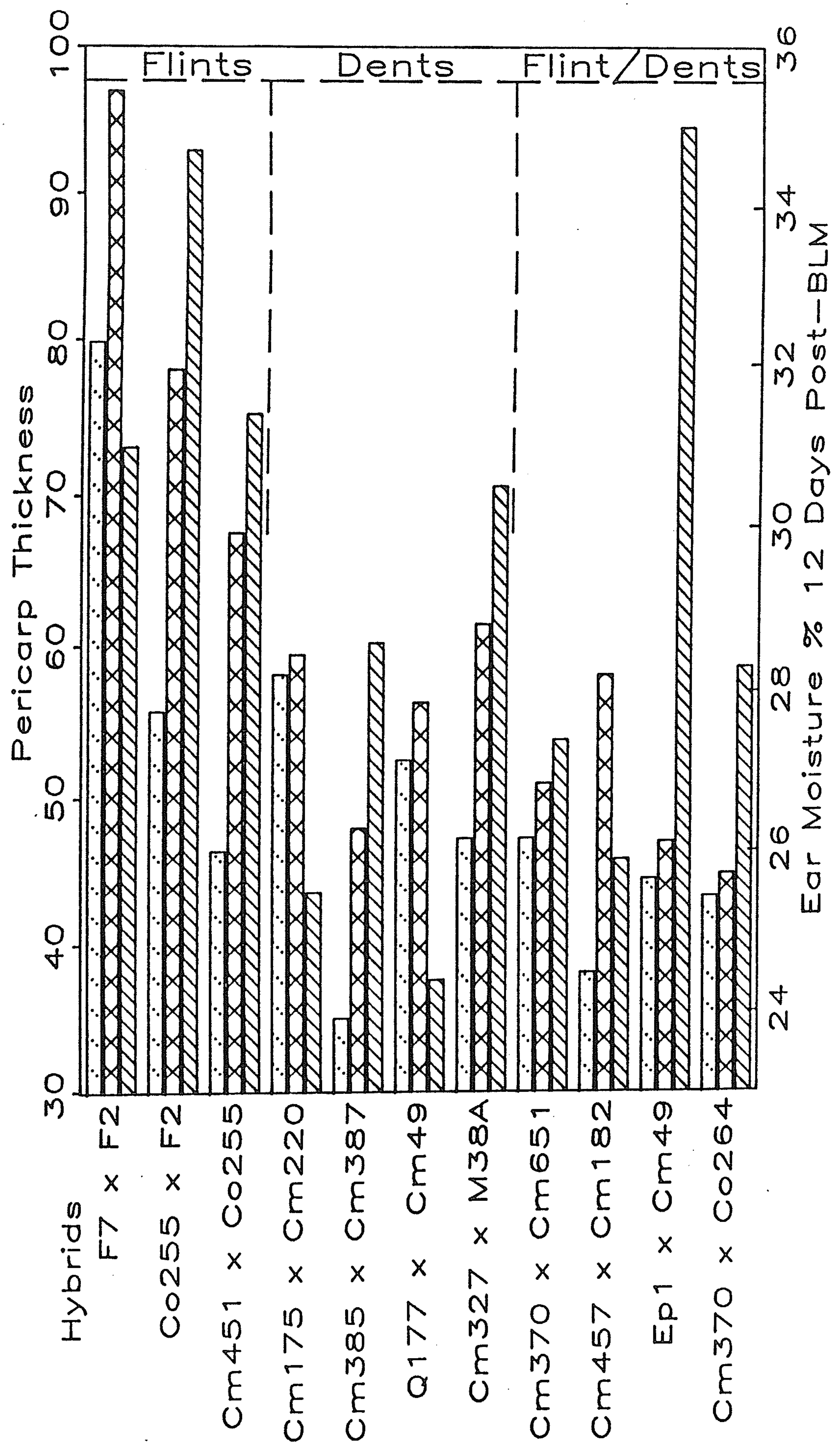
Figure 4. Thickness of the germinal and and abgerminal sides of pericarp tissue, and percent ear moisture of three groups of corn hybrids, twelve days after physiological maturity.

Legend:

Pericarp: abgerminal side

Pericarp: germinal side

% ear moisture


Pericarp Thickness
Ear Moisture % 12 Days Post—BLM
Flints
Dents
Flint/Dents
Hybrids
F7 x F2
Co255 x F2
Cm451 x Co255
Cm175 x Cm220
Cm385 x Cm387
Q177 x Cm49
Cm327 x M38A
Cm370 x Cm651
Cm457 x Cm182
Ep1 x Cm49
Cm370 x Co264
30
40
50
60
70
80
90
100
24
26
28
30
32
34
36

5. SUMMARY AND CONCLUSIONS

Eleven corn hybrids of Canadian (dents), European (flints), and European/Canadian (flint/dents) parentage were studied with the following objectives: (1) to determine differences in rates of dry-down, and (2) to establish which morphological features, if any, account for differences in moisture loss found between hybrids.

The European flint hybrids reached physiological maturity at 5.5% higher kernel percent moisture than the Canadian dents, and 4.2% higher moisture than the flint/dents. Rate of moisture loss was not significantly different between the three groups of hybrids, although on an individual basis there were significant differences between hybrids.

All groups reached 50% silking at approximately the same time. The 50% half-milk stage occurred in the dent group 4 days earlier than in the flints and 1 day earlier than in the flint/dents.

The dent group reached physiological maturity almost seven days earlier than did the flints and four days earlier than the flints/dents. The transition between flints and dents thus occurs between the stages of silking and black layer maturity, after which the drying rates between the hybrid groups are relatively similar. This suggests that the differences between hybrids might actually entail different rates of synthesis and deposition of storage metabolites rather than differences in moisture loss *per se*.

The percent kernel moisture at black layer maturity was found to be positively associated with the grain filling duration (the period from silking to physiological maturity) as well as with the final test weight of the grain.

Husk characteristics which had the greatest effect on the rate of dry-down after physiological maturity were: number of husks, husk density, and tendency for husks to loosen naturally. Husk length compared with cob length was not correlated with kernel percent moisture. Treatments whereby husks were manually opened to reduce the resistance to moisture loss were highly significant in increasing the rate of moisture loss for all groups of hybrids. Conversely, by closing the husks, the rate of moisture loss was effectively reduced. Breaking the shank of the ear had no significant effect on moisture loss and it is therefore assumed that moisture movement no longer occurs from the plant to the kernels after black layer maturity. These treatments affected the moisture loss of all hybrids equally, regardless of parentage.

Pericarp thickness was significantly different between hybids, but could not be associated with either percent kernel moisture at harvest or rate of moisture loss. Especially prominent is the fact that the flint/dent hybrid, EP1 x CM49, has a very thin pericarp and yet exhibited the highest moisture level at harvest as well as being one with the slowest rate of moisture loss.

It appears important to gain a better understanding of the chemical composition of the corn endosperm especially in the area of hydrophylic compounds in that tissue. Also of benefit would be to study the period of dry matter accumulation between the stages of silking and pysiological maturity more closely in order to gain a better understanding of the dry-down process in corn. Moisture gains and losses in this period are crucial in determining the percent kernel moisture at black layer maturity, after which moisture loss is regulated by resistance factors such as husk characteristics and possibly pericarp thickness.

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7. APPENDIX

TABLE 1. Mean moisture percentages at **physiological maturity** for four husk modification treatments of three groups of corn hybrids grown at Morden and Winnipeg.

Hybrids	Treatments				Mean
	Broken shank	Closed husks	Open husks	Control	
Flint:					
F7 X F2	45.78	47.18	45.35	46.82	46.28
CO255 X F2	45.33	44.65	46.32	45.38	45.42
CM451 X CO255	45.18	45.90	46.05	46.27	45.85
Mean	45.43	45.91	45.91	46.16	
Dent:					
CM174 X CM220	39.22	40.80	38.32	39.60	39.48
CM385 X CM387	36.83	37.98	38.23	37.08	37.53
Q177 X CM49	43.82	43.75	43.68	42.77	43.50
CM327 X M38A	43.40	44.40	43.43	43.00	43.56
Mean	40.82	41.73	40.92	40.61	
Flint/Dent:					
CM370 X CM651	40.77	39.20	41.70	40.72	40.60
CM457 X CM182	40.65	39.75	39.75	38.35	39.63
EP1 X CM49	43.37	44.33	45.18	44.87	44.44
CM370 X CO264	44.15	44.95	44.02	44.03	44.29
Mean	42.24	42.06	42.66	41.99	
Total mean	42.59	42.99	42.91	42.63	

TABLE 2. Mean moisture percentages for four husk modification treatments of three groups of corn hybrids grown at Morden and Winnipeg, **four days after physiological maturity.**

Hybrids	Treatments				Mean
	Broken shank	Closed husks	Open husks	Control	
Flint:					
F7 X F2	40.78	42.28	37.95	40.37	40.35
CO255 X F2	41.13	41.77	40.62	41.58	41.28
CM451 X CO255	38.70	39.90	39.18	39.03	39.20
Mean	40.20	41.32	39.25	40.33	
Dent:					
CM174 X CM220	34.57	38.05	33.08	35.60	35.33
CM385 X CM387	32.32	35.60	34.95	33.80	34.17
Q177 X CM49	37.27	36.48	35.12	33.13	35.50
CM327 X M38A	35.43	40.18	32.63	36.20	36.11
Mean	34.90	37.58	33.95	34.68	
Flint/Dent:					
CM370 X CM651	36.10	35.83	34.07	36.63	35.66
CM457 X CM182	35.52	35.25	33.95	34.25	34.74
EP1 X CM49	38.88	42.67	43.50	42.18	41.81
CM370 X CO264	38.42	39.22	37.05	38.33	38.25
Mean	37.23	38.24	37.14	37.85	
Total mean	37.19	38.84	36.55	37.37	

TABLE 3. Mean moisture percentages for four husk modification treatments of three groups of corn hybrids grown at Morden and Winnipeg, **eight days after physiological maturity.**

Hybrids	Treatments				Mean
	Broken shank	Closed husks	Open husks	Control	
Flint:					
F7 X F2	36.20	38.72	30.35	36.05	35.33
CO255 X F2	37.50	38.37	33.42	38.58	36.97
CM451 X CO255	34.33	35.55	33.97	35.73	34.90
Mean	36.01	37.55	32.58	36.79	
Dent:					
CM174 X CM220	29.28	34.32	25.97	31.88	30.36
CM385 X CM387	30.48	34.65	29.83	32.08	31.76
Q177 X CM49	30.93	33.05	28.38	29.30	30.42
CM327 X M38A	32.30	35.42	26.97	34.15	32.21
Mean	30.75	34.36	27.79	31.85	
Flint/Dent:					
CM370 X CM651	33.70	31.87	27.83	31.25	31.16
CM457 X CM182	32.90	32.92	28.23	30.90	31.24
EP1 X CM49	35.95	38.38	38.05	38.43	37.70
CM370 X CO264	34.68	36.17	28.68	34.10	33.41
Mean	34.31	34.84	30.70	33.67	
Total mean	33.48	35.40	30.15	33.86	

TABLE 4. Mean moisture retained by three groups of corn hybrids grown at Morden and Winnipeg, for four husk treatments, **four days after physiological maturity**. Moisture values given as a **percent** of moisture recorded at physiological maturity.

Hybrids	Treatments				Mean
	Broken shank	Closed husks	Open husks	Control	
Flint:					
F7 X F2	89.1	89.8	84.1	86.1	87.3
CO255 X F2	92.4	93.8	88.9	92.5	91.9
CM451 X CO255	85.8	87.1	84.6	84.6	85.5
Mean	89.1	90.2	85.9	87.7	
Dent:					
CM174 X CM220	89.3	93.2	86.8	90.9	90.1
CM385 X CM387	88.3	93.9	91.9	91.5	91.4
Q177 X CM49	85.4	83.6	80.6	77.0	81.7
CM327 X M38A	82.0	91.3	76.3	84.9	83.6
Mean	86.3	90.5	83.9	86.1	
Flint/Dent:					
CM370 X CM651	89.0	91.9	82.2	90.3	88.4
CM457 X CM182	87.9	89.2	85.6	89.4	88.0
EP1 X CM49	90.3	96.6	96.4	94.1	94.3
CM370 X CO264	87.2	87.4	83.9	87.1	86.4
Mean	88.6	91.3	87.0	90.2	
Total mean	87.9	90.7	85.6	88.0	

TABLE 5. Mean moisture retained by three groups of corn hybrids grown at Morden and Winnipeg, for four husk treatments, **eight days after physiological maturity**. Moisture values given as a **percentage** of moisture recorded at physiological maturity.

Hybrids	Treatments				Mean
	Broken shank	Closed husks	Open husks	Control	
Flint:					
F7 X F2	79.3	82.2	67.2	77.0	76.4
CO255 X F2	84.4	86.2	72.1	85.8	82.1
CM451 X CO255	76.6	77.6	73.6	77.8	76.4
Mean	80.1	82.0	71.0	80.2	
Dent:					
CM174 X CM220	76.0	84.2	68.0	80.9	77.3
CM385 X CM387	83.2	91.4	78.1	87.1	85.0
Q177 X CM49	71.1	76.0	65.0	68.2	70.1
CM327 X M38A	74.6	80.6	62.6	79.9	74.4
Mean	76.2	83.1	68.4	79.0	
Flint/Dent:					
CM370 X CM651	82.5	81.3	67.0	77.2	77.0
EP1 X CM49	83.4	87.2	84.6	85.6	85.2
CM370 X CO264	78.8	80.5	64.8	77.4	75.4
Mean	81.6	83.1	71.8	80.2	
Total mean	79.2	82.8	70.3	79.8	

TABLE 6. Mean moisture retained by three groups of corn hybrids grown at Morden and Winnipeg, for four husk treatments, **twelve days after physiological maturity.** Moisture values given as a **percentage** of moisture recorded at physiological maturity.

Hybrids	Treatments				Mean
	Broken shank	Closed husks	Open husks	Control	
Flint:					
F7 X F2	64.1	68.0	50.6	67.0	62.4
CO255 X F2	70.2	82.6	53.5	77.9	71.0
CM451 X CO255	66.0	70.6	59.0	68.1	65.9
Mean	66.8	73.7	54.4	71.0	
Dent:					
CM174 X CM220	60.0	68.3	42.0	64.5	58.7
CM385 X CM387	77.1	80.9	57.9	77.5	73.4
Q177 X CM49	62.8	67.1	50.0	56.5	59.1
CM327 X M38A	66.3	70.6	48.2	71.0	64.0
Mean	66.6	71.7	49.5	67.4	
Flint/Dent:					
CM370 X CM651	69.3	73.8	52.8	67.4	65.8
CM457 X CM182	67.2	69.8	52.6	67.5	64.3
EP1 X CM49	76.0	83.8	66.9	77.6	76.1
CM370 X CO264	65.2	70.0	54.1	64.4	63.4
Mean	69.4	74.4	56.6	69.2	
Total mean	67.7	73.2	53.4	69.0	

TABLE 7. Mean number of days from seeding to 50% silking for three groups of corn hybrids grown at Morden and Winnipeg.

	Morden	Winnipeg	Mean
<u>Flint</u>:			
F7 X F2	72.25	72.75	72.50
CO255 X F2	72.75	72.25	72.50
CM451 X CO255	73.50	73.50	73.50
Mean	72.83	72.83	
<u>Dent</u>:			
CM174 X CM220	74.75	74.00	74.38
CM385 X CM387	71.50	71.50	71.50
Q177 X CM49	73.25	72.50	72.88
CM327 X M38A	74.50	74.00	74.25
Mean	73.50	73.00	
<u>Flint/Dent</u>:			
CM370 X CM651	72.00	72.25	72.13
CM457 X CM182	71.25	71.00	71.13
EP1 X CM49	73.75	73.25	73.50
CM370 X CO264	72.25	71.50	71.88
Mean	72.31	72.00	
Total mean	72.89	72.59	72.74

TABLE 8. Mean number of days from seeding to 50% glazing for three groups of corn hybrids at Morden and Winnipeg.

	Morden	Winnipeg	Mean
Flint:			
F7 X F2	99.75	104.50	102.13
CO255 X F2	99.75	102.75	101.25
CM451 X CO255	102.75	104.75	103.75
Mean	100.75	104.00	
Dent:			
CM174 X CM220	105.50	103.75	104.63
CM385 X CM387	97.50	100.75	99.13
Q177 X CM49	99.25	100.50	99.88
CM327 X M38A	105.25	102.50	103.88
Mean	101.88	101.88	
Flint/Dent:			
CM370 X CM651	107.25	103.25	105.25
CM457 X CM182	99.00	103.75	101.38
EP1 X CM49	103.50	105.25	104.38
CM370 X CO264	101.75	99.75	100.75
Mean	102.88	103.00	
Total mean	101.93	102.86	102.4

TABLE 9. Mean number of days from seeding to 50% half-milk for three groups of corn hybrids grown at Morden and Winnipeg.

	Morden	Winnipeg	Mean
Flint:			
F7 X F2	116.8	123.5	120.0
CO255 X F2	115.8	122.8	119.3
CM451 X CO255	116.3	124.8	120.5
Mean	116.3	123.7	
Dent:			
CM174 X CM220	116.8	121.5	119.1
CM385 X CM387	110.5	115.8	113.1
Q177 X CM49	112.8	117.0	114.9
CM327 X M38A	115.0	118.3	116.6
Mean	113.8	118.2	
Flint/Dent:			
CM370 X CM651	114.5	119.0	116.8
CM457 X CM182	113.8	118.8	116.3
EP1 X CM49	113.8	123.3	118.5
CM370 X CO264	111.5	115.0	113.3
Mean	113.4	119.0	
Total mean	114.3	119.96	117.1

TABLE 10. Mean number of days from seeding to 50% black layer for three groups of corn hybrids grown at Morden and Winnipeg.

	Morden	Winnipeg	Mean
Flint:			
F7 X F2	130.5	136.0	133.3
CO255 X F2	132.3	133.5	132.9
CM451 X CO255	132.0	134.0	133.0
Mean	131.6	134.5	
Dent:			
CM174 X CM220	121.5	133.0	127.3
CM385 X CM387	120.8	122.5	121.6
Q177 X CM49	128.5	127.0	127.8
CM327 X M38A	129.3	126.5	127.9
Mean	125.0	127.3	
Flint/Dent:			
CM370 X CM651	132.3	127.8	130.0
CM457 X CM182	132.0	131.8	131.9
EP1 X CM49	129.5	134.5	132.0
CM370 X CO264	126.8	127.5	127.1
Mean	130.2	130.4	
Total mean	128.7	130.46	129.5

TABLE 11. Mean length of husks and length of ears (cm) of three groups of corn hybrids grown at Morden and Winnipeg.

	Length of husks		Length of husks	
	Morden	Winnipeg	Morden	Winnipeg
<u>Flint</u>:				
F7 X F2	20.26	20.37	17.18	17.72
CO255 X F2	20.16	20.44	18.31	20.13
CM451 X CO255	18.81	18.91	17.19	17.74
Mean	19.74	19.91	17.56	18.53
<u>Dent</u>:				
CM174 X CM220	20.22	20.09	17.18	19.24
CM385 X CM387	21.30	20.66	15.74	14.66
Q177 X CM49	19.16	19.94	16.11	16.50
CM327 X M38A	19.58	19.07	17.05	16.90
Mean	20.07	19.94	16.52	16.83
<u>Flint/Dent</u>:				
CM370 X CM651	21.79	21.91	18.24	18.47
CM457 X CM182	19.89	20.26	15.95	16.18
EP1 X CM49	20.81	20.95	15.51	16.69
CM370 X CO264	21.95	22.36	16.17	16.30
Mean	21.11	21.37	16.47	16.91
Total mean	20.36	20.46	16.78	17.33

TABLE 12. Mean number of husks for three groups of corn hybrids grown at Morden and Winnipeg.

	Morden	Winnipeg	Mean
Flint:			
F7 X F2	14.15	14.09	14.12
CO255 X F2	14.30	14.55	14.43
CM451 X CO255	15.25	15.19	15.22
Mean	14.57	14.61	
Dent:			
CM174 X CM220	12.95	14.15	13.55
CM385 X CM387	9.25	9.20	9.23
Q177 X CM49	13.40	11.60	12.50
CM327 X M38A	11.00	12.95	11.98
Mean	11.65	11.98	
Flint/Dent:			
CM370 X CM651	11.55	11.60	11.58
CM457 X CM182	14.10	15.30	14.70
EP1 X CM49	20.30	17.45	18.88
CM370 X CO264	11.30	10.85	11.08
Mean	14.31	13.80	
Total mean	13.41	13.36	13.39

TABLE 13. Mean tendency for husks to loosen naturally for three groups of corn hybrids grown at Morden and Winnipeg. These values are based on visual ratings from very tight husks (1) to very loose husks (5).

	Morden	Winnipeg	Mean
Flint:			
F7 X F2	1.50	1.93	1.72
CO255 X F2	1.85	2.05	1.95
CM451 X CO255	2.20	2.63	2.42
Mean	1.85	2.21	
Dent:			
CM174 X CM220	3.50	3.90	3.70
CM385 X CM387	2.60	2.45	2.53
Q177 X CM49	3.00	3.05	3.03
CM327 X M38A	2.90	4.05	3.48
Mean	3.00	3.36	
Flint/Dent:			
CM370 X CM651	2.15	3.35	2.75
CM457 X CM182	2.60	2.85	2.73
EP1 X CM49	3.90	3.55	3.73
CM370 X CO264	2.10	3.25	2.68
Mean	2.69	3.25	
Total mean	2.57	3.01	2.79

TABLE 14. Mean husk density (g) of three groups of corn hybrids grown at Morden and Winnipeg.

	Morden	Winnipeg	Mean
Flint:			
F7 X F2	0.153	0.144	0.148
CO255 X F2	0.155	0.138	0.147
CM451 X CO255	0.138	0.128	0.133
Mean	0.149	0.137	
Dent:			
CM174 X CM220	0.152	0.106	0.129
CM385 X CM387	0.110	0.094	0.102
Q177 X CM49	0.101	0.112	0.107
CM327 X M38A	0.136	0.125	0.130
Mean	0.125	0.109	
Flint/Dent:			
CM370 X CM651	0.129	0.119	0.124
CM457 X CM182	0.134	0.142	0.138
EP1 X CM49	0.111	0.122	0.116
CM370 X CO264	0.119	0.103	0.111
Mean	0.123	0.122	
Total mean	0.131	0.121	0.126

TABLE 15. Mean kernel test weight (kg/hl) for three groups of corn hybrids grown at Morden and Winnipeg.

	Morden	Winnipeg	Mean
Flint:			
F7 X F2	76.98	77.65	77.31
CO255 X F2	80.11	79.70	79.90
CM451 X CO255	77.32	77.99	77.65
Mean	78.14	78.45	
Dent:			
CM174 X CM220	75.64	74.63	75.13
CM385 X CM387	70.80	68.29	69.54
Q177 X CM49	77.49	75.96	76.72
CM327 X M38A	72.72	73.31	73.01
Mean	74.16	73.05	
Flint/Dent:			
CM370 X CM651	77.18	75.83	76.50
CM457 X CM182	77.57	75.09	76.33
EP1 X CM49	76.52	76.89	76.70
CM370 X CO264	77.16	77.30	77.23
Mean	77.11	76.28	
Total mean	76.32	75.69	76.00

TABLE 16. Mean pericarp thickness ( ) of the germinal and abgerminal sides of three groups of corn hybrids grown at Morden and Winnipeg.

	Locations		Kernel side	
	Morden	Winnipeg	Germinal	Abgerminal
Flint:				
F7 X F2	89.28	87.79	80.08	96.99
CO255 X F2	65.78	68.12	55.69	78.20
CM451 X CO255	57.50	56.21	46.29	67.41
Mean	70.85	70.71	60.69	80.87
Dent:				
CM174 X CM220	59.23	58.27	58.13	59.37
CM385 X CM387	43.91	38.92	35.02	47.81
Q177 X CM49	56.72	51.88	52.44	56.16
CM327 X M38A	54.56	53.93	47.11	61.38
Mean	53.61	50.75	48.18	56.17
Flint/Dent:				
CM370 X CM651	52.27	45.57	47.09	50.75
CM457 X CM182	49.33	46.65	38.01	57.97
EP1 X CM49	44.86	46.23	44.33	46.76
CM370 X CO264	44.85	42.82	43.09	44.58
Mean	47.83	45.32	43.13	50.02
Total mean	56.21	54.22	49.75	60.67

TABLE 17. Analysis of variance of percent ear moistures at physiological maturity for eleven corn hybrids grown at Morden and Winnipeg.

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F ratio	P value
Location (L)	1	1205.593	1205.593	1.16	0.275
Rep/L	4	4170.920	1042.730		
Hybrid (H)	10	10553.095	1055.310	4.19	0.000**
H*L	10	2079.076	207.908	0.83	0.607
Error H	40	10077.947	251.949		
Treatment (T)	3	40.090	13.363	0.59	0.621
T*L	3	135.663	45.221	2.01	0.116
H*T	30	531.525	17.717	0.79	0.775
H*T*L	30	1124.777	37.493	1.66	0.027*
Error T	132	2975.034	22.538		
Sub-error	1056	24877.599	23.558		
Total	1319	57771.317			

Mean = 42.78
Minimum = 24.50
Maximum = 68.00

*,** Significant at the 5% and 1% levels of significance, respectively.

TABLE 18. Analysis of variance of percent ear moisture four days after physiological maturity for eleven corn hybrids grown at Morden and Winnipeg.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
Location (L)	1	729.061	729.061	0.55	0.520
Rep/L	4	5292.606	1323.152		
Hybrid (H)	10	9258.006	925.801	3.62	0.002**
H*L	10	3039.105	303.911	1.19	0.327
Error H	40	10219.944	255.499		
Treatment (T)	3	923.304	307.768	8.42	0.000**
T*L	3	57.940	19.313	0.53	0.663
H*T	30	1767.479	58.916	1.61	0.035*
H*T*L	30	1160.210	38.674	1.06	0.398
Error T	132	4822.117	36.531		
Sub-error	1056	23869.099	22.603		
Total	1319	61138.872			

Mean = 37.49
Minimum = 20.00
Maximum = 59.00

*,** Significant at the 5% and 1% levels of significance, respectively.

TABLE 19. Analysis of variance of percent ear moisture at **eight days** after physiological maturity for eleven corn hybrids grown at Morden and Winnipeg.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
Location (L)	1	73.038	73.038	0.08	0.912
Rep/L	4	3732.267	933.067		
Hybrid (H)	10	8252.760	825.276	2.96	0.007**
H*L	10	3765.927	376.593	1.35	0.238
Error H	40	11152.616	278.815		
Treatment (T)	3	4829.884	1609.961	41.81	0.000**
T*L	3	213.759	71.253	1.85	0.141
H*T	30	2149.776	71.659	1.86	0.009**
H*T*L	30	1600.801	53.360	1.39	0.108
Error T	132	5082.417	38.503		
Sub-error	1056	29183.300	27.636		
Total	1319	70036.545			

Mean = 33.2
Minimum = 11.5
Maximum = 55.5

*,** Significant at the 5% and 1% levels of significance, respectively.

TABLE 2Ø. Analysis of variance of percent ear moisture **twelve days** after physiological maturity for eleven corn hybrids grown at Morden and Winnipeg.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
Location (L)	1	36.5ØØ	36.5ØØ	Ø.Ø8	Ø.913
Rep/L	4	1942.742	485.685		
Hybrid (H)	1Ø	1Ø655.143	1Ø65.514	5.Ø8	Ø.ØØØ**
H*L	1Ø	4383.819	438.382	2.Ø9	Ø.Ø49*
Error H	4Ø	8394.Ø76	2Ø9.852		
Treatment (T)	3	12488.86Ø	4162.953	98.39	Ø.ØØØ**
T*L	3	158.151	52.717	1.25	Ø.296
H*T	3Ø	1592.Ø65	53.Ø69	1.25	Ø.193
H*T*L	3Ø	1297.1Ø4	43.237	1.Ø2	Ø.446
Error T	132	5585.282	42.313		
Sub-error	1Ø56	31555.1ØØ	29.882		
Total	1319	78Ø88.841			

Mean = 28.Ø6
Minimum = 8.ØØ
Maximum = 52.ØØ

*,** Significant at the 5% and 1% levels of significance, respectively.

TABLE 21. Analysis of variance of percent ear moisture **four days** after physiological maturity relative to **percent** ear moisture at physiological maturity for eleven corn hybrids grown at Morden and Winnipeg.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
Location (L)	1	0.002651	0.002651	0.02	0.865
Rep/L	4	0.614164	0.153541		
Hybrid (H)	10	1.678885	0.167888	1.86	0.081
H*L	10	1.367004	0.136700	1.51	0.171
Error H	40	3.613448	0.090336		
Treatment (T)	3	0.434595	0.144865	12.41	0.000**
T*L	3	0.072953	0.024318	2.08	0.105
H*T	30	0.560869	0.018695	1.60	0.038*
H*T*L	30	0.385811	0.012860	1.10	0.344
Error T	132	1.541006	0.011674		
Sub-error	1056	8.318388	0.007877		
Total	1319	18.589774			

Mean = 0.88046
Minimum = 0.45536
Maximum = 1.35000

*,** Significant at the 5% and 1% levels of significance, respectively.

TABLE 22. Analysis of variance of percent ear moisture **eight days** after physiological maturity relative to **percent** ear moisture at physiological maturity for eleven corn hybrids grown at Morden and Winnipeg.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
Location (L)	1	0.140363	0.140363	0.85	0.323
Rep/L	4	0.670730	0.167683		
Hybrid (H)	10	2.485898	0.248589	2.561	0.017*
H*L	10	1.358233	0.135823	1.399	0.216
Error H	40	3.882873	0.097072		
Treatment (T)	3	2.839916	0.946639	61.208	0.000**
T*L	3	0.209231	0.069744	4.509	0.005**
H*T	30	0.753737	0.025125	1.625	0.033*
H*T*L	30	0.673175	0.022439	1.451	0.08
Error T	132	2.041506	0.015466		
Sub-error	1056	12.032080	0.011394		
Total	1319	27.087742			

Mean = 0.78019
Minimum = 0.28395
Maximum = 1.34146

*,** Significant at the 5% and 1% levels of significance, respectively.

TABLE 23. Analysis of variance of days required to reach 50% silking and 50% glazing for eleven corn hybrids grown at Morden and Winnipeg.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
50% Silking					
Location (L)	1	1.920	1.920	0.80	0.405
Error L	6	14.341	2.390		
Hybrid (H)	10	92.114	9.211	29.23	0.000**
L*H	10	3.705	0.370	1.18	0.325
Error H	60	18.909	0.315		
Total	87	130.989			

Mean = 72.74
Minimum = 71.00
Maximum = 75.00

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
50% Glazing					
Location (L)	1	19.102	19.102	1.12	0.331
Error L	6	102.705	17.117		
Hybrid (H)	10	345.955	34.595	11.01	0.000**
L*H	10	188.773	18.877	6.01	0.000**
Error H	60	188.545	3.142		
Total	87	845.080			

Mean = 102.40
Minimum = 97.00
Maximum = 108.00

*,** Significant at the 5% and 1% levels of significance, respectively.

TABLE 24. Analysis of variance of days required to reach 50% half-milk and 50% black layer maturity for eleven corn hybrids grown at Morden and Winnipeg.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
50% Half-milk					
Location (L)	1	698.909	698.909	29.20	0.002**
Error L	6	143.591	23.932		
Hybrid (H)	10	538.364	53.836	12.10	0.000**
L*H	10	81.091	8.109	1.82	0.076*
Error H	60	266.909	4.449		
Total	87	1728.864			

Mean = 117.11
Minimum = 110.00
Maximum = 129.00

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
50% Black layer					
Location (L)	1	63.920	63.920	6.77	0.041*
Error L	6	56.614	9.436		
Hybrid (H)	10	1026.114	102.611	22.02	0.000**
L*H	10	389.705	38.970	8.36	0.000**
Error H	60	279.636	4.661		
Total	87	1815.989			

Mean = 129.51
Minimum = 119.00
Maximum = 137.00

*,** Significant at the 5% and 1% levels of significance, respectively.

TABLE 25. Analysis of variance of the length of husks and length of ears for eleven corn hybrids grown at Morden and Winnipeg.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
Length of husks					
Location (L)	1	1.024	1.024	0.45	0.831
Rep/L	6	13.728	2.288		
Hybrid (H)	10	355.485	35.548	23.35	0.000**
Error	60	91.312	1.522		
Subsample ERROR	352	468.830	1.332		
Total	429	930.380			
Mean = 20.44 Minimum = 16.30 Maximum = 24.30					
Length of ears					
Location (L)	1	27.060	27.060	6.49	0.015*
Rep/L	6	25.024	4.171		
Hybrid (H)	10	572.989	57.299	17.287	0.000**
Error	60	198.864	2.114		
Subsample ERROR	352	744.178	2.114		
Total	429	1568.116			
Mean = 17.10 Minimum = 8.90 Maximum = 22.40					

*,** Significant at the 5% and 1% levels of significance, respectively.

TABLE 26. Analysis of variance of the number of husks and the tendency for husks to loosen for eleven corn hybrids grown at Morden and Winnipeg.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
Number of husks					
Location (L)	1	0.278	0.278	0.26	0.901
Rep/L	6	6.365	1.061		
Hybrid (H)	10	2530.448	253.045	55.89	0.000**
Error	60	271.675	4.528		
Subsample error	352	1186.072	3.370		
TotaL	429	3994.838			

Mean = 13.35
Minimum = 7.00
Maximum = 26.00

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
Tendency of husks to loosen					
Location (L)	1	16.900	16.900	16.97	0.000**
Rep/L	6	5.978	0.996		
Hybrid (H)	10	142.086	14.209	6.979	0.000**
Error	60	185.650	2.036		
Subsample error	352	185.650	0.527		
Total	429	472.770			

Mean = 2.77
Minimum = 1.00
Maximum = 5.00

*,** Significant at the 5% and 1% levels of significance, respectively.

TABLE 29. Analysis of variance of the husk density and kernel test weight of eleven corn hybrids grown at Morden and Winnipeg.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F ratio	P value
Husk density					
Location (L)	1	0.008	0.008	4.00	0.060
Rep/L	6	0.015	0.002		
Hybrid (H)	10	0.084	0.008	3.51	0.001**
Error	60	0.143	0.002		
Subsample error	352	0.765	0.002		
Total	429	1.015			
Mean = 0.125 Minimum = 0.049 Maximum = 0.880					
Kernel test weight					
Location (L)	1	8.243	8.243	6.21	0.047*
Error L	6	7.963	1.327		
Hybrid (H)	10	585.179	58.518	40.13	0.000**
L*H	10	28.696	2.870	1.97	0.539
Error H	58	84.572	1.458		
Total	85	714.654			
Mean = 75.9 Minimum = 67.35 Maximum = 80.68					

*,** Significant at the 5% and 1% levels of significance, respectively,