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Comparative Field Drying of *Bt* and Non-*Bt* Corn Stover Fractions after Grain Physiological Maturity*

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Abstract: Information is limited about dry down of corn stover fractions of standing plants in the field after grain physiological maturity has been reached, especially for the new *Bt* hybrids. These data are important in scheduling grain/stover harvest for bioenergy production or other industrial applications. Dry down of the aboveground morphological components of two corn cultivars (Pioneer 32K61 and 32K64 *Bt*) was studied in standing plants from roughly one week before the R6 stage (40% MC w.b.) until four weeks after grain was harvested from surrounding field plots. When moisture of the various aboveground corn plant fractions was expressed on a dry matter basis and plotted over time, the resulting curves visually displayed a linear decrease to a flat asymptote. Linear multi-source regression indicated that dry down of all plant fractions of *Bt* and non-*Bt* hybrids is a linear process and that rates of dry down did not differ between cultivars except for the husk.

Key words: *Bt* corn, field drying, field drydown, plant fractions, *Bt* hybrids, husk, corn stover fractions

Introduction

Corn stover is considered a primary crop residue for bioenergy and industrial applications because of its abundance and its current underutilization (Glassner *et al*., 1998; Hettenhaus *et al*., 2000; Sokhansanj *et al*., 2002). However, key issues that need addressing are how to harvest and process corn stover to maximize its quality as a fuel or industrial feedstock, minimize material losses and improve handling efficiencies (Erbach, 2003; Pordesimo *et al*., 2004). Data on quality, quantity and drying rate of the corn plant fractions are essential in the development of equipment and cost-effective systems for corn stover collection and handling. This data is also important in scheduling grain/stover harvest so that harvest amounts of grain and biomass are maximized, determining strategies for moisture control and quantifying available material for bioenergy production.

Information is limited about the drying of corn stover fractions of standing plants in the field after the R6 Stage (grain physiological maturity) has been reached. Grain physiological maturity is defined as the time of attainment of maximum grain dry weight. Moisture content of corn at this stage may

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range from 35 to 40% w.b. The information lack is further compounded by the increased planting of the new transgenic corn hybrids containing a modified *Bacillus thurengensis* (*Bt*) gene to minimize crop loss due to the European corn borer (*Ostrinia nubilalis* [Hübner]), a major economic pest of corn throughout the US Corn Belt and much of North America (Graeber *et al*., 1999). These transgenic plants, commercially available since 1996 (Faust, 1999), produce a protein in their tissues that is insecticidal to the European corn borer and other Lepidopteran pests. During the 1996 cropping, transgenic *Bt* corn accounted for just about 1% of the commercial corn acreage in the US by 1998, almost 22% of the US commercial corn acreage was planted to *Bt* corn (James, 1998). Despite the reported higher analyzed lignin content of *Bt* corn compared to their respective non *Bt* isolines (Folmer *et al*., 2002; Saxena and Stotzky, 2001), it was hypothesized there would be no differences in the dry down rates. Thus, the objective of this study was to compare the in-field drying rates of aboveground fractions (stalk, cob, leaf, husk and grain) of standing *Bt* and non-*Bt* corn plants just before, during and after the grain reaches a suitable moisture for harvest.

Materials and Methods

Test Material

As described in Pordesimo *et al*. (2004), available Pioneer 32K64 (Pioneer Hi-Bred USA, Des Moines, Iowa), a *Bt* hybrid and its non-*Bt* isoline, Pioneer 32K61, planted in experimental plots at the University of Tennessee, Knoxville Experiment Station, Plant Sciences Unit in 2001. Sampling started at the late R5 stage (August 9, 2001) and continued until four weeks after the time the grain was deemed suitable for harvest (November 26). Examination of product literature indicated that Pioneer 32K64 was likely derived through the MON810 transformation event. Two replicate samples consisting of two plants were obtained from hybrid each over the monitoring period. The replicates were harvested from different experimental blocks. The cut plants were carefully separated into leaves (leaf blades only), stalks (including tassel and leaf sheaths), husks (including the shank) and ears. Grain was separated from the cob through hand shelling.

Moisture content of the different plant components was determined according to ASAE (2000a, b). All plant fractions except the grain were treated as forage and were dried for 24 h at 103°C. To improve sample uniformity and enhance drying, the cob and husk were cut into 2.54 cm pieces before being placed into the convection oven. Stalks and leaves were separately shredded in a chipper/shredder. The grain was dried for 72 h at 103°C.

Statistical Methods

Dry down of the aboveground morphological components of standing *Bt* and non-*Bt* corn plants is shown as a change in wet basis moisture content over time in Fig. 1. As noted by Edens *et al*. (2002), visually there was no apparent difference in the field drying trends for the different components of the two hybrids. Statistical analysis of the time change in dry basis moisture contents was undertaken to confirm this observation. Figure 1 shows that all the plant fractions lost moisture slowly except the leaf, which dried very rapidly after grain physiological maturity was reached (around 40% grain moisture in this study). Consistent with Brooking (1990), the grain started losing moisture even before grain physiological maturity had been reached.

Dry down curves showing the change in dry basis moisture content of the different aboveground plant components over the monitoring period, represented as the time from the start of sampling, visually displayed a linear decrease to a flat asymptote. The break point date for each component was

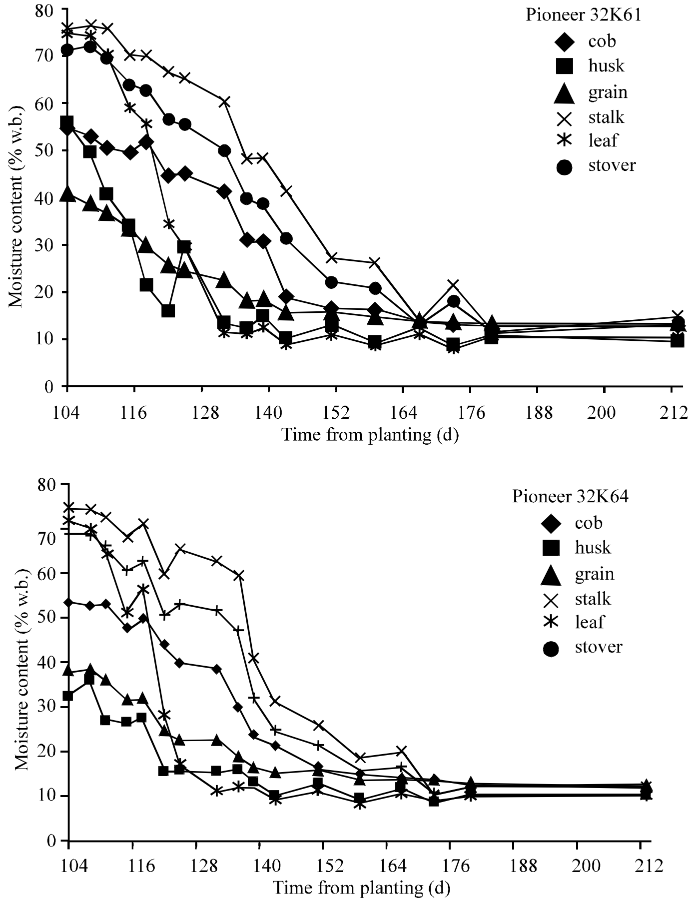

Fig. 1: Variation in moisture content of morphological components of standing *Bt* and non-*Bt* hybrids over a 109-day sampling period after grain physiological maturity had been reached

visually set and data before and after this date were separately analyzed with a linear multi-source regression model using the GLM procedure (SAS Institute Inc., 2000). Differences between replications were blocked on.

Results and Discussion

Table 1 shows regression equations during the dry down period. Rate of drying differed only for husk, where 32K61 began with higher moisture, then dried out about twice as fast to reach the same asymptote. For both hybrids, drying rates during the dry down period were highest for the leaf, followed in turn by the stalk, cob and grain. Hybrid intercepts differed for leaf, husk, stover and the whole plant, with 32K61 always having higher moisture content at the start of the study. These results imply that 32K64 began dry down sooner, or had lower moisture contents systematically. Figures 2-8 reflect the high R-squares in Table 1 and show parallel dry down lines for both hybrids with 32K64 having the lower curve and therefore, comparatively lower moisture content of its morphological

Table 1: Variety comparison of dry down linear regressions

Variables	Intercept 32K61	Intercept 32K64	Slope 32K61	Slope 32K64	R-square
Cob	128.0 (4.2)	125.3 (4.6)	-2.4 (0.2)	-2.5 (0.2)	0.90
Husk	108.7* (7.4)	53.6* (8.3)	-3.8* (0.4)	-1.4* (0.5)	0.79
Grain	66.6 (1.8)	64.2 (1.8)	-1.4 (0.1)	-1.3 (0.1)	0.93
Stalk	333.3 (12.5)	306.7 (13.5)	-6.5 (0.5)	-5.9 (0.6)	0.88
Leaf	327.5* (16.6)	274.0* (19.1)	-13.3 (1.2)	-11.6 (1.3)	0.91
Stover	282.3* (9.9)	251.9* (10.7)	-5.9 (0.4)	-5.1 (0.4)	0.90
Whole Plant	221.5* (7.3)	195.7* (8.0)	-4.8 (0.3)	-4.2 (0.3)	0.92

*Interceptor slope parameters differ between varieties ($p<0.05$), **Numbers in parenthesis are standard errors

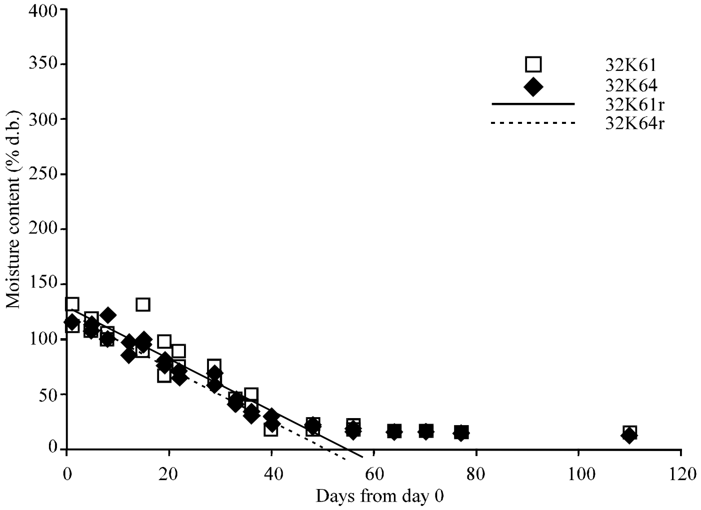

Fig. 2: Comparative dry down of cobs in standing *Bt* and non-*Bt* corn plants after grain physiological maturity

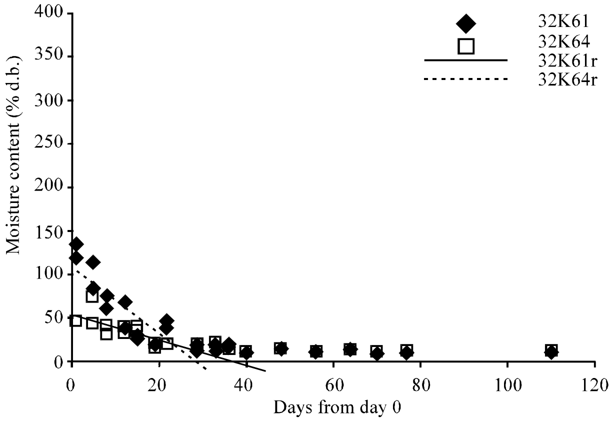

Fig. 3: Comparative dry down of husks in standing *Bt* and non-*Bt* corn plants after grain physiological maturity

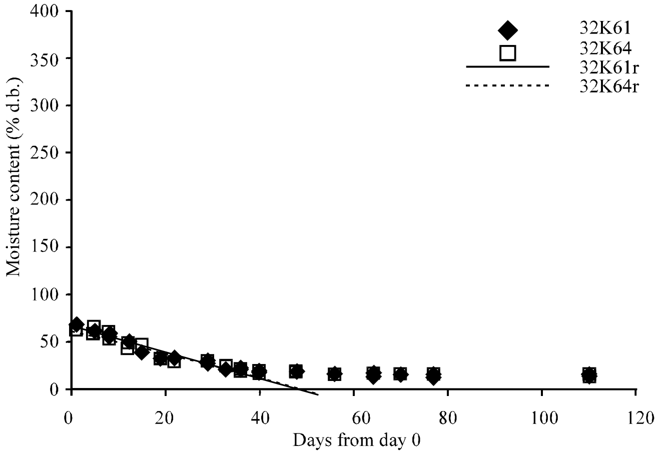

Fig. 4: Comparative dry down of grain in standing *Bt* and non-*Bt* corn plants after grain physiological maturity

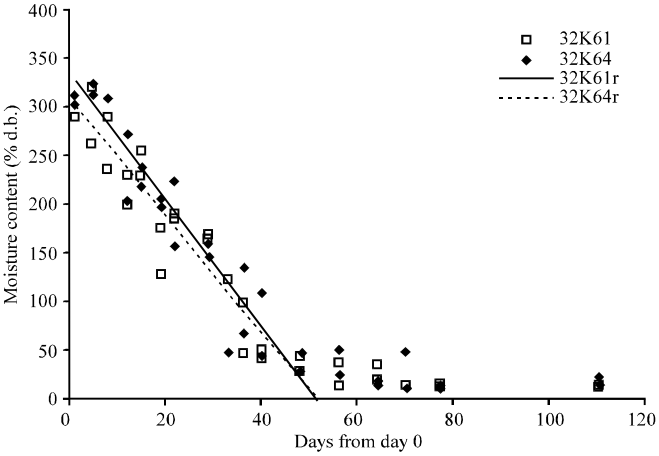

Fig. 5: Comparative dry down of stalks in standing *Bt* and non-*Bt* corn plants after grain physiological maturity

components. As indicated by the regression analysis, the dry down process of corn plants standing in the field after grain physiological maturity is a linear process, apart from fluctuations that can be attributed to environmental conditions. After dry down to the asymptote at about 10-13% moisture d.b., all stover fractions except leaf continued to slow dry down ($p<0.05$), but no differences in intercepts or slopes were found between varieties.

In evaluating *Bt* corn for silage (plant stages before R6), Faust (1999) found MON810 hybrids to have higher moisture contents than similar silage from their near isogenic counterparts when harvested as fresh silage at early R6. This reported result is difficult to explain considering that there was a relative lack of chemical composition differences between the *Bt* and non-*Bt* hybrids. Studying *Bt* and non-*Bt* hybrids from transformation event *Bt* 11, Folmer *et al*. (2002) likewise found a relative lack of chemical composition differences between the hybrids. Faust (1999) noted that the moisture

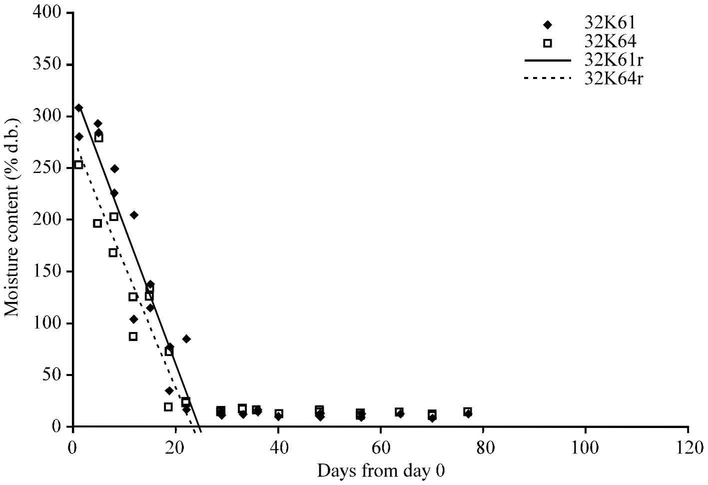

Fig. 6: Comparative dry down of leaves in standing *Bt* and non-*Bt* corn plants after grain physiological maturity

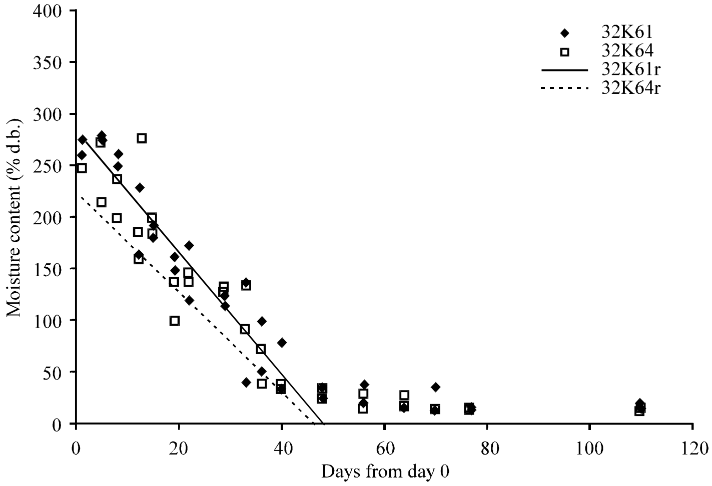

Fig. 7: Comparative dry down of aggregate stover in standing *Bt* and non-*Bt* corn plants after grain physiological maturity

content difference between fresh cut silage from MON810 hybrids and their near isogenic counterparts at blacklayer supports other reports documenting the greater stay-green tendency for *Bt* hybrids. Since this result is for a different corn plant maturity stage, it is not necessarily in conflict with the results of this present study. Rather the previous results for early R6 corn and the results of this study for late R6 corn combine to indicate that *Bt* hybrids seemingly stay greener (higher moisture content) before grain physiological maturity than their isogenic counterparts and tend to have lower moisture contents once that plant stage is reached.

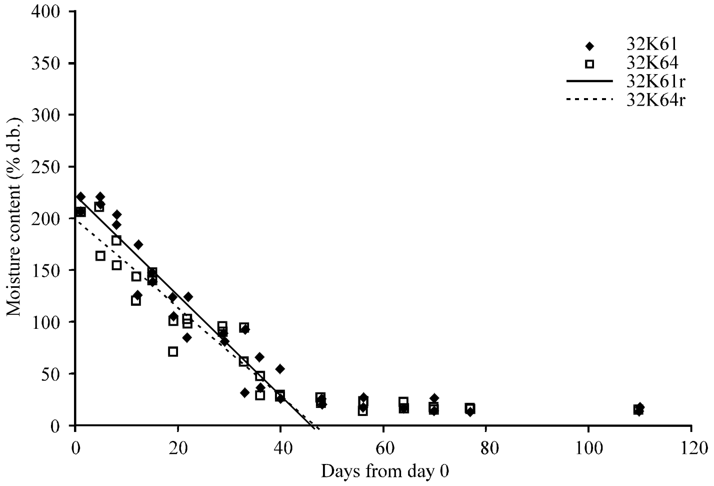

Fig. 8: Comparative dry down of whole plants in standing *Bt* and non-*Bt* corn plants after grain physiological maturity

Conclusions

When moistures of the different aboveground corn plant fractions sampled at intervals at the R6 stage were expressed on a dry matter basis and plotted over time, the resulting curves visually displayed a linear decrease to a flat asymptote. Linear multi-source regression indicated that dry down of all plant fractions of *Bt* and non-*Bt* hybrids is a linear process and that rates of dry down did not differ between cultivars except for the husk. It also confirmed the visual observation that the dry down rates were highest for the leaf followed in turn by stalk, cob, husk and grain for both hybrids. After dry down to about 10-13% d.b., changes over date occurred for all stover fractions except leaf, but no differences were found between varieties. The resultant lower intercepts and lower linear slopes obtained for the *Bt* hybrid indicate that after grain physiological maturity the *Bt* hybrid had a lower moisture content than its near isogenic counterpart. Combined with results obtained for *Bt* hybrids at early R6, this result from this study indicates that *Bt* hybrids seemingly stay greener before grain physiological maturity than their near isogenic counterparts and tend to dry out faster once grain physiological maturity is reached.

Acknowledgements

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