SILAGE SPECIFIC CORN HYBRIDS FOR SILAGE PRODUCTION IN KENTUCKY

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Abstract

Four corn hybrid types at three plant densities and two nitrogen rates were evaluated for forage yield, forage quality and ensiled quality. The four hybrid types included nutri-dense (ND), waxy (WX), leafy (LF), and dual-purpose (DP); while the three target plant densities were 54 000, 68 000, and 81 000 plants ha; and the nitrogen rates were 134 and 224 kg ha^{-1}. WX consistently had low forage and grain yields compared with the other types. When averaged over nitrogen rate and hybrid, plant density had no effect on grain yield for the 2005 growing season but did in 2003 and 2004. When averaged over plant density and hybrid, nitrogen rate had no effect on forage yield. Crude protein increased with increased nitrogen when averaged over all hybrids and plant densities in 2003.

Introduction

With the decrease in tobacco production, many farmers in Kentucky are increasing the number of cattle in their operations. Potential high quality forage for those cattle is corn silage. The United States is the world leader in corn forage area, producing up to 4 million ha annually (Lauer et al., 2001). However, seed companies have become interested in developing hybrids that are targeted at silage producers (Ballard et al., 2001; Johnson et al., 1997; and Kuehn et al., 1999). These silage specific hybrids have traits other than increased grain yield that may benefit silage producers.

Traditionally producers have used dual purpose hybrids (DP) for both grain and silage production. Increases in forage yield can be attributed to increases in grain yield by the corn hybrids (Lauer et al., 2001). Akay et al. (2002) determined that two of the silage type hybrids, nutri-dense (ND) and waxy (WX) were suitable replacements for DP corn when producing silage. Dwyer et al. (1998) indicates that approximately 16% of the silage corn produced in North America is from Leafy hybrids (LF), while Clark et al. (2002), through a personal interview with J. Varnett of Tender Leafy Corn, notes that 17.5% of North American Silage is produced from LF.

Studies have shown that corn hybrid will affect yield (Clark et al., 2002; Hunt et al., 1992; Hunt et al., 1993; Johnson et al., 1985; Roth, 1994; Xu et al., 1995). Johnson et al. (2002) also found hybrid to affect dry matter (DM) of whole plant corn silage (WPCS), while Darby and Lauer (2002) found hybrids to not affect DM yield. Also, Coors et al. (1994) determined that hybrids with high grain yields may not necessarily be the highest yielding silage hybrids. Bal et al. (2000) showed a forage yield advantage for LF over DP hybrids. Widdicombe and Thelen (2002) also found full season LF hybrids to provide a yield advantage, with ND having the second highest yield, followed by DP and an early season LF.

Lauer et al. (2001) stated that little change in forage quality has occurred in the stover of corn hybrids available in the Northern Corn Belt. However, Johnson (2002) found that the chemical characteristics of corn silage were affected by hybrid. Clark (2002) notes that studies have shown hybrid differences in percent ear, percent grain, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and invitro dry matter digestibility (IVDMD) (Hunt et al., 1992; Hunt et al., 1993; Johnson et al., 1985; Roth, 1994; and Xu et al., 1995). When working with DP, WX, and ND hybrid types Akay and Jackson (2001) found the WX to have lower NDF, ADF and CP than the other hybrids, but ND had the highest levels of starch. Bal et al. (2002) reported lower pH and lactate concentration for a LF hybrid than a DP. While Clark (2002) states that the softer starch in the grain of LF hybrids may enhance digestibility. Bal et al. (2000) found the high starch digestibility for LF hybrids to be offset by lower NDF digestibility. Kuehn et al. (1999) reported increased IVDMD for a LF hybrid over DP. Akay et al. (2002) found the starch in WX to be more digestible in the rumen that that of DP.

Cox (1997) determined that silage corn should, on average be planted at plant densities 7.5% higher than DP corn grown for grain in New York State. Seed companies often, however, recommend lower populations for LF corn hybrids than DP (Bal et al., 2000). Plant density plays an important role in yield because according to Andrade and Abbate (2005) early signals allow plants to detect neighboring plants and respond to them. This response may include changing the allocation of DM (Aphalo and Ballare, 1995; Ballare et al., 1994). Tollenaar (1999) determined modern hybrids were able to produce at higher densities, and have less lodging at those densities than were older hybrids. Widdicombe and Thelen (2002) found an increase in plant density significantly increased yield. They observed that their maximum density of 88 900 plants ha^{-1} did not allow for the establishment of a maximum yield. Cox and Cherney (2001) also observed increased yield at higher densities in one study, but found no yield differences across densities in a second study. Martin et al. (2004) determined that higher plant densities increased interplant competition which may increase plant to plant variability, but Andrade and Abbate (2005) reported less tillering in dominant plants, and since higher densities promote dominant plants there should also more effectively use resources. Widdicombe and Thelen (2002) verified this when they found that the highest plant density used in their study (90 000 plants ha^{-1}) produced the highest grain yield.

Nitrogen (N) is often the limiting factor in corn production. Mehdi et al. (1999) concluded that changes in crop N may be influential in yield and plant growth. Since silage is harvested as a whole plant the plant growth aspect is very important. In the same study Mehdi et al. (1999) also determined that corn yield is not related to the concentration of N in corn stover.
Typical N recommendations in Kentucky for corn silage and grain are the same, and range from about 112 kg ha^{-1} and 224 kg ha^{-1} depending upon previous crop, soil drainage type, and tillage.

Materials and Methods

The study was conducted for three years at one location. The first two years four corn hybrids were used, and the third year a fifth hybrid was introduced into the study. The study was conducted as a split-split plot design with hybrid being the main plot, plant density the first split, and N-rate the second split. Three replications were used and the plot area was 3 m by 9 m in 76 cm rows. The hybrid types used the first two years were ND, WX, LF, and DP, while for the third year an additional Dual Purpose (DP2) was added. Target plant densities were 54 300, 68 000, and 81 500 plants ha^{-1}. N-rates were 134 kg ha^{-1} and 224 kg ha^{-1}.

Seed was planted in late April of 2003, 2004, and 2005 into no-till conditions at University of Kentucky Spindletop research farm. All nutrients other than N were applied based upon soil test results at the recommendations made by the University of Kentucky for corn production. Growth stage was checked periodically throughout the growing season. Silage harvest was targeted for ½ to ¾ kernel milk line. At silage harvest two 3m sections of row were harvested with whole plant weights, stover weights, and ear weights were taken on one 3 m row, while the other 3 m of row was chopped. From the chopped material samples were taken to determine DM, and pre-ensiling quality.

Corn grain was harvested at harvest maturity, Harvest weights were taken, DM calculated, and both cob and grain dry weights taken. Grain yield was then determined.

Data was analyzed using Proc GLM in SAS v9.1 (SAS institute, Cary, NC). Differences were determined based upon protected LSD results.

Results

Growing season interacted with forage DM yield, corn grain yield, and NDF of green chop, so those crop characteristics are reported by year. Corn hybrid significantly effected silage DM yield in 2003 and 2005, while it did not affect silage DM yield in 2004. In both 2003 and 2005 the WX hybrid yielded significantly lower than the other hybrids in the study. Contrary to the findings of Widdicombe and Thelen (2002), a yield advantage was not found for LF over the other hybrids any year.

Seeding rate did not significantly affect silage yield in 2003, but did in 2004 and 2005. In those years the lowest seeding rate (54 300 seeds ha^{-1}) produced significantly lower yields than the other two rates. As with Widdicombe and Thelen (2002) a maximum yield could not be establish based upon seeding rate in 2004 and 2005 because the highest yield was observed at the highest seeding rate. N-rate did not significantly affect yield in any year.

Table 1. Silage yield for 2003, 2004, and 2005 for each hybrid type, seeding rate, and N-rate.

		Year		
		2003	2004	2005
		Silage DM Yield (Mg ha^{-1})		
Hybrid	ND	7.5	22.3	9.7
	DP	8.0	19.2	10.3
	LF	7.5	18.7	10.3
	WX	5.8	19.8	7.9
	DP2			9.9
	LSD(0.05)	0.6	*NS	0.9
Seeding Rate	54 300 ha^{-1}	7.0	18.3	8.9
	68 000 ha^{-1}	7.1	20.2	9.9
	81 500 ha^{-1}	7.4	21.5	10.2
	LSD(0.05)	*NS	1.3	0.7
N-Rate	134 kg ha^{-1}	7.0	20.5	9.7
	224 kg ha^{-1}	7.3	19.5	9.6
	LSD(0.05)	NS	NS	NS

*NS signifies non-significance due to experimentwise error

Hybrid type significantly effected grain yield all three years of the study with LF and WX consistently being among the lowest yielding hybrids. This seems logical because the silage benefits that they are supposed to provide are directly related to the stover, while ND's benefits are related to the grain. Seeding rate significantly effected grain yield in 2003 and 2004, but did not in 2005. This was probably a result of low yields in 2005 due to a drier growing season. N-rate was only significant in 2004 when growing conditions were the most favorable.

Table 2. Grain yield for 2003, 2004, and 2005 for each hybrid type, seeding rate, and N-rate.

		Year		
		2003	2004	2005
		Grain Yield (Mg ha^{-1}) at 15.5% moisture		
Hybrid	ND	13.1	14.7	5.9
	DP	13.5	14.1	5.1
	LF	11.4	9.9	5.7
	WX	10.9	12.4	4.7
	DP2			5.9
	LSD(0.05)	1.1	1.0	0.6
Plant Density	54 300 ha^{-1}	11.5	11.9	5.6
	68 000 ha^{-1}	12.7	12.9	5.5
	81 500 ha^{-1}	12.4	13.5	5.3
	LSD(0.05)	1.0	0.9	*NS
N-Rate	134 kg ha^{-1}	12.0	13.2	5.6
	224 kg ha^{-1}	12.4	12.4	5.4
	LSD(0.05)	NS	0.7	NS

*NS signifies non-significance due to experimentwise error

NDF of the forage green chop was significantly affected by hybrid in 2003 and 2004, but not in 2005 (Table 3). As with the grain yield, this could also be contributed to the poor growing conditions experienced in 2005. WX had relatively low NDF all three years, which would agree with Akay and Jackson (2001). Seeding rate was only significant in 2003, and N-rate did not significantly affect NDF.

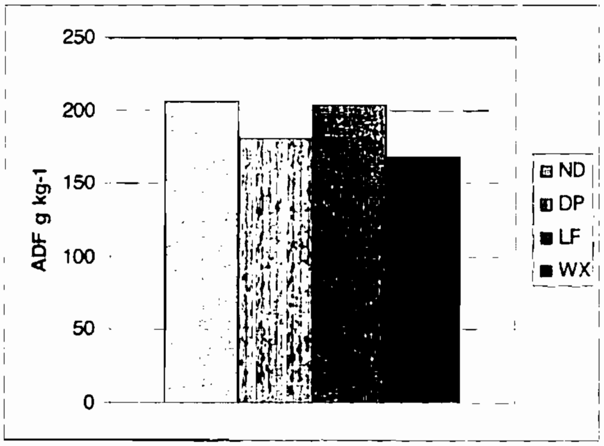
Table 3. ADF of green chop for 2003, 2004, and 2005 for each hybrid type, seeding rate, and N-rate.

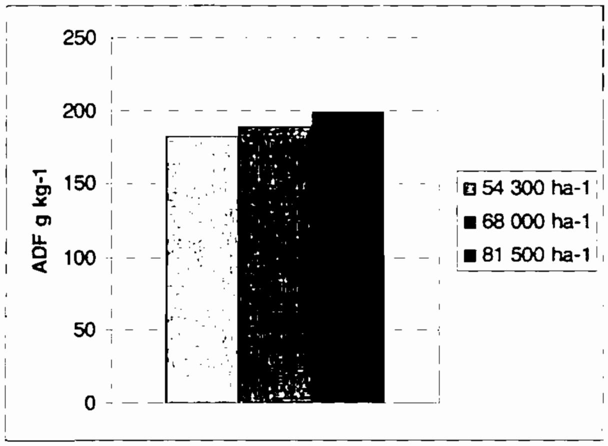
		Year		
		2003	2004	2005
		NDF green chop (g kg^{-1})		
Hybrid	ND	417	383	464
	DP	383	353	459
	LF	414	400	448
	WX	375	317	455
	DP2			472
	LSD(0.05)	22	26	*NS
Plant Density	54 300 ha^{-1}	383	359	463
	68 000 ha^{-1}	396	360	455
	81 500 ha^{-1}	412	371	461
	LSD(0.05)	19	*NS	*NS
N-Rate	134 kg ha^{-1}	401	367	467
	224 kg ha^{-1}	393	360	452
	LSD(0.05)	NS	NS	NS

*NS signifies non-significance due to experimentwise error

Hybrid and seeding rate significantly influenced ADF of green chop. WX had the lowest ADF for 2003 and 2004, which agrees with Akay and Jackson (2001). The highest plant density produced the highest ADF.

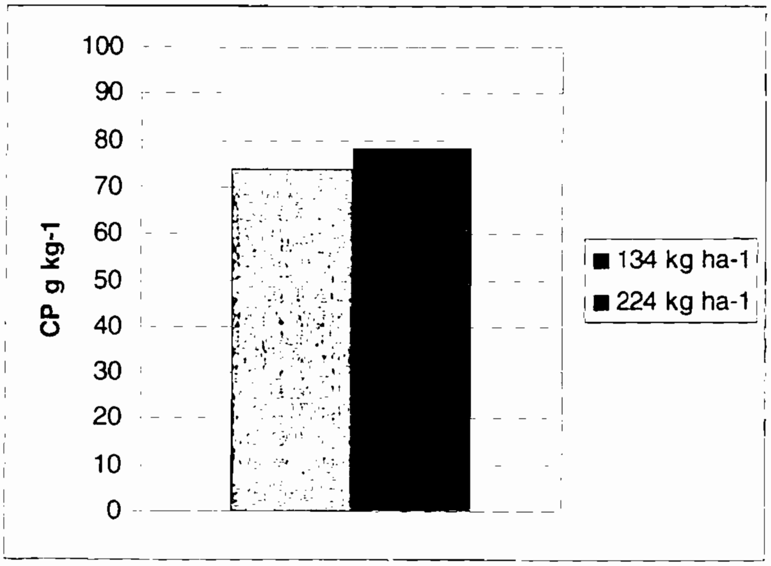
Figures 1 and 2. ADF g kg^{-1} by hybrid (LSD=11 g kg^{-1}), and by seeding rate (LSD=9 g kg^{-1}), averaged over 2003 and 2004.





CP was significantly affected by N-rate in 2003. The higher N-rate (224 kg ha^{-1}) produced significantly higher CP in the green chop sample. Hybrid and seeding rate were not significant for CP.

Figure 3. Crude Protein (g kg^{-1}) for each N-rate in 2003 (LSD= 3 g kg^{-1})



Conclusion

Preliminary results indicate that no change is needed in the current Kentucky silage production recommendations for hybrid or N-rate. While some of the silage specific hybrids did excel at individual aspects of the study, and may be equally as effective as a DP hybrid, none thus far have proven to be better overall than a DP hybrid. Seeding rates used in the study did not allow for an establishment of a maximum silage yield for any of the three years of the study. Additional research on forage yield and seeding rate is needed.

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