FACTORS AFFECTING DEER USE OF HYBRID CORN IN WINTER

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ABSTRACT

We compared white-tailed deer (Odocoileus virginianus) use of 15 field corn (Zea mays) hybrids grown in food plots near 3 deer wintering areas in southwestern Minnesota, 1987-88. Physical and morphological characteristics of corn varied significantly among sites, subplots and among hybrids. Deer use of hybrids was significantly different and 5 use groups of hybrids were identified. A significant linear relationship was found between use and ear height. Hybrids with higher ears and less husk coverage were preferred by deer. These findings suggest that deer preferences for corn hybrids are affected more by deer pressure, ear height and husk coverage than by morphological variables which could affect deer mastication and mouth prehension. A 1988-89 study of 2 hybrids planted in food plots corroborated our preference rankings.

INTRODUCTION

Field corn has been the principal source of winter food for white-tailed deer in the Midwestern agricultural states (Erickson et al. 1961, Korschgen 1962, Nixon et al. 1970). In late fall deer feed on corn left as crop residue, but when snow becomes deep they shift to available standing corn. Because availability of crop residue was often reduced by fall plowing (Warner et al. 1985), snowfall or consumption by other wildlife, standing corn in food plots has been provided for deer by state agencies (Ludwig 1980). The Minnesota Department of Natural Resources (DNR) has provided 1-3 ha corn food plots near selected deer wintering areas to sustain deer populations until other foods become available (Kopischke 1975).

Deer wintering areas in southwestern Minnesota are located in wooded river valleys or wetlands and commonly hold 10-40 deer/km^2. When winter weather has been severe, feeding pressure on corn food plots has been high. Alternatively, when inclement fall weather delays the corn harvest, stands of unharvested corn have been susceptible to deer depredation (Erickson et al. 1961). Although corn damage most often occurs in summer, severe depredation has occurred on unharvested fields adjacent to deer wintering areas (Dahlberg and Guettinger 1956, Erickson et al. 1961). Where corn food plots have been available to wintering deer, most crop depredation has been reduced (Ludwig 1980).

Hybrid corn has been used in food plots because the ears usually extend above snow cover and the stalks withstand strong winds and/or heavy precipitation without falling (standability). Deer preference for corn hybrids planted in winter food plots has not been investigated. If deer exhibit preferences among corn hybrids, farmers could reduce

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Table 1. Deer abundance, wintering area size and food plot size on sites used to evaluate deer preference for hybrid corn in southwestern Minnesota, 1987-1989.

Site	Estimated 1988 deer abundance[a]	Wintering area (ha)	Food plot (ha)
Bennett	50-70	135	1.8
Kilen	100-140	1220	0.7
Olson	50-70	136	1.2
Monson[a]	NA	148	2.0

[a]This site was used for the food plot management study only.

crop depredation by planting less preferred hybrids, while wildlife managers could plant more preferred hybrids in food plots. In this study we evaluated the variation in hybrid corn morphological and physical characteristics, and compared deer preference for corn hybrids in food plots. We subsequently tested the strength of deer preference for corn hybrids with a food plot management study.

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STUDY AREA AND METHODS

Corn food plots were established at 3 sites adjacent to deer wintering areas (Table 1). Sites were 13-56 km apart in an area managed primarily for row crop agriculture in southwestern Minnesota. Deer wintering area cover at both the Kilen and Olson sites was located in wooded riparian corridors. Vegetation was predominantly box elder (Acer negundo), bur oak (Quercus macrocarpa) and cottonwood (Populus deltoides). Cover at the Bennett site was heavy marsh vegetation dominated by wide-leaved cattail (Typha latifolia) and phragmites (Phragmites communis).

Deer abundance was estimated in February 1988 from 1 ground observation of deer and 1 aerial count from fixed wing aircraft (Table 1). Greater weight was given to ground counts which we believed were more accurate. Potential deer feeding pressure on the food plots (deer/food plot area) was greatest at Kilen, intermediate at Olson and least at Bennett. At all sites, standing hybrid corn was

Table 2. Field and morphological variables developed for evaluating hybrid corn use by deer in southwestern Minnesota, 1987-1988.

Variable	Description	Units
Field		
HUSK	Estimate of proportion of ear covered by husk	deciles
USE	Estimate of proportion of kernels consumed per ear	deciles
HT	Height from ground to point of ear's attachment to stalk	cm
Morphological		
DIAM	Diameter of ear at midpoint	mm
HOLD	Weight required to remove a kernel from ear with forceps	g
DENS	Weight of a liter of kernels	g/l
HARD	Weight of a 5 mm cylinder required to shatter pericarp	kg
LENG	Length of kernel row	mm
FALL	Falling number (measure of density). Number out of 50 kernels falling in 1.115 sp. gr. solution of sodium chloride (NaCl)	No.
WT	Weight of ear	g
KWT	Weight of kernels on ear	g

available only in the food plots.

At each site, 3 or 4 subplots (30 m x 15 m) were located 7 m apart within the food plot. In May 1987, subplot soils were mechanically prepared and corn was planted with a hand planter. The remainder of each site was mechanically planted with a "background" hybrid which varied among sites.

Fifteen locally grown corn hybrids of 100-110 day maturity were selected as treatments. Treatments were randomly assigned to alternate rows (experimental units) within each subplot, leaving a row of background hybrid between experimental units as a buffer. Data were taken from each stalk within a row which resulted in 12-84 observations per experimental unit. All corn was allowed to stand throughout the winter.

Because deer consume corn without removing ears from stalks, we developed data on several variables that could affect deer feeding on ears (Table 2). The amount of husk covering each ear (HUSK) was estimated by viewing ears from the approximate foraging level of deer (1 m) before deer feeding began. The amount of corn consumed from the ear (USE) and height of the ear above the ground (HT) were measured for each ear in a subplot after feeding had occurred, yet before it had been completely consumed.

Eight morphological variables that we felt could impact deer feeding behavior once deer began feeding on an ear were measured on 9 randomly selected ears of each hybrid on each site. Data included measurements of ear diameter (DIAM), ear length (LENG), density (DENS), hardness (HARD), specific gravity (FALL), ear weight (WT), kernels/ear weight (KWT) and the strength of kernel retention to the ear (HOLD). These variables describe characteristics that might impact 3 stages of deer feeding; sighting (HT, HUSK and LENG), mouth prehension (HUSK, DIAM, HOLD and LENG) and mastication (DENS, HARD, FALL, WT, and KWT).

Correlation analysis and principal component analysis were used to reduce redundancy among morphological variables. Data with normal distributions were analyzed using general linear model (GLM) of ANOVA (SAS Inst. Inc. 1988b). Non-normal data were analyzed with GLM applied to transformed ranks created by the RANK procedure (SAS Inst. Inc. 1988a: p. 297). F-values reported here were calculated from partial sums of squares computed for the Type III hypothesis in GLM (SAS Inst. Inc. 1988b). The Tukey method was used to compare means.

RESULTS AND DISCUSSION

Two Bennett subplots and 1 Olson subplot had to be dropped from the analysis due to deep, hard-packed snow. After inspection, the HUSK data were pooled into 2 categories; complete coverage of kernels and incomplete coverage. The morphological variables FALL, WT and KWT were eliminated from the analysis because each was highly correlated with other variables that were more easily interpreted in relation to deer use.

Variability of Corn Hybrids

Our results revealed that hybrid corn grown in food plots exhibited substantial variation. Significant differences among sites ($P < 0.01$), subplots ($P < 0.01$) and hybrids ($P < 0.01$) were found for HT and HUSK (Table 3). Although hybrid and subplot differences were significant, site effects accounted for a greater portion of the variation in HT and HUSK. Site was also a significant effect ($P < 0.01$) for DENS, HARD and LENG (Table 4). Hybrid differences were significant for each of the morphological variables tested ($P < 0.01$) (Table 4).

The differences in the characteristics of corn among sites were likely due to influences of weather (precipitation, insolation, temperature and humidity), soils (moisture and quality) and land management practices (tillage method and previous crop) on the growth form of corn (Jugenheimer 1976). The significant differences among hybrids for HT, HUSK and each of the morphological variables were not unexpected because hybrid corn has been bred for such traits as high yield, rapid maturity, standability, and heat and drought tolerance (Jugenheimer 1976).

Effects of Site and Height On USE

The amount of variation in USE explained by HT was significant and the direct, positive relationship between the 2 variables was similar on all sites (for each site: $r^2 = 0.14$; $P < 0.01$; slope = 0.11). The level of consumption (y-intercept) varied among sites (Kilen > Bennett > Olson), due to variation in deer feeding

Table 3. Effects of site, subplot and corn hybrid on ear height (HT) and on husk coverage (HUSK) of field corn in southwestern Minnesota, 1987-1988.

Dependent variable	HT		HUSK	
Source	df	*F*	df	*F*
Site	2	1428.0**	2	319.5**
Subplot	4	15.4**	7	56.6**
Hybrid	15	121.2**	14	43.0**

**Significant at *P* < 0.01

Table 4. Effects of site and corn hybrid on 5 morphological variables of field corn in southwestern Minnesota, 1987-1988.

Dependent variable		DIAM	HOLD	DENS	HARD	LENG
Source	df	*F*	*F*	*F*	*F*	*F*
Site	2	2.0	0.3	18.4**	7.4**	10.0**
Hybrid	14	28.3**	9.0**	8.4**	5.8**	3.6**
Site x Hybrid	28	1.7*	3.3**	2.0**	1.4	1.5

*Significant at *P* < 0.05.
**Significant at *P* < 0.01.

pressure (Table 1) and in dates of data collection between sites. We staggered the timing of measuring USE because of differences in the rate of use among sites and subplots. Our intent was to measure USE after feeding had begun but before consumption of an experimental unit was complete. Thus, our sampling procedure may have contributed to the variation in use among sites and among subplots.

The significant relationship between corn use and height of the ear suggested that deer were selectively feeding on ears attached at a higher level on the stalk. Mean ear heights of hybrids across all sites ranged from 70.9-108.7 cm. Black-tailed deer (*O. heimonius*) have also demonstrated height-correlated preferences when feeding on Douglas fir seedlings (Dimock 1971). For corn, higher ears could facilitate prehension or simply may be more accessible to deer during feeding.

We used HT as the concomitant variable in a covariance

Table 5. Effects of site, subplot and hybrid, with HT used as the concomitant variable, on deer USE of corn in southwestern Minnesota, 1987-1988.

Dependent variable	USE	
Source	df	*F*
Site	2	220.2**
Subplot	4	3.4**
Hybrid	14	68.9**
HT[a]	1	239.3**

**Significant at $P < 0.01$.
[a]HT was concomitant variable

analysis of corn USE (Table 5) and found significant differences in USE among sites ($P < 0.01$), subplots ($P < 0.01$) and hybrids ($P < 0.01$). The effects of site and HT accounted for the majority of the variation in USE. These site differences could have been caused by the variation in deer feeding pressure among sites (Table 1) or by the variation in dates when data were collected. Subplot variation in use could also have been affected by deer feeding patterns within a site. Observation of trails within the food plots revealed an uneven distribution of activity within the food plots as well as within the subplots. The significant differences in USE found among hybrids were not unexpected as deer are known to be selective feeders and have demonstrated preference among races of Douglas fir (*Pseudotsuga menziesii*) (Dimock 1971) and hybrid poplar (*Aspen tremuloides*) clones (Verch 1979).

Effects of Corn Morphology on USE GROUPS

Five significantly different groups of hybrids (Table 6) were identified (USE GROUPs 1-5). Comparisons among USE GROUPs for HUSK, DIAM, HOLD, DENS, HARD and LENG were used to examine the relationship between each corn characteristic and USE. This indirect method of examining the relationship between USE and these variables was necessary because HUSK and the morphological variables were not measured concurrently with USE.

Significant differences among USE GROUPs were detected for HUSK ($P < 0.01$) (Table 7) and at least one difference among USE GROUPS was detected ($P < 0.01$) for each of the 5 morphological variables ($P < 0.01$) (Table 8). Examination of the ranks of USE GROUPs for each variable revealed that the preferred USE GROUPs (1, 2 and 3) had significantly less HUSK than USE GROUPs 4 or 5 ($P < 0.05$) (Table 9). With only one exception (USE GROUP 3), the USE GROUPs were inversely ranked for HUSK. This suggests that deer preferred hybrid ears that were not completely covered by husk.

Relationships between each of the 5 morphological variables and USE GROUPs were not clear because the ranks were not consistent and there were fewer significant differences among USE GROUPS. From this analysis, accessibility of corn as measured by HT and HUSK had a greater influence on deer use than the morphological variables which could have affected deer feeding once contact was made with the ear.

Food Plot Management Study

Because our 1987-88 study of corn hybrid preferences involved many treatments and limited

Table 6. USE GROUPs determined by rank of deer use of corn hybrids in relation to mean height of ears and rank of husk coverage in southwestern Minnesota, 1987-1988.

USE GROUP[a]	Brand	Hybrid	Mean USE rank	Mean HT (cm)	Mean HUSK rank
1	Funks	G4234	575.5	105.2	345.8
2	Pioneer	3540	491.1	100.9	312.4
	DeKalb	DK524	482.1	108.7	416.3
	Cargill	859	478.3	97.9	307.4
	Cargill	4167	452.9	92.1	352.8
3	Pioneer	3704	401.4	91.1	320.6
4	PAG	SX182	336.7	90.1	362.1
	PAG	5157	331.2	91.0	380.8
	DeKalb	XL25A	317.3	70.9	358.6
	Funks	G4326	315.5	91.9	384.9
	DeKalb	T1100	308.4	91.6	414.3
	Pioneer	3780	301.2	86.8	370.5
5	DeKalb	T1000	251.0	87.1	425.9
	Funks	G4312	226.8	87.8	425.7
	DeKalb	DK587	226.2	87.2	434.6

[a]USE GROUP's differ significantly for corn consumption (USE) at $P < 0.05$.

Table 7. Effects of site, subplot and USE GROUP on husk coverage (HUSK) of corn in southwestern Minnesota, 1987-1988.

Dependent variable	HUSK	
	df	F
Site	2	306.0**
Subplot	7	53.1**
USE GROUP	4	93.7**

**Significant at $P < 0.01$.

amounts of each hybrid (one 15-m row per subplot), we decided to conduct a study in 1988-89 to evaluate the strength of hybrid preferences by deer. The intent in this choice trial was to test 2 hybrids of different preference ranking under conditions similar to those that exist under food plot management programs. A more preferred corn hybrid from USE GROUP 2 (Pioneer hybrid 3540) and a less preferred hybrid from USE GROUP 5 (Funks hybrid G4312) were selected as treatments. Each hybrid was planted in May 1988 on subplots that comprised approximately half of the Olson, and the Monson food plots (Table 1). Each subplot was subdivided into 225-m^2 sampling units. The

Table 8. Effects of site and USE GROUP on corn morphological variables in southwestern Minnesota, 1987-1988.

Dependent variable		DIAM	HOLD	DENS	HARD	LENG
Source	df	*F*	*F*	*F*	*F*	*F*
Site	2	1.0	0.1	4.9**	3.9*	3.3*
USE GROUP	4	3.8**	3.8**	6.0**	4.2**	2.4*
USE GROUP x site	8	0.7	0.9	1.9	0.3	2.4*

*Significant at $P < 0.05$.
**Significant at $P < 0.01$.

Table 9. USE GROUPs of corn hybrids ranked by Tukey method for morphological variables of corn characteristics in southwestern Minnesota, 1987-1988.

RANK	HUSK*	DIAM	HOLD	DENS	HARD	LENG
Highest USE	5A	5A	1A	1A	1A	2A
	4 B	3A	3AB	3AB	3AB	1AB
	2 C	4AB	5 B	4 B	4 B	4AB
	1 CD	2 B	4 B	5 BC	5 B	3AB
Lowest USE	3 D	1 B	2 B	2 C	2 B	5 B

*USE GROUPS within a column sharing a common letter are not significantly different ($P > 0.05$)

number of sampling units per subplot ranged from 38-68 and varied because units were proportionally allocated by subplot area. Consumption was determined as mean USE (Table 2) of 4 adjacent ears measured at a randomly chosen location >3 m from the borders of each sampling unit.

We found significant differences in use between sites ($F = 82.5$; 1, 203 df; $P < 0.01$) and hybrids ($F = 98.9$; 1, 203 df; $P < 0.01$). In this study, site effects did not account for as much variation in use as hybrid preferences. We believe the site differences were due to variation in deer pressure since all data were collected on the same date. Although deer population estimates were not made in winter of 1989, we believe more deer were using the Olson food plot (approx 57% consumed) than the Monson food plot (approx 22%).

The preference ranking obtained in 1987-1988 was upheld in this study. The ratios of use of preferred Pioneer hybrid 3540 to Funks hybrid G4312 were 3.0:1 at the Olson site and 2.5:1 at the Monson site. This study indicates that deer will demonstrate preferences among corn hybrids planted in typical deer management food plots.

MANAGEMENT IMPLICATIONS

For farmers, our results suggest that planting corn hybrids with lower ears (approx <92 cm) that are covered completely by husk may reduce deer use. Alternatively, wildlife managers could reduce the impact of deer depredation on agricultural crops by planting food plots of preferred hybrids with high ears and open husks. In areas where deer pressure on corn food plots is expected to be high, wildlife managers could plant hybrids with a range of preference rankings which may extend the feeding period of wintering deer, thereby increasing the efficiency of food plot management.

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