INDIANA

High Oil Corn Yield and Quality Responses to Fertilizer Potassium versus Exchangeable Potassium on Variable Soils

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Potassium (K) is important in the production of high oil corn (HOC) because of its benefit to yield and overall role in improvement of HOC grain quality parameters as soil exchangeable K (SEK) levels increase.

High oil corn production (Topcross[R] pollination system) is currently recommended only for productive soil types under conventional tillage. The reasons include concerns for achieving desired plant populations (of both the male-sterile female and male pollinator plants), minimizing stress to the grain pollinator, and achieving consistency in grain yields and oil concentration. There is little information available on HOC response to fertilizer K, and whether oil concentrations are at all affected by K fertilizer rate or placement.

Aside from a general recommendation to plant HOC on productive soils, and presumably those with phosphorus (P) and K concentrations above the critical level for yellow dent corn, little information is available on whether K fertilizer requirements for HOC are any different from those with dent corn. Potassium availability to HOC may be important since K is so essential in the plant enzymes responsible for oil synthesis in plants, and because grain oil concentrations in HOC are approximately double those in normal dent corn.

In addition, the justification for the conventional tillage recommendation for HOC is vague. More variability in stand establishment and productivity is presumed, especially on

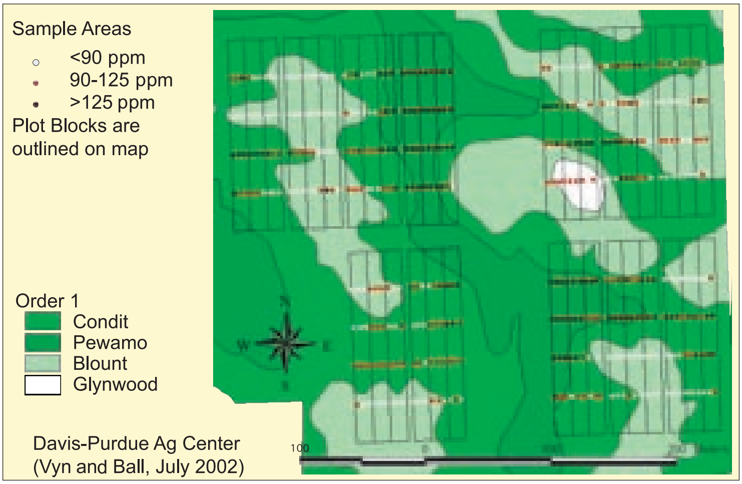

Figure 1. Order 1 soil survey of the experimental field in 2000 (east block) and 2001 (west block). Soil exchangeable K status is indicated in colored circles for samples taken at a depth of 2 to 6 in. during spring of the respective year.

variable soils, when HOC is planted with residue-conserving tillage systems. The basis for the conventional tillage recommendation has not been experimentally verified.

Another common concern in HOC production is the within-field consistency of oil concentrations in the grain. Fields with uniform soil types have been generally considered desirable for HOC, even though no real reason to exclude HOC production from fields with more variable soil types has been demonstrated. Certain tillage and K fertility management systems might affect the consistency of oil concentrations on fields with variable soils.

Experiments were conducted in 2000 and 2001 to evaluate the response of HOC to conservation tillage systems and associated K fertilizer placements on soils varying in texture, drainage, and SEK. The field site was located at the Davis-Purdue Agricultural Center (PAC) in east-central Indiana. This site was selected because of its soil variability, because no-till corn is not a common practice on these poorly drained soils, and because of availability of appropriate site-specific technologies.

Three tillage (main) treatments were evaluated: fall chisel with spring cultivation (CT), fall strip tillage at 8 in. depth (ST), and no-tillage (NT) following no-till soybeans in rotation. Three K (sub-block) treatments were also evaluated within each main tillage treatment: fall application of 90 lb K_2O/A via broadcast or deep-banded (Fall K), fall application with an additional 50 lb K_2O/A

TABLE 1. Ear-leaf K concentrations as affected by tillage, K fertilizer, soil series, and soil exchangeable K in 2000 and 2001.

2000		Soil series			Soil exch. K at 2 to 6 in., ppm		
Treatment	Mean	Blount	Condit	Pewamo	<90	90-125	>125
	Earleaf K, %						
No-till	1.82	1.74	1.85	1.90	1.72	1.84	1.91
Chisel	1.85	1.77	1.91	1.96	1.65	1.91	1.94
Strip-till	1.82	1.74	1.83	1.91	1.71	1.84	1.94
No K	1.72 *b*	1.62	1.77	1.79	1.52	1.80	1.86
Fall K	1.86 *a*	1.77	1.89	1.93	1.74	1.91	1.93
F&S	1.91 *a*	1.86	1.92	2.04	1.82	1.89	1.99
Mean	1.83	1.75 B	1.86 A	1.92 A	1.69 C	1.86 B	1.93 A

2001		Soil series			Soil exch. K at 2 to 6 in., ppm		
Treatment	Mean	Blount	Condit	Pewamo	<90	90-125	>125
	Earleaf K, %						
No-till	1.33 *b*	1.16	1.44	1.36	1.10	1.44	1.46
Chisel	1.47 *a*	1.34	1.55	1.49	1.35	1.48	1.59
Strip-till	1.41 *a*	1.25	1.48	1.57	1.29	1.54	1.55
No K	1.29 *b*	1.14	1.35	1.44	1.12	1.40	1.46
Fall K	1.44 *ab*	1.24	1.52	1.56	1.26	1.46	1.63
F&S	1.48 *a*	1.38	1.59	1.41	1.36	1.61	1.52
Mean	1.40	1.25 B	1.49 A	1.47 A	1.25 B	1.49 A	1.53 A

Data followed by the same letter, or no letter, within a row or column are not significantly different according to a protected LSD $p = 0.05$ or a t test (GLM model) at $t_{crit} = 0.05$. Letters distinguishing differences among individual tillage and K treatment means within a column are italicized. Overall mean differences within a row are shown in upper case. No K = no K, Fall K = fall applied K, F&S = fall and spring applied K.

spring banded (F&S), and no K (No K). High oil corn followed no-till soybeans in both 2000 and 2001, and the fields had been in conservation tillage systems for at least five years previously. Response of HOC in the 24 sampling positions (six replications and four sampling positions per plot) associated with each tillage and fertility treatment combination was evaluated in three manners: a) mean response, b) after partitioning sampling positions into three soil series (Blount, Condit, Pewamo), and c) after partitioning sampling positions into three ranges of SEK concentrations...<90, 90-125, >125 parts per million (ppm)...present in the depth interval of 2 to 6 in. See **Figure 1**.

An Order 1 soil survey was completed for the experimental site in the fall of 2001. The Order 1 survey has a representative accuracy of 3 to 15 ft. Its differentiation of soil series may be even more useful in outlining the boundaries of management zones than earlier soil surveys. For example, the Order 2 soil survey for this county was published in the mid 1970s mainly for utilization in soil conservation decisions and had an accuracy varying from approximately 100 to 150 ft. Theoretically, the Order 1 soil survey should be more precise in evaluating responses in crop yield and quality in large plots on variable soils, but this has not been widely evaluated.

Pioneer high oil hybrid 34B25 was planted on May 12, 2000 and May 1, 2001 at populations of 31,000 seeds/A. Nitrogen (N) and P starter fertilizer was applied to all plots at a rate of 38 lb N/A and 25 lb P_2O_5/A as all, or part of, a liquid blend. In treatments with spring applied K, an additional 50 lb K_2O/A was applied in the starter. Application of 190 lb N/A as anhydrous ammonia was sidedressed at the V4 to V6 corn growth stage in both years.

Soil K stratification was observed in the plot area across all tillage and broadcast treatments. **Figure 2** shows the mean soil K concentrations (ammonium acetate extraction) for the combined year data. In 2000 the concentrations at the 0 to 2 in. depth averaged 228 ppm, while in 2001 the 0 to 2 in. concentration average was 179 ppm. Soil exchangeable K concentrations averaged 107 ppm in the 2 to 6 in. depth and 96 ppm at the 6 to 12 in. depth for both years.

Grain yield was obtained from the combine's yield monitor. Grain quality (oil and protein) was determined from HOC grab samples pulled from each harvest area. Grain kernel concentrations were obtained through near infrared analysis. Each corn sampling position was assigned to a soil series using ArcView Geographic Information Systems (GIS) software.

Results

Ear-leaf K concentrations responded positively to K fertilizer in both years (**Table 1**). We observed no differences among tillage systems in 2000, but in 2001 ear-leaf K values were lower in the NT treatment when compared with CT and ST. Corn leaf K responses to tillage and K fertilizer treatments were consistent across the three soil groups and SEK ranges.

Ear-leaf K concentration was significantly affected by both soil series and inherent SEK in both years. It is interesting to note that the lower topographical soils (Condit and Pewamo) had the higher ear-leaf K concentrations, while the Blount soil on the higher elevations had significantly lower concentrations. This may be due to the inherently higher SEK concentration and higher available soil moisture on the Condit and Pewamo soils. Consistently higher ear-

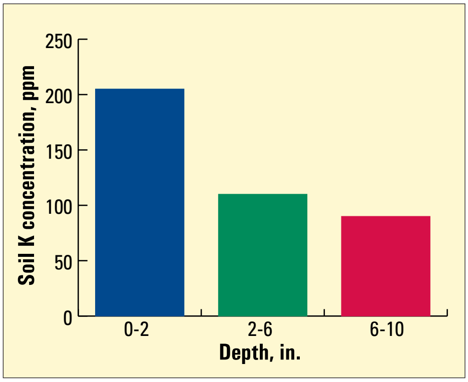

Figure 2. Combined year soil exchangeable K concentration from different depth intervals.

leaf K was observed when soil K was high. As anticipated, considerable spatial variability of leaf K response to K fertilizer resulted from the initial soil characteristics.

Tillage systems did not affect grain yields in either year, but higher K fertilizer rates increased yields in both years (**Table 2**). A particularly large yield advantage occurred with starter K band application in 2000. Soil series did not significantly affect yields in either year; however, lowest yields in both years were evident on the Blount soil. Highest yields occurred with both fall-applied and starter-banded K in both years. This positive response is an indication of the possible importance of K in the starter or, alternatively, a possible response associated with higher overall K fertilizer rates.

In 2000, all HOC yields with the highest SEK category (>125 ppm K) were lower than expected because of poor corn stands. Excessive rain after emergence thinned plant populations more in this category than those with lower SEK. In fact, average final populations per acre were 25,000 with SEK <90 and 23,000 with SEK from 90 to 125, but only 21,600 at the highest SEK. Plant populations in 2001 were higher and more consistent, and the proportion of male pollinators (always above 8%) was not affected by tillage or K treatments in either year. Despite the population challenges in 2000, HOC yield response to the fall plus starter K treatment was not affected by the inherent SEK category in either year.

It is encouraging for soil conservation-

TABLE 2. Grain yield as affected by tillage, K fertilizer, soil series, and soil exchangeable K in 2000 and 2001.

		2000					
		Soil series			Soil exch. K at 2 to 6 in., ppm		
Treatment	**Mean**	**Blount**	**Condit**	**Pewamo**	**<90**	**90-125**	**>125**
	Grain yield, bu/A						
No-till	126	120	130	140	129	122 *b*	132
Chisel	134	138	133	125	135 AB	148 a *A*	124 B
Strip-till	135	134	133	142	135	137 *a*	133
No K	127 *b*	123	127	133	119	136	130
Fall K	129 *b*	132	128	123	137	127	123
F&S	140 *a*	137	140	123	142	144	136
Mean	132	130	132	136	133	136	130

		2001					
		Soil series			Soil exch. K at 2 to 6 in., ppm		
Treatment	**Mean**	**Blount**	**Condit**	**Pewamo**	**<90**	**90-125**	**>125**
	Grain yield, bu/A						
No-till	178	178	179	175	180	177	178
Chisel	178	173	179	182	172	179	183
Strip-till	181	178	184	176	180	182	182
No K	174 *b*	171	176	175	173	173	177
Fall K	179 *ab*	178	180	179	178	179	182
F&S	183 *a*	180	185	178	182	185	183
Mean	179	176	180	177	177	179	181

Data followed by the same letter, or no letter, within a row or within a column are not significantly different according to a protected LSD $p = 0.05$ or a t test (GLM model) at $t_{crit} = 0.05$. Letters distinguishing differences among means within columns are italicized. Mean differences within a row are shown in upper case. No K = no K, Fall K = fall applied K, F&S = fall and spring applied K. Populations with >125 ppm in 2000 were 8, 18, and 15% lower for No K, Fall K, and F&S, respectively, relative to <90 ppm.

ists to note that both NT and ST resulted in HOC yields similar to those with CT. The latter confirms the possible successful adoption of conservation tillage (even on more challenging poorly drained soils), just as is currently possible in regular yellow dent production when planting dates are not delayed.

Overall, oil concentrations averaged 7.15% in 2000 and 8.18% in 2001. Year to year variation in oil concentration of HOC is a relatively common occurrence; lower oil concentrations are sometimes attributed to late planting and poor growing conditions in certain years. These annual variations were bigger than those resulting from tillage and K fertility management factors within a year.

Oil concentrations were significantly lower in NT versus CT and ST in 2000 (**Table 3**). Tillage treatments did not significantly affect oil contents in 2001, but did

TABLE 3. Grain oil concentrations as affected by tillage, K fertilizer, soil series, and soil exchangeable K (2 to 6 in. depth) in 2000 and 2001.

2000

		Soil series			Soil exch. K at 2 to 6 in., ppm		
Treatment	**Mean**	**Blount**	**Condit**	**Pewamo**	**<90**	**90-125**	**>125**
	Oil concentration, %						
No-till	7.04 *b*	7.00	7.07	7.17	6.99	7.04	7.14
Chisel	7.24 *a*	7.19	7.29	7.28	7.18	7.24	7.31
Strip-till	7.17 *a*	7.09	7.23	7.20	7.13	7.07	7.27
No K	7.12	7.05	7.16	7.11	7.04	7.18	7.22
Fall K	7.15	7.08	7.21	7.30	7.08	7.04	7.29
F&S	7.18	7.14	7.23	7.24	7.18	7.13	7.21
Mean	7.15	7.09 B	7.20 A	7.22 A	7.10 B	7.12 B	7.24 A

2001

		Soil series			Soil exch. K at 2 to 6 in., ppm		
Treatment	**Mean**	**Blount**	**Condit**	**Pewamo**	**<90**	**90-125**	**>125**
	Oil concentration, %						
NT No K	8.17 *ab*	8.25	8.08	8.51	8.06	8.10	8.34
Fall K	8.13 *b*	8.09	8.06	8.25	8.05	8.08	8.12
F&S	8.23 *a*	8.09	8.32	8.32	8.08	8.26	8.38
Mean	8.16	8.14	8.15	8.36	8.06	8.15	8.30
CT No K	8.16	8.00	8.18	8.39	8.10	8.15	8.34
Fall K	8.16	7.94	8.14	8.45	8.05	8.08	8.30
F&S	8.12	7.96	8.11	8.33	8.10	7.86	8.28
Mean	8.15	7.97	8.14	8.39	8.05	8.03	8.31
ST No K	8.21 *ab*	8.07	8.22	8.49	8.06	8.29	8.44
Fall K	8.31 *a*	8.19	8.30	8.65	8.25	8.31	8.48
F&S	8.14 *b*	8.03	8.17	8.32	8.12	8.07	8.30
Mean	8.22	8.10	8.23	8.49	8.14	8.22	8.41
Grand mean	8.18	8.07 C	8.17 B	8.42 A	8.09 B	8.13 B	8.34 A

Data followed by the same letter, or no letter, within a row or within a column are not significantly different according to a protected LSD $p = 0.05$ or a t test (GLM model) at $t_{crit} = 0.05$. Letters distinguishing differences among tillage and K treatment means within a column are italicized. Overall mean differences resulting from soil series and SEK are shown as upper case. No K = no K, Fall K = fall applied K, F&S = fall and spring applied K.

have a significant interaction with K fertilizer treatments because lower oil concentrations occurred with fall K in NT treatments, compared to CT and ST treatments. Potassium fertilizer applications did not significantly increase kernel oil concentrations in either year. Oil concentration responses to tillage and K treatments, although relatively small, were not influenced by the inherent soil series or the initial SEK status of the soil at the sampling positions.

Soil series significantly affected grain oil concentrations in both years. The Pewamo was observed to have the highest concentration in 2001, and both the Pewamo and Condit soils resulted in somewhat higher oil than the Blount soil in 2000. The effects of soil series are largely associated with differences in SEK in these soil series (data not shown).

Grain oil concentrations responded more to initial SEK than K fertilizer treatments (annual additions of K). Consistent increases of oil were observed with increasing SEK in both years in nearly all treatments; oil concentrations were significantly higher in both years with >125 ppm SEK than with the lower SEK concentrations. More research is needed to confirm our findings that oil concentrations can be increased in HOC through maintaining SEK at higher levels.

Conclusions

Analysis of site-specific data within and among replicated plots indicated that HOC response to tillage and K fertilizer treatments was not affected by either soil series or the SEK status of the individual sampling positions. Both soil series and the initial SEK status below the 2 in. depth had more influence than either tillage or K fertilizer treatments on both ear-leaf K and oil concentrations. However, grain yield in HOC was more dependent on K fertilizer treatments than on inherent soil characteristics.

Both soil series and SEK concentrations accounted for most of the within-field variability in HOC performance. Higher SEK concentrations were consistently associated with increased concentrations of ear-leaf K and grain oil, as well as higher concentrations of grain protein and grain K (data not shown).

High oil corn receiving fall K plus starter K (at left) showed a height advantage and higher yields compared to the zero K plot (right) at Davis-PAC.

Potassium management is important in the production of HOC, both for its initial benefit to yield and its overall role in maintaining SEK concentrations high enough to obtain maximum possible oil concentrations. The consistency of HOC response to tillage and fertility treatments across variable soil series and SEK levels suggests that conservation tillage systems are feasible in HOC production, and that decisions about short-term and long-term K fertilizer management are more important in obtaining optimum yields and quality of HOC than decisions about tillage. BC

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