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Corn Tiller Yield Contributions and Ear Development in Low Plant Densities

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Abstract

Research in modern corn (*Zea mays* L.) hybrids investigating tiller contributions and ear development at low plant densities is scarce, particularly in water-limited environments. To fill this research gap, a second season of replicated experiments was conducted in 2020 at 7 sites across Kansas (Keats, Buhler, Greensburg, Garden City, Goodland, and two sites in Colby) evaluating two common, tiller-prone corn hybrids (P0805AM and P0657AM) at three target plant density levels (10000, 17000, and 24000 plants/a). Five of the listed sites also considered a tillering factor (tiller removal at development stage V10 [tenth-leaf] or tiller maintenance). Seasonal phenology, partitioned grain yield, harvested ear type characterizations, and environmental conditions were recorded and analyzed to quantify tiller contributions in each site. Results showed that intact tillers had either no effect or were able to boost yields. In the best environments, tillers were able to successfully compensate for losses of 60% in plant density. Five of the seven tested sites produced approximately 50% of total harvested ears as desirable tiller lateral ears in the 10000 plants/a target plant density. The highest percentage of undesirable tiller tassel ear development in the 10000 plants/a density was 13%. Future research will seek to find explanations of the ear type relationships on a deeper level and predict tiller yield contributions considering various environments and ear development outcomes.

Keywords

corn, tillers, plant density, yield, ear development

Authors

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Summary

Research in modern corn (*Zea mays* L.) hybrids investigating tiller contributions and ear development at low plant densities is scarce, particularly in water-limited environments. To fill this research gap, a second season of replicated experiments was conducted in 2020 at 7 sites across Kansas (Keats, Buhler, Greensburg, Garden City, Goodland, and two sites in Colby) evaluating two common, tiller-prone corn hybrids (P0805AM and P0657AM) at three target plant density levels (10000, 17000, and 24000 plants/a). Five of the listed sites also considered a tillering factor (tiller removal at development stage V10 [tenth-leaf] or tiller maintenance). Seasonal phenology, partitioned grain yield, harvested ear type characterizations, and environmental conditions were recorded and analyzed to quantify tiller contributions in each site. Results showed that intact tillers had either no effect or were able to boost yields. In the best environments, tillers were able to successfully compensate for losses of 60% in plant density. Five of the seven tested sites produced approximately 50% of total harvested ears as desirable tiller lateral ears in the 10000 plants/a target plant density. The highest percentage of undesirable tiller tassel ear development in the 10000 plants/a density was 13%. Future research will seek to find explanations of the ear type relationships on a deeper level and predict tiller yield contributions considering various environments and ear development outcomes.

Introduction

Tiller prolificacy in corn has been deemed undesirable since the beginning of the species domestication process. A main concern of farmers, agronomists, and breeders alike with these secondary vegetative shoots is their inability to produce grain with consumed plant resources, thus earning corn tillers the common name, "suckers." Modern corn hybrids are typically not tested by breeders at the very low plant populations employed in marginal environments, such as central and western dryland regions of Kansas. In these areas, having plant densities under 20000 plants/a is a key management component in conserving available soil moisture. However, when planting at this sparse density, conditions are prime for corn tiller development, which raises new questions about tiller impacts on yield and the plant water balance.

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While corn tillers can develop typical axillary ears ("lateral ears"), this desirable situation is not always the case. Unproductive tillers may never reach reproductive stages or may produce apical ears (commonly "tassel ears") instead of desirable lateral ears. These development scenarios are likely key to understanding potential tiller contributions in various environments.

The objectives of this study were to 1) determine the qualitative effect of corn tillers on yields considering differences in plant density, hybrid, and environment, and 2) evaluate corn tiller ear development resulting in each site as an indicator of tiller productivity.

Procedures

Data presented in this report were collected in the second year of a multi-year study (2019–2021) conducted across the state of Kansas (Veenstra et al., 2020). Location geographical coordinates and soil data are shown in Table 1. All plots were fertilized as necessary to avoid nutrient deficiencies and maintained with appropriate pesticides. Climatic data of interest downloaded with site coordinates from ClimateEngine are shown in Table 2 (Huntington et al., 2017).

Five sites were arranged in a split-split-plot design, with three factors evaluated: planting density with three levels as the whole plot, hybrid with two levels in the sub-plot, and tiller treatment with two levels in the sub-sub-plot (Table 1). That is, both levels of tiller (removal at the V10 [tenth-leaf] development stage [NT], or maintenance [YT]) were evaluated for both levels of hybrid (P0805AM and P0657AM [two Pioneer corn hybrids common in the region of study]) within each level of plant density (10000, 17000, and 24000 plants/a). Each site had at least three replications.

Two sites were arranged in a split-plot design, with two factors evaluated: planting density with three levels as the whole plot, and hybrid with two levels in the sub-plot (Table 1). That is, both levels of hybrid (P0805AM and P0657AM) were evaluated in each level of plant density (10000, 17000, and 24000 plants/a). Each site had three replications.

Measurements throughout the growing season included ear type characterization counts and partitioned grain yields. Ear characterization counts were conducted at harvest, and accounted for the number of harvestable ears in a plot that belonged to each of three predetermined categories—main plant ears (productive), tiller lateral ears (productive), and tiller apical ears (commonly "tassel ears," unproductive). Partitioned grain yields were hand-harvested from the two central plot rows, separated by ear type category, and shelled by hand.

The selected experimental design structure allowed for quantification of the effect of corn tillers on yield. For analysis, data were classified into the following three partitions: full plant (main + tillers), main plant (main only), and tiller (tillers only). In addition, due to differences in yield goals, environmental conditions, and responses observed among sites, experimental sites were analyzed separately. Linear mixed models were fit to the data from each location and an analysis of variance (ANOVA) was performed to determine the significance of nested factors in the experimental design with regard to each yield partition as listed previously. All analyses, calculations, and figures were completed with the R software (R Core Team, 2020).

Results

Grain Yields

Full partitioned grain yields of sites considering the tiller removal factor (i.e., sites with split-plot-plot design structures) are shown in Figure 1. Each site is divided into factor combinations based on results from the performed ANOVA (data not shown). Yield potential for all fields was similar, with the exception of the Colby (B) location, which is a continuous-crop dryland site as indicated in Table 1.

Full yields in Keats were only affected by tiller removal in the 10000 plants/a density with the P0805AM hybrid. The P0805AM hybrid also out-yielded the P0657AM in this density when tillers were present. Planting density was a significant component of each treatment with regard to yield potential in this location, as the stepped effect of yields was obvious as target population increased. Tillers were unable to compensate for the presence of fewer plants at this site.

Garden City and Goodland full yields followed similar patterns. At both sites, tiller treatment was only significant in the 10000 plants/a, and plant density was only significant when tillers were not present. At these sites, the presence of tillers allowed statistically similar yields, even when comparing a plant density reduced to 40%. Tillers were able to successfully compensate for significantly fewer corn plants (up to 14000 plants/a) in these sites.

Yields at the Colby (A) site were only affected by tiller removal in the 10000 plants/a level. Plant density was only significant at the 10000 plants/a level when tillers were not present, and at all treatments at the 24000 plants/a level. Tillers were able to successfully compensate for a plant density lowered to 59%, but not to the impressive degree observed in the Garden City or Goodland sites.

Yields at the Colby (B) site were not affected by any factor or interactions included in this study.

In all tested sites, intact tillers either neutrally or positively influenced yields. In some cases, tillers successfully compensated for significantly fewer plants per acre.

Ear Development

Due to the nature of the data collected for ear development (i.e., lack of normality), only the ear type characterization as a percentage of the total ears harvested is provided in this report. The summary is shown in Figure 2.

Most sites produced approximately half of their total developed ears as tiller lateral ears in the 10000 plants/a target density, except for Buhler (33%) and Keats (13%). Keats produced the greatest percentage of tiller tassel ears of any location in the 10000 plants/a target density (19%). Buhler, Colby (A), and Greensburg produced 8%, 2%, and 6% of their ears as tiller tassel ears at this density, respectively.

Considering the 17000 plants/a that Keats and Colby (B) produced < 1% of their harvested ears on tillers. Tiller lateral ears were developed in Buhler (3%), Colby (A) (12%), Garden City (20%), Goodland (21%), and Greensburg (31%). Sites producing

≥ 1% of harvested ears as tiller tassel ears were Buhler (4%), Garden City (2%), and Greensburg (1%).

In the 24000 plants/a level, four sites produced tiller ears, and all of them (≥ 1%) were tiller lateral ears—Colby (A) (1%), Garden City (2%), Goodland (1%), and Greensburg (1%).

When summarizing ear development by hybrid across sites (data not shown), P0805AM produced the following harvested ear percentages for main ears, tiller lateral ears, and tiller tassel ears, respectively: 47%, 52%, and 1% (10000 plants/a); 83%, 16%, and 0% (17000 plants/a); and 98%, 2%, and 0% (24000 plants/a). For P0657AM, the main, tiller lateral, and tiller tassel harvested ear percentages were as follows: 54%, 37%, and 8% (10000 plants/a); 89%, 10%, and 1% (17000 plants/a); and 99%, 0%, and 0% (24000 plants/a).

Conclusions

The overall conclusion is that corn tillers do not reduce yields. In all sites, regardless of irrigation status or yield potential, tiller removal never had a positive influence on yields.

Effects of tiller removal are often tied to plant density in productive fields, as can be observed in the results shown from the 2020 season [See Figure 1; Colby (A), Garden City and Goodland]. In these cases, as plant density increases, tiller yield contributions decrease. Under certain circumstances, tillers have demonstrated potential to compensate for plant densities reduced by up to 60%. Although this relationship is certainly not always the case, it sparks imagination at the definite possibility of reducing plant densities while achieving similar yields in both marginal and adequate environments.

With regard to corn tiller yield relationships, a second key conclusion is the identified correlation between tiller ear development and yield outcomes. The specific environmental factors surrounding ear type determination remain unclear, but these processes appear to be a key part of predicting tiller outcomes and maximizing plant efficiency and productivity in low plant density corn fields.

References

Huntington, J., Hegewisch, K., Daudert, B., Morton, C., Abatzoglou, J., McEvoy, D., and T., Erickson. (2017). Climate Engine: Cloud Computing of Climate and Remote Sensing Data for Advanced Natural Resource Monitoring and Process Understanding. *Bulletin of the American Meteorological Society*. http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-15-00324.1.

R Core Team. (2020). R: A Language and Environment for Statistical Computing. Version 4.0.3. R Foundation for Statistical Computing. Vienna, Austria.

Veenstra, R., Messina, C., Haag, L., Prasad, P. V. Vara, and Ciampitti, I. A. (2020). Tiller Contributions to Low-Density Corn Biomass and Yield. *Kansas Agricultural Experiment Station Research Reports, 6*(5). https://doi.org/10.4148/2378-5977.7919.

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Table 1. Site geographical coordinates, sowing date, and soil characteristics of interest

Site	Latitude	Longi-tude	Sow date	pH	OM	NO_3-N	NH_4-N	P	CEC
	°N	°W		H_2O	% LOI	--------- ppm ---------		Mehlich, ppm	meq $100g^{-1}$
Keats, KS*	39.23	96.72	May-02	7.0	4.5	18.0	4.1	118.0	24.4
Buhler, KS**	38.14	97.73	Apr-29	6.4	2.9	17.9	4.8	24.0	23.1
Greensburg, KS**	37.58	99.37	May-05	5.4	2.6	37.1	13.6	84.9	18.9
Garden City, KS*	37.83	100.86	May-18	5.2	1.6	18.4	10.7	55.0	10.6
Goodland, KS*	39.25	101.78	May-07	5.8	3.8	36.9	17.9	106.0	24.0
Colby A, KS*	39.39	101.06	May-07	5.4	3.3	19.9	4.3	70.0	21.2
Colby B, KS*	39.38	101.06	May-15	6.5	3.2	43.5	36.4	31.0	24.0

OM = organic matter. CEC = cation exchange capacity.
* Site arranged in a split-split-plot design. ** Site arranged in a split-plot design.

Table 2. Site climatic data of interest for the 2020 growing season (April - August)

Site	Mean daily solar radiation	Mean maximum temperature	Mean minimum temperature	Seasonal water supply
	MJ m^{-2} day^{-1}	-------------------------- °F --------------------------		Precipitation + irrigation, in.
Keats, KS	22.5	79.0	58.3	20.3
Buhler, KS	23.4	82.4	58.6	19.0
Greensburg, KS	24.4	82.6	55.4	18.8
Garden City, KS	25.1	83.3	54.9	17.3
Goodland, KS	24.5	81.5	51.3	14.4
Colby, KS	24.4	81.0	51.6	10.7

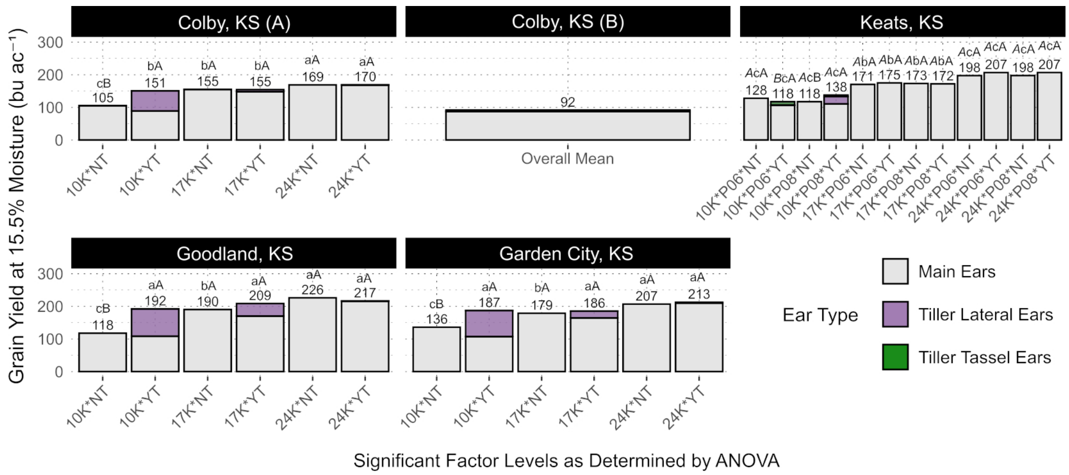

Figure 1. Mean full grain yields (adjusted to 15.5% standard moisture) and means comparisons (Tukey test) for each factor level deemed significant by ANOVA tests considering each location separately. (Lowercase letters are used to compare densities at a given factor level; uppercase letters are used to compare tiller treatments at a given factor level; uppercase italic letters are used to compare hybrids at a given factor level.) Only sites with tillering as a factor were considered (see split-split-plot sites in Table 1). Densities are denoted by 10K, 17K, and 24K; hybrids are denoted by P06 and P08; and tiller levels are denoted by NT (tillers removed) and YT (tillers maintained).

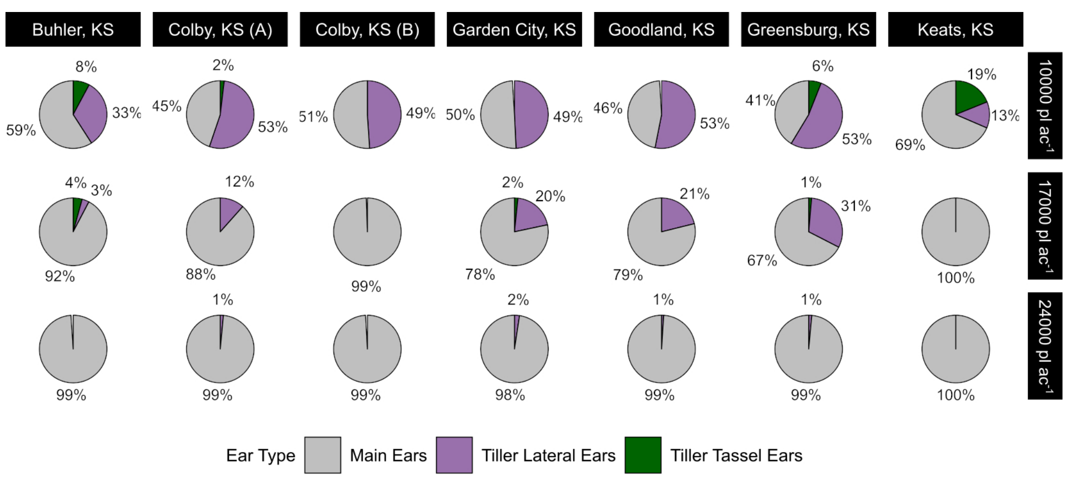

Figure 2. Ear development data by plant density, partitioned and shaded by ear type. Pie charts represent the total harvested ears, with slices representing the percentage of total ears belonging to each development category. Hybrids were averaged together and plots with tillers removed were not considered. All tested sites are shown.