LANDSCAPE POSITION AFFECTS MANAGEMENT DECISIONS FOR CROP PRODUCTION

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ABSTRACT

Landscape positions influence crop growth and yield by impacting the water and nutrients movement in the soil. Previous studies have evaluated the impacts of topography, N management and hybrids on corn grain yield individually; however, limited information is available on the interaction of these factors on corn yield, N uptake and grain quality. The objectives of this study were to determine the effects of landscape positions, nitrogen rates, corn hybrids and seeding rates on corn grain yield. Additionally, in a separate study, we evaluated the performance of the nitrification inhibitor N-serve on corn grain yield at three landscape positions. The experiments were set up in a randomized block design with a split-split plot arrangement. Corn production data including harvest moisture, grain yield and grain quality were collected from the experiments. Corn grain yield was increased with an increase in seeding rate for DKC62-53 hybrid at the backslope position. No differences were observed in hybrids planted at three different seeding rates at the footslope position. Average over the years corn grain yield was highest 165 bu ac^{-1} at the backslope position with AA + N-Serve treatment followed by 163 bu ac^{-1} at the shoulder with AA + N-Serve treatment. Anhydrous ammonia when applied without any nitrification inhibitor at the footslope position had the lowest 144 bu ac^{-1} corn grain yield when average over the four years.

INTRODUCTION

Landscape attributes including topographic positions, slope, curvature, elevation, water flow direction, and water flow accumulation are well documented in the literature for their effects on crop productivity. Topography influences crop growth and yield by impacting water and nutrient movement in the soil. Under dryland crop production systems, water availability generally depends on topsoil depth, soil organic matter, and curvature of the micro-topography. To improve the overall productivity of a spatially diverse landscape, site-specific crop management practices have been advocated through the use of precision agriculture technology. However, on-farm adoption of site-specific crop management practices on landscape positions can be limited due to several reasons including the time needed to implement variable source technology when the spring planting window is shortened by wet springs, unavailability of reliable datasets providing recommendations for varying sources and rates applications, and limitation of equipment and skillset of the growers and consultants. Nitrogen (N) is one of the most important inputs that can maximize yields and economic returns if managed sensibly. Historically, a lot of research has been conducted on site-specific N management. Additionally, research on other inputs including seeding rates and hybrid selection has been conducted extensively. However, the interaction between input factors including N-rates, hybrid selection, and plant population has not been studied well in site-specific zones classified by landscape positions. In addition, there are minimal recommendations available for using nitrification inhibitors based on landscape positions for corn production. The overall goal is to understand variability due to landscape positions and develop general recommendations based on the selection of technology that improves crop productivity and returns on topographically diverse landscapes.

MATERIALS AND METHODS

To address the above goal two separate studies were set up in 2019 at the University of Missouri's Lee Greenley Jr. Research Center near Novelty, MO. The first study evaluated the performance of drought and flood-tolerant corn hybrids planted at three population densities and two N-rates at shoulder, backslope and footslope landscape positions (Figure 1). Landscape positions were classified according to Singh et al. (2016). Corn hybrids used in this study were DKC62-53 and DKC65-95 planted at 28,000, 33,000, and 38,000 seeds ac^{-1}. The DKC62-53 is a flood-tolerant hybrid whereas DKC65-95 is drought tolerant hybrid. The N-rates were 120 and 180 lbs N ac^{-1} applied as anhydrous ammonia with strip-tillage equipment in the fall. The experiment was set up as a randomized complete block design with a split based on landscape positions and nitrogen rates. Treatments were replicated three times across the landscape positions. Corn was planted at 30-inch row spacing with a cone planter on plots of 10 x 30 feet. Treatment plots were kept weed free. Agronomic production data including plant population, corn yields, test weights, and harvest moisture were collected from 2019 to 2022. Corn was harvested using a Wintersteiger plot combine equipped with a harvest master grain gauge. Corn grain was collected at the time of harvest and analyzed for grain quality including oil, protein and starch.

The second study evaluated the performance of a nitrification inhibitor, N-serve (nitrapyrin), applied with anhydrous ammonia in fall on corn grain yields and quality at three landscape positions (shoulder, backslope and footslope) for four years from 2019 to 2022. Anhydrous ammonia fertilizer was applied at 150 lbs N ac^{-1} with an 8-row strip-tillage implement equipped with a Raven rate control system. The treatments were set up as randomized completed block designs with either six or ten replicates. Real-time as-applied data for treatments were collected from the tractor controller. The as-applied data was used to make GIS-based plot maps for evaluating the treatment performed on the landscape scale field experiment. Plant population data was collected before harvest. Ten ear cobs were manually collected from each landscape position and nitrification inhibitor treatment combinations to test for grain quality. Corn was harvested using CASE-IH Axial-Flow 7250 commercial combine with an 8-row head equipped with a yield monitor. The yield monitor was calibrated each year before harvesting. Yield measurements were taken by grain sensors, with each measurement covering an area of about 5 by 20 ft (5 ft is an average forward distance traveled by a combine during 1 s, and 20 ft is the width of the combine header). Simultaneously, site coordinates were determined by a GPS unit of the combine. The moisture content for corn grain yield was adjusted to 15%. The collected point yield data was cleaned using yield editor software (Sudduth et al. 2012). After removing outliers, developed yield data sets were imported to ArcGis Pro software for extraction of landscape positions and yield features for 2019 to 2022 yield data that matched each yield point collected by the combine.

Datasets for both studies were analyzed for normality in SAS statistical software using the univariate procedure. The normalized datasets were subjected to ANOVA analysis using the glimmix procedure in SAS. For the first study, N rates were not significant therefore data were averaged over N rates for the analysis. The replications were treated as random factors. For the second study, yield points data having coordinated were set up as spatial and temporal covariate structures. The mean values were estimated using T-grouping at an alpha of <0.05.

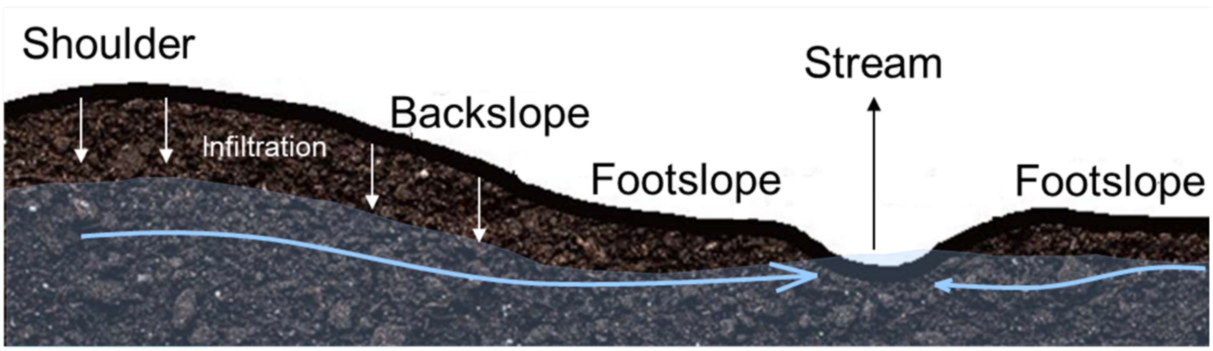

Figure 1. Common landscape position on a terraced field with a spacing of 120 ft of every terrace. Lidar data with a resolution of 9 sq ft/pixel was used to classify terraces in landscape positions using the Topographic Position Index Model.

RESULTS AND DISCUSSION

Corn grain yield was significantly affected by the landscape positions in all four years (P <0.0001). The corn grain yields were highest at the shoulder position followed by the backslope and footslope positions (Figure 2). In 2021, the corn grain yield was affected by the interaction of landscape position, hybrids, and seeding rate (P =0.047). At the shoulder position, corn grain yield was 18% greater with the 38,000 seeds ac^{-1} seeding rate than the 28,000 seeds ac^{-1} seeding rate for DKC65-95 hybrid (Figure 3). However, the 33,000 seeds ac^{-1} seeding rate performed better for yield production than the other two seeding rates for the same hybrid at the backslope position. Corn grain yield was increased with an increase in seeding rate for DKC62-53 hybrid at the backslope position. At a higher seeding rate of 38,000 seeds ac^{-1}, DKC65-95 had 19% higher yield than the DK62-53 hybrid at the shoulder position, whereas DK62-53 hybrid had 18% greater yield than DKC65-95 at the backslope position. No differences were observed for both hybrids due to seeding rates at the footslope position (Figure 3). N-uptake was significant in all four years for the main effects of landscape positions only (p<0.0001, data not shown). The grain quality data including oil protein and starch showed variable results for the main effects. The three-way interaction between landscape positions, hybrid, and seeding rates were not significant for grain quality parameters (p>0.05).

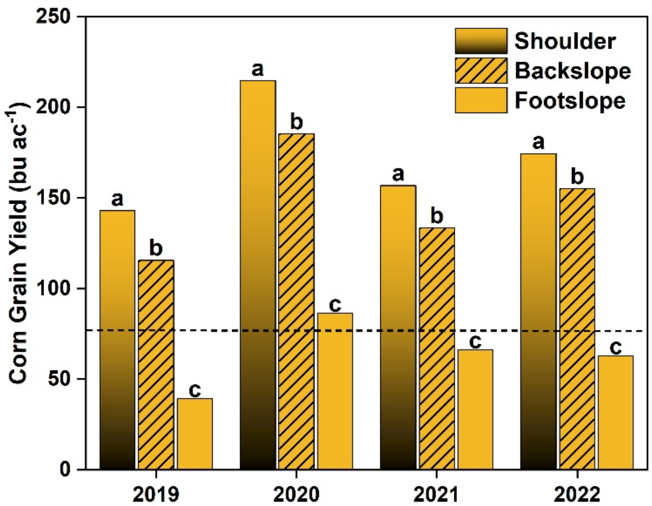

Figure 2. Corn grain yield determined by the main effects of landscape positions. Similar letters on the bars are not statistically different (α = 0.05). Grain yields were analyzed separately for years. The dashed verticle line indicates 75 bu ac^{-1}.

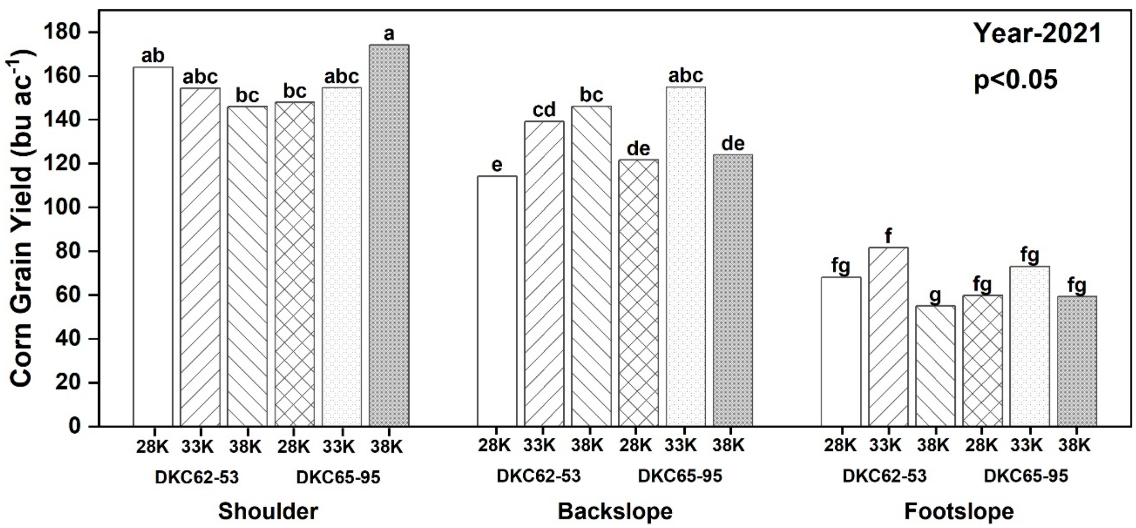

Figure 3. Corn grain yield determined by the three-way interaction of landscape positions, corn hybrids, and plant densities in 2021. Similar letters on the bars are not statistically different from each other (α = 0.05).

In the second study, corn grain harvest moisture and grain yields were significant for the two-way interaction of landscape positions and nitrification inhibitor treatments (Table 1). The highest grain moisture of 16.71% was observed for AA + N-Serve treatment at footslope compared to all other treatments. Within landscape positions, AA + N-Serve treatment had higher grain moisture compared to the control treatment (AA only). Average over the years corn grain yield was highest 165 bu ac^{-1} at the backslope position with AA + N-Serve treatment followed by 163 bu ac^{-1} at the shoulder with AA + N-Serve treatment. Anhydrous ammonia when applied alone without any nitrification inhibitor at the footslope position had the lowest 144 bu ac^{-1} corn grain yield. The nitrogen fertilizer was applied in the fall and environmental losses of nitrogen might have occurred during the winter and spring period contributing to lower N availability at the footslope positions.

In summary, precision management of inputs including seeding rate, nitrogen fertilizer application rate and timing, nitrogen stabilizers and hybrid selection is needed to increase production on the landscape positions. During four years of these studies, the footslope position yielded the lowest and is considered a marginal production ground when compared to the shoulder landscape position. At footslope position, N applied in fall has a greater chance of environmental loss, therefore best management practice could be to feed corn as per need. Hybrid selection and seeding rate should also be considered important factors when planning for production at landscape positions.

Table 1. Mean values of the harvest moisture and grain yields collected from three landscape positions from 2019 to 2022. Similar letters within a column are not significantly different from each other at $p<0.05$.

Landscape Positions (LP)	**Treatments (T)**	**Average Harvest Moisture (%) 2019-2022**	**Average Corn Grain Yield (bu ac^{-1}) 2019-2022**
Shouder		15.57c	159a
Backslope		15.93b	160a
Footslope		16.47a	151b
	Anhydrous Ammonia (AA)	15.81b	162a
	AA + N-Serve	16.18a	152b
Shoulder	AA	15.48d	156cd
Shoulder	AA + N-Serve	15.65c	163b
Backslope	AA	15.70c	154d
Backslope	AA + N-Serve	16.18b	165a
Footslope	AA	16.24b	144e
Footslope	AA + N-Serve	16.71a	158c
Source of Variation	**df**	**p-values**	
LP	1	<0.0001	<0.0001
T	2	<0.0001	<0.0001
LP x T	2	0.0011	0.0044

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