EVALUATION OF STRIP-TILLAGE AND FERTILIZER PLACEMENT IN SOUTHERN IDAHO CORN PRODUCTION

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ABSTRACT

Strip tillage (ST) and associated nutrient placement can potentially help producers reduce fuel and machinery costs, increase yield, and reduce soil erosion compared to chisel tillage (CT). This study was initiated to evaluate corn production (*Zea mays* L.) under ST and CT, and various nitrogen (N) and phosphorus (P) fertilizer placements. The effects of tillage practice and N and P placement on grain and biomass yield of field corn was assessed on two sites at the USDA-ARS Northwest Irrigation & Soils Research Laboratory at Kimberly, ID with different levels of soil fertility and productivity. Two sites were selected in a furrow irrigated field that had been previously cropped to alfalfa. Site A was located in the top half of the field and Site B was located in the bottom half of the field. Site A had lower levels of soil organic C (OC) and soil test P and K compared to Site B. The treatments were 1) ST with deep placement of N and broadcast P; 2) ST with 2 by 2 placement of N and broadcast P; 3) ST with deep placement of N and P; 4) CT with 2 by 2 placement of N and broadcast P; and 5) CT with broadcast N and P. The grain yields at Site A were greater for ST compared to CT. The deep band placement of N and P with ST had a yield (175 bu acre^{-1}) advantage of 23 and 16 bu acre^{-1} over both CT treatments, respectively and increased yields to levels similar to the average of Site B (178 bu acre^{-1}). No differences in grain yield occurred at Site B for all treatments. There were no differences in biomass yield of corn at the VT (tassel) growth stage and grain harvest time at both sites. The average total dry matter biomass at grain harvest time was 9.1 and 10.4 tons acre^{-1} averaged over all treatments, respectively. Data from year one of this study indicates that ST and deep band placement of N and P increased corn grain yield over CT and conventional fertilizer placement methods in highly eroded low fertile soils. Irrespective of the potential yield increases there may be an economic advantage associated less fuel due to less tillage passages with ST compared to CT. Because the data presented in this paper is from one year, caution should be exercised in extrapolating these results from year to year due to the variability in crop production associated with time-specific factors. This study will be carried out over a least one to two more years before final conclusions and recommendations are issued.

INTRODUCTION

The use of strip tillage (ST) and other conservation tillage practices are used to conserve soil and soil water through residue management and reduce tillage costs in many areas of the Corn Belt. However, in the Pacific Northwest these tillage practices are less common. Research is needed to evaluate these tillage practices in the Pacific Northwest to determine their production and economic feasibility. Strip tillage is a practice that creates a residue free and tilled zone, approximately 6 to 15 inches wide and 6 to 8 inches deep. The remaining portion of the field is not tilled and the residue from the previous crop remains on the soil surface. Studies have shown that corn production under ST is comparable to or greater than chisel tillage (CT) (Vetsch and Randall, 2002; Mallarino et al., 1999; Griffith et al., 1973). However, Vyn and Raimbault (1992) showed that ST reduced corn yields compared to moldboard plow in southern Ontario.

Although ST allows for the deep banding of fertilizers, differences in fertilizer placement must be compared to CT practices in order to assess overall differences between the systems. Many studies have observed mixed results when evaluating fertilizer placement in corn production. Most studies, though, have shown that starter fertilizer placed in a band near the seed can benefit early corn growth (Vetsch and Randall, 2002). However, increases in corn grain yields are less common. Low initial soil test P concentrations are the most common conditions in which corn grain yields increased as a result of starter fertilizer applications. Wolkowski (2000) found that corn yield with 2 by 2 (2 inches to the side and 2 inched below the seed) placement of starter fertilizer at planting was better than deep placement of fertilizer in the fall under zone tillage.

The objective of this research was to evaluate the production of corn under ST and CT, and various N and P fertilizer placements.

METHODS

The field study was initiated in 2007 at the USDA-ARS Northwest Irrigation & Soils Research Lab in Kimberly, ID on a Portneuf silt loam soil (coarse-silty mixed mesic Durixerollic Calciorthid). The site was cropped to alfalfa (*Medicago sativa* L.) from 2004 to 2006 under furrow irrigation. In October 2006 and April 2007 the alfalfa at the field site was sprayed with LV4 at a rate of 1.5 qt acre^{-1} and roundup at a rate of 1 qt acre^{-1}, respectively. The field sloped from east to west and was divided into two study sites. Site A was located on the east side of the field and had an average slope of 2%. Site B was located on the west side of the field and had a slope of 1%. Each site had the same treatments and replication strategy.

In 2007, prior to field operations, twenty soil sub-samples were collected at depths of 0 to 12 and 12 to 24 inches across all replications for both Site A and Site B. The subsamples from each site and depth were composited. The composited samples were air dried, ground to pass through a 2 mm sieve, and analyze for organic C (OC) by combusting 50 mg of sample in FlashEA1112 CNH analyzer (CE Elantech, Lakewood, NJ), soil test P and K (bicarbonate extractable, Olsen et al., 1954), and NO_3-N and NH_4-N (Keeney and Nelsen, 1982).

Treatments consisted of: 1) ST with deep placement of N and broadcast P; 2) ST with 2 by 2 placement of N and broadcast P; 3) ST with deep placement of N and P; 4) CT with 2 by 2 placement of N and broadcast P; and 5) CT with broadcast N and P (Table 1). Total N and P rates of 105 lbs N acre^{-1} and 58 lbs P_2O_5 acre^{-1} were applied to the treatments as urea (46-0-0) and mono-ammonium phosphate (11-52-0). Nitrogen fertilizer application rate was based on University of Idaho recommendations for corn grain (Brown and Westermann, 1988) at a yield goal of 175 bu acre^{-1} and NO_3-N and NH_4-N concentrations in the 0-12 and 12-24 inch depth at Site A. A 60 lbs N acre^{-1} alfalfa credit was applied. All treatments were replicated 4 times in a randomized complete block design. Fertilizers were either broadcast prior to tillage (Broadcast), placed 2 inches to the side and 2 inches below the seed at planting (2*2), or placed 7 inches below the soil surface directly below the seed during ST (Deep). Fertilizer application rates and timing information are presented in Table 1.

Chisel tillage treatments consisted of chisel plow and tandem disk (May 11) and roller harrow (May 16). The broadcast application of urea on May 16 to Treatment 5 was immediately incorporated with the roller harrow. Strip tillage occurred on May 23. Corn (Pioneer 3523, GDD_{50F} = 2530) was planted to the entire study area on May 24 at a rate of 31,000 seeds acre^{-1}. All plots were irrigated at rates to meet the crop water requirement. On June 21, all ST plots were sprayed with Clarity herbicide at a rate of 0.75 pints acre^{-1} to kill volunteer alfalfa.

Table 1. Rates and timing of N and P applications for all treatments.

Treatment	**1**	**2**	**3**	**4**	**5**
Tillage	**ST**	**ST**	**ST**	**CT**	**CT**
N Placement	**Deep**	**2*2**	**Deep**	**2*2**	**Broadcast**
	----------------------------	----------------------------	lbs N acre^{-1}	----------------------------	----------------------------
May 15	12	12		12	12
May 16					92
May 23	92		104		
May 24		92		92	
Total	*104*	*104*	*104*	*104*	*104*
P Placement	**Broadcast**	**Broadcast**	**Deep**	**Broadcast**	**Broadcast**
	--------------------------	--------------------------	lbs P_2O_5 acre^{-1}	--------------------------	--------------------------
May 15	58	58		58	58
May 23			58		
Total	*58*	*58*	*58*	*58*	*58*

A 12-plant sample was taken from each plot at Sites A and B at the V12 growth stage (July 20) to determine plant biomass (dry matter [DM] basis). The entire plant sample from each plot was weighted as-is directly after removal from the plots, chopped with a commercial wood chipper, and a subsample collected and weighted. The subsample was dried in an oven at 140 degrees F and re-weighted to determine the percent dry matter of the sample. On October 9, corn grain and plant samples were collected from each plot at Sites A and B. A 6-plant sample was collected to determine final plant biomass (DM basis). All ears from 40 ft of row, was collected to determine grain yield (reported at 15.5% moisture).

RESULTS AND DISCUSSION

Soil Analysis

Soil OC, soil test P, and soil test K in the 0 to 12 and 12 to 24 inch depth were lower at Site A than Site B (Table 2). At Site A, soil test P in the surface 12 inches was considered low to marginal according to the University of Idaho fertilizer recommendations for field corn (Brown and Westermann, 1988). The recommendations suggested application of 20 to 140 lbs P_2O_5 acre^{-1} depending on the soil lime content (from 5 to 15 calcium carbonate equivalents). The soil test K at Site A suggested no additional K fertilizer inputs (the critical level is 150 ppm). At Site B, soil test P and K were high in the surface 12 inches and fertilizer inputs for these nutrients would not be recommended. The difference in OC, soil test P and K levels between the two sites was likely due to furrow irrigated induced soil erosion from Site A (2% slope) to Site B (1% slope). Due to fertility differences, Site B would likely be more productive than Site A.

Table 2. Selected soil chemical properties from Site A and Site B at depths of 0-12 and 12-24 inches.

Soil Sample Depth (in)	Analyte	Site A	Site B
0-12	OC (%)	0.14	0.23
	P (mg/kg)	11.3	26.5
	K (mg/kg)	142.1	253.7
	NO_3-N (mg/kg)	13.1	19.8
	NH_4-N (mg/kg)	8.0	5.3
12-24	OC (%)	0.05	0.12
	P (mg/kg)	3.2	9.2
	K (mg/kg)	126.0	228.8
	NO_3-N (mg/kg)	3.3	8.2
	NH_4-N (mg/kg)	3.5	4.3

Grain Yield

There were significant differences in grain yields between treatments at Site A (Figure 1). Treatment 3 (ST-deep N-deep P) at Site A had greater grain yields than both the CT treatments. Treatment 3 grain yields were 23 and 16 bu acre^{-1} greater than Treatment 4 (CT-2*2-broadcast P) and Treatment 5 (CT-broadcast N-broadcast P), respectively. A direct comparison of tillage effects on grain yield could be made between Treatments 2 (ST 2*2 N and broadcast P) and 4 (CT 2*2 N and broadcast P) due to the two treatments having the same fertilizer placments. Strip tillage had a greater grain yield compared to CT (+14 bu acre^{-1}). There was no significance difference in grain yield between the ST treatments (Treatments 1, 2, and 3) but a trend for increased yield with the deep N and P placement was evident (Treatment 3). Averaged over all treatments, the grain yield at Sites A and B were 164 bu acre^{-1} and 178 bu acre^{-1}, respectively. Unlike site A, there were no grain yield differences between treatments at Site B.

The response of grain yield to tillage and nutrient placement at Site A was likely a result of the overall lower fertility status associated with furrow irrigated induced soil, OC, and nutrient transport. The impact of tillage and nutrient placement was negligible at Site B due to an overall greater level of fertility, a result of soil, OC, and nutrient deposition from Site A. These results indicate that corn grown in areas of fields with shallower soil depths, low in OC and nutrients due to erosion and other factors may have a greater yield response to ST and deep placement of N and P compared to CT and conventional fertilizer placements.

Biomass Yield

There were no significant differences in the biomass yield between treatments at the V12 growth stage (data not shown) or a final harvest at both sites (Figure 2). Site A biomass yield trends were similar to Site A grain yield trends.

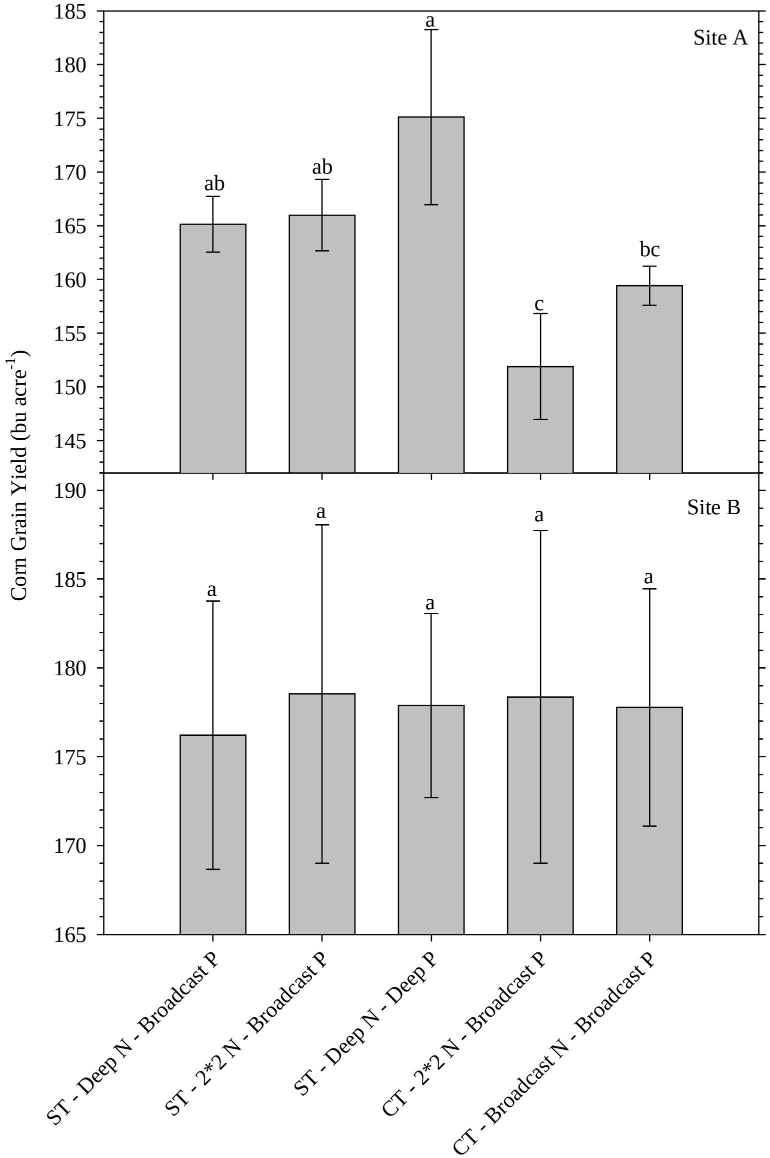

Figure 1. Corn grain yield for tillage and fertilizer placement treatments at Site A and Site B locations in 2007. Error bars are the standard errors of the treatment means. Treatments with the same letter are not significantly different at the 0.05 level.

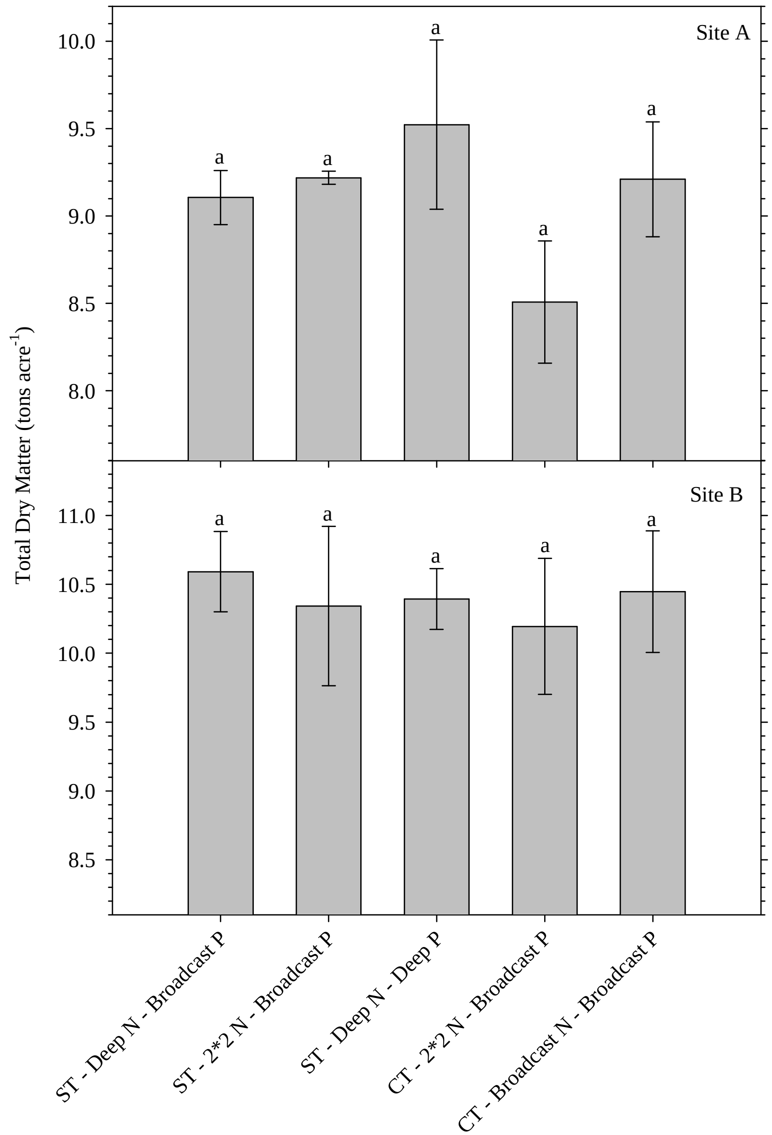

Figure 2. Corn biomass yield at grain harvest time for tillage and fertilizer placement treatments at Site A and Site B locations in 2007. Error bars are the standard errors of the treatment means. Treatments with the same letter are not significantly different at the 0.05 level.

Conclusions

Results from one year of research indicated that ST provided a corn grain production advantage over CT associated with tillage as well as fertilizer placement on highly eroded, low fertile soils. On the more fertile site, there were no differences in corn grain yield between ST and CT or fertilizer placement strategies. Although no economic analysis has been conducted to date, there may be an economic advantage for ST over CT due to potential fuel savings associated with less tillage passes at both research sites. Remember, due to the variability in crop production associated with time-specific factors, caution should be exercised in extrapolating these results from year to year. This study will be carried out over a least one to two more years before final conclusions and recommendations are issued. These data should be viewed as only preliminary.

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