Undergraduate Research Journal

Volume 19 Article 4

2015

Crop Yields: Stripper Header Technology vs. Conventional Header Technology

Kyle D. Michaelis
University of Nebraska at Kearney

M. F. Vigil
USDA-ARS Central Great Plains Research Station

W. B. Henry
USDA-ARS Central Great Plains Research Station

Crop Yields: Stripper Header Technology vs. Conventional Header Technology

Kyle D. Michaelis

INTRODUCTION

Increasing crop residues on the surface of the soil can increase precipitation storage efficiencies from 15% to almost 35% as residue is increased from 0 to 10 Mg/ha^{-1} (Nielsen et. al 2005). As crop residues increase, there is increased shading of the soil surface, cooler soil temperatures, decreased wind speed on the soil surface, and an increase in the precipitation infiltration, all of which protect the surface of the soil and suppress evaporation of precipitation. In addition, the increased residues allow for a greater amount of snow catch, which ultimately increases the amount of moisture in the soil.

Stripper header technology is a type of technology that effectively leaves more crop residue on the soil surface. Conventional harvest methods cut the stalk of the plants fairly close to the soil surface, whereas a stripper header "strips" the grain from the head of the plant. Therefore, the entire stalk of the plant is left on the surface of the soil. Because less residue goes through the machine, there is less wear and the combine is able to drive faster, reducing harvesting times (Henry et. al 2008). Harvesting crops, such as proso millet, using a stripper header eliminates expenses to the swathing operations when compared to conventional harvest methods. This is because a stripper header can directly harvest the millet instead of first swathing into windrows. With the rising costs of fuel this is beneficial as there is ultimately fewer passes made on each field harvested.

The purpose of this paper is to compare crop yields on acres where stripper header technology was used to those where conventional header technology was used in a dryland cropping system. The results are based on experimental data collected at the USDA-ARS Central Great Plains Research Station, and include information on Northeastern Colorado wheat, millet, and sorghum yields. This analysis is important to demonstrate the benefits of using stripper header technology in a dryland cropping system. In the next section, the approaches and major findings of the previous literature are reviewed.

LITERATURE REVIEW

Stripper header technology can help to improve water efficiency by leaving more stubble to catch snow and prevent erosion. Stripper header technology can also keep the cost of operations down, after the initial purchase of the header, making for a more efficient farming operation. Preceding studies have examined efficient water use in dryland cropping systems, evaluated proso millet yields and residue mass following direct harvest with a stripper header, analyzed precipitation storage efficiency, and compared wheat loss in stripper header technology to conventional header technology. The discussion below examines selected studies that focus on the utilization of stripper header technology.

Efficient use of limited water supplies in dryland cropping systems is critical for success. Nielsen et al. (2005) conducted an experiment on precipitation use efficiency in a dryland cropping system and management in the Great Plains. Data was collected from states in the Great Plains over the time period from 1990 to 2004. The authors evaluated how the precipitation use efficiency changed with different residue management in the dryland system. The results suggest that as tillage is reduced, precipitation use efficiency is increased. Reducing tillage also leaves more residue on the surface to trap moisture, which reduces runoff. The authors found that as residue is increased by 10 Mg/ha^{-1}, precipitation storage is increased by almost 25%. Also, the results indicate that with more residue, infiltration of precipitation increases, which increases use efficiency as well. As a result, one may infer that because a stripper header leaves a greater amount of residue on the surface, it would be beneficial to farmers to use stripper header technology in a dryland cropping system. These findings support that precipitation use efficiency is increased with more residue; therefore, using a stripper header should increase precipitation use efficiency.

Determining yield differences between conventionally swathed and stripper header harvested proso millet is crucial in determining which method is the more efficient. Henry et al. (2008) conducted an experiment to compare the two harvesting methods for proso millet. The data was collected from field experiments at the USDA – ARS Central Great Plains Research Station in Akron, CO. The conventional method involves swathing the millet into windrows and letting it dry before picking it up. Using a stripper header, the millet can be directly harvested by the header rather than making several passes. The data was analyzed using linear regression methods. The authors found that over a four-year period, there was little to no difference in the yields of the proso millet. However, using a stripper header allowed for farmers to make a single pass over the millet, whereas the conventional method required a couple of passes. One pass to swath out the millet into windrows, another to pick up the windrows for harvest. They found that swathing operation costs range from \$10 ha^{-1} to \$45ha^{-1}, which is otherwise zero when using a stripper header, as it is unnecessary to swath the millet with direct harvesting methods. As a result, using stripper header technology to harvest proso millet can be beneficial. There are less fuel costs associated with using the stripper header, all while maintaining the same yields as conventional millet harvesting methods.

Precipitation storage efficiency is also crucial for success in a dryland cropping system. Nielsen and Vigil (2010) conducted an experiment to examine precipitation storage efficiency in a dryland cropping system in the Great Plains. The data was collected from field experiments at the USDA – ARS Central Great Plains Research Station, which is located near Akron, CO. The experiment was started in 1996 and ended in 2006. The data was analyzed using a subset linear regression. Given water storage is important in a climate with such little annual precipitation, the authors evaluated the precipitation storage with different tillage methods. They found that with no tillage came greater storage efficiency. That is, when there is more residue leftover, the stubble catches more snow, which allows for more moisture to be trapped in the soil. Precipitation storage and precipitation use are both important in a dryland cropping system.

When the residue is absent due to conventional tillage, precipitation storage ranged from 8.3% to 34.0%. When the residue is left on fields due to no tillage, the precipitation storage ranged from 19.7% to 50.5%, which is significantly higher than when conventionally tilled. As a result, one may infer that when using a stripper header with no tillage, farmers are maximizing their precipitation storage and precipitation use. The extra stubble that comes with using stripper header technology helps to both collect and keep moisture in the ground.

Comparing wheat loss when using stripper header technology to wheat loss when using conventional header technology is an important factor in determining yields for wheat. Chegini and Mirnezami (2012) conducted an experiment to test for seed loss between these two types of harvesting methods for wheat. The data was collected from field experiments conducted in Shiraz, Iran. The data was analyzed by using regulation tests, evaluation tests, and efficiency tests. The authors found that seed loss in stripper headers was much less than in conventional headers. Specifically stripper headers had around a 3.5% seed loss, whereas conventional headers had around a 6.5% seed loss. The results indicate that stripper headers are more efficient in terms of seed loss during wheat harvest than conventional headers, which overall means that yields will be higher when stripper headers are used.

As can be noted from above, stripper header technology can be beneficial in a dryland cropping system. Past studies have demonstrated that leaving more residue can increase both precipitation use efficiency and precipitation storage efficiency, decrease overall costs, and even improve yields by minimizing seed loss. These findings provide supporting evidence for why the benefits of using stripper header technology outweigh those of conventional harvesting methods. The current study extends the previous findings by comparing the yields for wheat, millet, and sorghum in Northeastern Colorado. In the next section, the data and methods used in this study will be discussed.

DATA AND METHODS

This study compares crop yields on acres where stripper header technology was utilized to those where conventional header technology was utilized in a dryland cropping system. In this section, the economic theory, empirical methods, and data will be discussed.

Method

In much of the literature, it is apparent that soil precipitation storage efficiency, precipitation usage efficiency, and seed loss reduction are all important factors that affect crop yields. One way to enhance these factors is by using stripper header technology. Stripper header technology is a type of technological advancement in agriculture. According to the theory of supply, a technological advancement increases the supply of any good or service. Thus, it is hypothesized that crop yields (e.g., supply) will be higher when using stripper header technology than conventional header technology. This is because the stripper header technology should increase the precipitation usage and the precipitation storage efficiencies, and should decrease the seed loss during harvesting.

To test if yields on fields harvested using stripper header technology are higher compared to conventional header technology, a comparative analysis was conducted. The analysis involves two tests. First, we test that the variances of the yields for each crop are the same using an F-test. This is necessary for determining the appropriate test statistic to use when conducting the t-test. Specifically, the F-test hypotheses are:

$$H_0: \sigma^2_{Ci} = \sigma^2_{Si}$$
$$H_1: \sigma^2_{Ci} \neq \sigma^2_{Si}$$

σ^2_C denotes the variance of crop yields in fields in which conventional header technology was utilized for harvest and σ^2_S denotes the variance of crop yields in fields in which stripper header technology was utilized for harvest. The *i* denotes the specific crop being analyzed in the data. The three crop types are wheat, millet, and sorghum.

The t-test is used to compare the mean crop yields on fields harvested by conventional header technology to those harvested with stripper header technology. Specifically, the t-test hypotheses are:

$$H_0: \mu_{Ci} \geq \mu_{Si}$$
$$H_a: \mu_{Ci} < \mu_{Si}$$

μ_C denotes the mean crop yields in fields in which conventional header technology was utilized for harvest and μ_S denotes the mean crop yields in fields in which stripper header technology was utilized for harvest. The *i* denotes the specific crop being analyzed in the data. The three crop types are wheat, millet, and sorghum. The following section discusses the data that is analyzed.

Data

All data was obtained from the USDA-ARS Central Great Plains Research Station. The Central Great Plains Research Station is an agricultural research station located in Akron, CO. The Research Station was established in 1907. The mission of this station is to enhance the economic and environmental well-being of agriculture by the development of integrated cropping systems and technologies for maximum utilization of soil and water resources. The station also places an emphasis on efficient use of plant nutrients, pesticides, and water and soil conservation/preservation. Experiments at the station have helped identify the best crops suited for growing in the area. It has also helped local producers improve yields of several crops. The station has been able to work through many of the problems that are present in a semi-arid climate, even during a shortage of rain.

The data was collected from several test plots located at the station in 2009-2011. Overall there were 32 test plots, each with a four year crop rotation of wheat-sorghum-millet-fallow. Each year one fourth of the plots were wheat, millet, sorghum, or fallow, respectively. There were 4 replications of all treatments and the plots were arranged in a randomized complete block design. Plot sizes were ninety feet long by ninety feet wide. Half of the plots were managed using stripper header technology, while the other half were managed using conventional header technology. However, to prevent confounding of harvest method and the effects of stubble produced by each harvest method, the yields reported were collected with a small plot combine using conventional harvesting methods from a five foot wide swath down through the center of

each 90 foot wide plot. The data consists of yields from wheat, proso millet, and sorghum. Three years of wheat data were collected from 2009, 2010 and 2011, whereas the millet and sorghum data was collected in 2009 and 2010. The following section discusses the results found from the comparative analysis.

RESULTS

Table 1 presents the descriptive statistics as well as the comparative analysis results. The first section shows the results for wheat. On average, the wheat yield on acres using stripper header technology is 52.9 bushels per acre with minimum and maximum yields of 43.4 and 63.7 bushels per acre, respectively. To compare, the average, the minimum, and the maximum yields on acres using conventional technology were 46.2, 35.5, and 62.1 bushels per acre, respectively. The F-test results indicate that the variance of the wheat yields on acres using stripper header technology is not significantly different than the variance of the wheat yields on acres using conventional header technology. However, the t-test results indicate that the mean yield on stripper header technology acres (52.9 bushels per acre) is significantly higher than the mean yield on conventional header technology acres (46.2 bushels per acre). This is consistent with what was expected. Moreover, in much of the literature, increasing the amount of crop residue left on the surface can help to increase the moisture content of soil, which is beneficial to the next year's crop (Nielsen et al. 2005). One way to do this is by using a stripper header, as it leaves more residues on the surface. The previous findings have also shown that seed loss in wheat harvest is lower in a stripper header than a conventional header (Chegini et. al 2012). This could be a factor into this study as reducing seed loss can help increase the yields of wheat.

The second and third sections show the results for millet and sorghum. On average, the millet yield on acres using stripper header technology is 33.1 bushels per acre with a minimum and maximum yields of 14.8 and 65.6 bushels per acre, respectively. To compare, the average, the minimum, and the maximum yields on acres using conventional technology were 28.3, 9.9, and 58.6 bushels per acre, respectively. The sorghum yield on acres using stripper header technology is 25.8 bushels per acre with a minimum and maximum yields of 3.0 and 47.7. To compare, the average, the minimum, and the maximum yields on acres using conventional technology were 27.5, 3.3, and 61.9 bushels per acre, respectively. It is also important to point out that the sorghum crop in 2009 was damaged by a hailstorm that came after millet harvest. That storm greatly reduced sorghum yields in 2009. Ultimately the hail damaged sorghum resulted in another source of variability that made it more difficult to sort out treatment effects for the sorghum crop.

The F-test results indicate that the variance of the millet and sorghum yields on acres using stripper header technology is not significantly different than the variance of the wheat yields on acres using conventional header technology. The t-test results indicate that the mean yield for sorghum and millet managed with stripper header technology is not significantly higher than the mean yield of those crops managed with conventional header technology. Overall, these results are not consistent with what was expected; however, data from only the 2009 and 2010

harvests were available when analyzing millet and sorghum (about 20 observations). To increase preciseness of the test results, more observations are necessary.

Table 1: Conventional vs. Stripper Header

	Wheat		***Millet***		***Sorghum***	
	Conventional	Stripper	Conventional	Stripper	Conventional	Stripper
Avg. Bu/AC	46.224	52.943	28.279	33.100	27.450	25.794
Std. Deviation	7.032	5.741	17.636	20.129	19.826	17.296
Max	62.093	63.681	58.602	65.553	61.898	47.706
Min	35.314	43.381	9.846	14.789	3.289	2.955
F-Statistic	2.014		0.355		2.818	
P-Value	0.169		0.334		0.329	
α=0.05	$p > \alpha$		$p > \alpha$		$p > \alpha$	
T-Statistic	1.679		1.717		1.717	
P-Value	0.000		0.270		0.415	
α=0.05	$p < \alpha$		$p > \alpha$		$p > \alpha$	

Source: USDA – ARS CGPRS

SUMMARY AND CONCLUSIONS

Using a unique dataset on Northeastern Colorado wheat, millet, and sorghum yields, this study compared crop yields on acres where stripper header technology was used to those where conventional header technology was used in a dryland cropping system. It was hypothesized that because stripper header technology is a technological advancement, the yields of the three crops would be higher when this technology was used compared to when conventional technology was used.

It was found that for wheat, the yields were significantly higher on test plots in which stripper header technology was utilized when compared to yields on test plots in which conventional header technology was utilized. These results are consistent with previous findings. As explained in much of the literature, increasing the amount of crop residue left on the surface can help to increase the moisture content of soil, which is beneficial to the next year's crop. One way to do this is by using a stripper header as it leaves more crop residue on the surface. The previous findings have also shown that seed loss in wheat harvest is lower in a stripper header than a conventional header. This could be a factor in this study, as well, as reducing seed loss can help increase the yields of wheat.

As for millet and sorghum, no significant difference was found across the technology types. One limitation of this study is the lack of observations for millet and sorghum. Had there been more observations, the estimation would have been more precise and may have resulted in different conclusions. In regards to future research, it would be beneficial to include more variables in the estimation. That is, yields are influenced by many factors including soil moisture content, annual precipitation, and even annual temperature. While these variables were not included, they could provide for a better understanding of the yield differences. These variables were not included due to the data availability.

REFERENCES

Chegini, G.R, Mirnezami, S.V. (2012). Analysis and comparison of wheat losses in two harvesting methods. Agricultural Engineering International: CIGR Journal, 14(3): 91－98.

Henry, Brien W., Nielsen, David C., Vigil, Merle F., Calderon, Francisco J., West, Mark S. (2008). Proso Millet Yield and Residue Mass following Direct Harvest with a Stripper-Header. Agronomy Journal. 100(3): 580 – 584.

Nielsen, David C., Unger, Paul W., Miller, Perry R. (2005). Efficient Water Use in Dryland Cropping Systems in the Great Plains. Agronomy Journal. 97(2): 364 – 372.

Nielsen, David C., Vigil, Merle F. (2010). Precipitation Storage Efficiency during Fallow in Wheat-Fallow Systems. Agronomy Journal. 102(2): 537 – 543.

USDA – ARS CGPRS, Akron, CO. (2014). Wheat, Millet, and Sorghum Yield Data. Obtained on 9/25/14.

ADDITIONAL AUTHORS

M.F.Vigil- Soil Scientist – USDA-ARS Central Great Plains Research Station

W.B. Henry- Research Agronomist – USDA-ARS Central Great Plains Research Station