AN ASAE MEETING PRESENTATION

Wheel Ridges - Concepts, Construction and Yields

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Written of presentation at the
1992 International Winter Meeting
sponsored by
THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Nashville Convention Center
Nashville, Tennessee
15-18 December 1992

SUMMARY:

Wheel ridges are defined and their advantages and disadvantages to dryland agriculture in the west-central Great Plains are described. Yield results are compared between conventional-flat, ridge-plant, and wheel-ridge farming practices, for grain sorghum, corn, sunflowers and soybeans.

KEYWORDS:

controlled traffic, water harvesting, ridges, arid agriculture

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Wheel Ridges - Concepts, Construction and Yields[1]

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Abstract

Wheel ridges are raised soil ridges that are constructed parallel through a field and replace one row out of every three. The objective of this research is to evaluate wheel ridge farming as a more sustainable dryland system. The ridges serve as raised wheel tracks, as microwatersheds to harvest water onto the cropped area between the ridges, and to protect young plants from high winds. The advantages and disadvantages of using wheel ridges for the production of summer annual crops are described. Construction and maintenance of the wheel ridges is also described. Grain yield results from two sets of experimental plots show total grain yield from wheel-ridge, skip-row farming were 13.8% greater than conventionally farmed corn and sorghum. Without wheel ridges, skip-row farming alone reduced grain yields 18.4 percent. In another set of plots, corn, sunflowers and soybeans were grown in rotation, with soybeans exhibiting the greatest yield increase with wheel ridges. On a cropped area basis, corn yields were greater between wheel ridges than conventionally grown corn.

Introduction

Dryland cropping practices that use more spring and summer annual crops and less fallow can better utilize the precipitation that falls in the Central Great Plains. At Akron Colorado, almost two-thirds of the annual precipitation (84 year average) occurs during the late spring and summer months of May (7.72 cm = 3.04"), June (6.38 cm = 2.51"), July (6.78 cm = 2.67"), August (5.16 cm = 2.03"), (Shawcroft, 1992). Fallowing the land during the second summer of the fallow period does not contribute greatly to recharging soil moisture (Smika, 1990). Much of the precipitation occurring during the summer fallow period is lost by natural evaporation after a rainfall event or as a result of soil drying resulting from tillage operations used to control weeds. Therefore, the practice of fallowing the land, although saving the moisture from an additional winter's snowfall to reduce the risk of crop failure and being a successful long-time farming practice, has much lower precipitation use efficiency (PUE) when compared to more intensive cropping practices such as annual cropping (Halvorson, 1990).

Annual cropping (no fallow period) with tillage used for weed control, is a more marginal farming practice due to the limited total annual precipitation. However, it can be successful on a long-term sustainable basis in the semi-arid western Great Plains when used with less tillage which increases surface crop residues and reduces soil surface water evaporation and runoff, and increases infiltration. Reduced tillage farming requires a high level of management and timeliness of field operations to be successful. These concerns have been a deterrent to the adoption of reduced or no-till farming practices.

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As energy costs increase, the cost of human-added inputs to crop production increase, and consequently the intrinsic value of natural crop inputs (i.e., precipitation, organic matter, soil tilth) also increase. Therefore, the practice of harvesting water for crop production has significant value. Crop producers have shown a renewed interest in old (i.e., bench terraces) and any new water harvesting techniques which could maintain or increase crop production in the western Great Plains.

Small basins or ridges can be used to form microwatersheds to harvest water from a non-cropped water contributing area onto a cropped area, thus increasing the effective use of precipitation on a cropped area basis. Research done in the late 1960's and early 1970's (Aase and Kemper, 1968; Aase et al, 1968; Fairborne et al, 1970, 1971, 1972) showed that the water harvesting feature of microwatersheds (or wheel ridges) could increase total crop production per total area during high precipitation years over conventional crop production methods. Therefore, farming practices using annual cropping and wheel ridges to harvest water potentially could be more successful than the traditional crop and fallow rotations.

Objectives

The initial objectives of this study are to:

1. Compare a wheel-ridge farming practice to ridge-plant and conventional flat farming practices.
2. Determine which crops could potentially benefit most by wheel-ridge farming in terms of increasing total grain production.
3. Determine optimum plant populations of corn produced between wheel ridges.

Potential Advantages of Wheel Ridges

Some possible potential advantages of farming with wheel ridges are:

1. Water harvesting - greater concentration of the collected rain water in the soil near the growing crop so it can be better utilized.
2. Annual cropping - better precipitation utilization, no fallow
3. Controlled traffic
   a. crop chemical application without damage to drilled crops.
   b. better tractor tractive efficiency
   c. less draft force per tillage component and lower power needs, due to reduced soil bulk density in the cropped area.
4. More timely field operations. Raised wheel ridges allow earlier re-entry into fields after rainfalls because the surface soil of the raised wheel ridges will drain and dry sooner and because of less concern with compaction on the wheel ridges (increased compaction on the wheel-ridges can increase tractive efficiency).
5. More of the available water is used for transpiration. Greater plant populations of normally low-density dryland crops like corn, which will result in less water loss by direct soil water evaporation from the soil surface, as a percent of total water use.
6. Potentially similar yields, with less inputs (pesticides, seed, ...)
7. Lower wind velocities near the surface, due to the wheel ridges.
   a. less soil water evaporation in the cropped area
   b. less soil erosion, by wind
   c. less direct snow removal and sublimation
   d. less plant injury when plants are young

8. Greater snow catch, particularly with surface harvested crops like soybeans or forages. Ridges are like miniature snow fences.
9. Enhanced possibilities for lower water stress crops. Crops that normally exhibit poor water stress characteristics could have the most significant yield increases, which could give them a renewed potential for arid agricultural regions. In extreme arid regions, grain could possibly be produced where it couldn't before with conventional methods.

Potential Disadvantages of Wheel Ridges

Some potential disadvantages of using wheel ridges are:

1. Equipment will need to be modified, particularly equipment used to harvest crops that are cut off near the soil surface (i.e., soybeans).
2. The wheel ridges will probably need to be maintained (groomed, compacted), which could require a separate field operation but this operation could be incorporated with another field operation. Deep chiseling may be needed to improve infiltration or check dams installed perpendicular to the ridges to retain rainwater.
3. Initial construction costs and the lost value of soil water evaporated due to the construction.
4. Removal of top soil from the cropped area.

Experimental Design

This project used two separate sets of experimental plots, both using a randomized block statistical design. The center of each wheel ridge is located in the place of every third row with a row spacing of 0.76 m (30 inches) apart. Row crops are planted with a six-row planter with the second row from each end of the planter omitted so that only four out of the six rows are planted, as shown in figure 1. The plots are harvested with a two-row plot combine that has wheels that straddle the two rows of crop. The corn, sorghum and sunflowers can be harvested with a conventional field combine. The two sets of plots are:

1. A wheel-ridge (WR) production area using three annual crops grown in rotation (corn, then sunflowers, then soybeans) with each crop grown each year and replicated four times. Plot size is 9.15 m by 30.5 m (30' x 100'). The WR plots were established and deep chiseled to break up any compaction due to construction in the fall of 1990 and were then initially cropped in 1991. Four plant population plots existed in the WR corn plots only.
2. Surface profile comparison (SPC) plots to compare:
   a.) wheel ridge, with four out of six rows cropped (denoted as W4)
   b.) skip-row, ridge-plant, with four out of six rows cropped (denoted as R4), in which planting is done on top of formed row ridges.
   c.) skip-row conventional flat surface profile farming with four out of six rows cropped, (denoted as F4), and
   d.) conventional flat with all six rows cropped, (denoted as F6)

   Plots were 4.57 m by 36.6 m (15' x 120') with four replications. The SPC plots were established in the spring of 1990, but the cropped area was not deep chiseled to break up any compaction due to their construction until the fall of 1990, after the initial crop in 1990. The crops grown in the two plot areas from 1990 to 1992 are shown in Table 1.

The minimum necessary tillage was done to the plots during this study. Herbicides were applied to all crop areas for weed control. No preplant tillage was performed. The only tillage operation performed on any of the plots was a single pass with a row cultivator during July to remove existing weeds not controlled with the herbicides. The row cultivation was performed on the WR soybeans and sunflowers in 1991 and 1992, and on the SPC grain sorghum in 1992. Weeds in the corn plots were adequately controlled with herbicides and received no tillage during the study. All crops were planted with a row crop planter equipped with bubble coulters and double-disk openers.

Construction

The wheel ridges were constructed by simply pushing approximately 8 cm (3.1 inches) of the topsoil from the area between the wheel ridges into the ridge. The ridges were aligned parallel through the field. In the SPC area, a tractor with a three-point mounted rear blade was used. Six or seven passes with the blade were required to form the ridges by this method. In the WR area, the wheel ridges were constructed using three implements: a two-bottom moldboard plow, a four-disk border diker, and bed former. Each wheel ridge was first formed with two passes on each side with the moldboard plow. Then a pass with the border diker, a pass with the bed former, and a final pass again with the border diker were made. Two deep ripper shanks were then pulled through the cropped area to break up any compaction due to the construction. Ridge height averaged 25 cm (10 inches).

A standard road grader or other commercially available bedder implement could be used to construct the wheel ridges in a one-pass field operation. Using a road grader, other construction scenarios can be used to form the wheel ridge that uses subsoil to form the ridges and leaves top soil in the cropped areas.

A shaper was also constructed and used to reshape the wheel ridges. This shaper consisted of two blades approximately 1.2 m (4') long pulled on both sides of the wheel ridge at approximately 30 degrees to the centerline of the ridge. This shaper pulled soil back up to the center of the ridge and also removed any weeds that existed on the ridge. It was pulled on the wheel ridges in both plot areas one time during July of both 1991 and 1992.

Grain Yield Results and Discussion

Surface Profile Comparison Plots: Grain yields on a total area basis for the SPC plots for three years are shown in Table 2. The sorghum grain yields in 1990 were lower in the W4 plots due to surface compaction that probably reduced crop growth and grain production. The SPC plots were not deep chiseled to break up compaction due to construction until the fall of 1990. After rainfall events in 1990, water would pond between the wheel ridges for up to two days. Excluding the 1990 results, the combined 1991 and 1992 grain yields on a total area basis are shown in Table 3.

The combined corn and sorghum grain yields were 13.8 percent greater (statistically different at an alpha level of 0.23) in the wheel ridge plots with 4 out of 6 rows cropped, than the conventional F6 plots with all six rows cropped on a flat soil profile. Surprisingly, the ridge-planted (R4) crops had grain yields 2.6 percent greater (not stat. diff.) than the F6 plots. However, ridge-planted crops in the western Great Plains have a much higher risk of being damaged by high winds when the plants are small. The four out of six row conventionally farmed (F4) plots had grain yields 18.4 percent less (statistically diff. at alpha level of 0.12) than the F6 plots.

Wheel Ridge Production Plots - Corn, Sunflowers, and Soybeans: Pioneer variety 3732 (100-day relative maturity) was grown in the WR plots with population plots that were two rows by 15.24 m (50') long, replicated four times. Grain yields on a total area basis for 1991 and 1992 are shown in Table 4. The corn populations results were not significantly different because of large data variation among replications. However, the 33333 pl/ha (13333 pl/acre) plots in both years had the greatest yields at 2873 and 5193 kg/ha (46 and 83 bu/ac) on a total area basis. What is interesting is how the 1992 corn at 33333 pl/ha (total area basis) yielded on a cropped area basis. Yields for the four replications were 6267, 7736, 7789 and 9367 kg/ha (100, 123, 124 and 149 bu/ac) with an average grain yield of 7789 kg/ha (124 bu/ac). At Akron Colorado, long-term dryland corn yields with conventional and no-till practices range from zero up to 6400 kg/ha (100 bu/ac).

Dryland corn in the western Great Plains is typically grown at plant populations of 20000 to 37500 pl/ha (8000 to 15000 pl/acre). However, if corn could be grown at greater populations, more total water evaporation goes to transpiration and less to evaporation from the soil. When corn populations approach 45000 to 50000 pl/ha (18000 to 20000 pl/ac), the amount of leaf area approaches a leaf area index (LAI) value of approximately 2.8 to 3.0, which is recognized as "full cover". LAI is defined as leaf area per land area. At or greater than full cover, a crop has enough leaf area that transpiration can be equal to the total evapotranspirative demand.

The sunflower grain yields on a total area basis in the WR plots averaged 1219 (1088 lb/ac) in 1991 and 1213 kg/ha (1083 lb/ac) in 1992. These yields are typical for sunflowers in eastern Colorado. Sunflowers are relatively drought tolerant because they are able to compensate their growth and seed production (head size) with different climatic conditions. Therefore, sunflowers appear to be a crop that may not benefit as much from a wheel ridge farming practice because of their growth compensating characteristics.

Soybeans yields were greater in the WR production plots than on adjacent, conventional farmed soybean plots that followed winter wheat. Row spacing (0.76 m) and plant population (333000 pl/ha) and variety (Pioneer 9202) were the same for all soybean plots. In 1991, soybeans in the WR plots yielded an average of 891 kg/ha (13.3 bu/ac) on a total area basis, as compared to an average of 586 kg/ha (8.7 bu/ac) on conventionally farmed plots. In 1992 under much cooler summer temperatures (third coolest in 84 years), soybeans in the WR plots yielded an average of 1284 kg/ha (19.1 bu/ac) on a total area basis, as compared to an average of 1210 kg/ha (18.0 bu/ac) for the conventionally farmed soybeans. Of interest again, are the yields on a cropped area basis. The soybean yields averaged 1337 kg/ha (19.9 bu/ac) in 1991, and 1925 kg/ha (28.6 bu/ac) in 1992 in the WR plots on a cropped area basis.

The two climatically contrasting years (average 1991 versus much cooler 1992) show how the wheel ridges may protect soybeans from hot, dry winds and improve yields. Yields in 1992 were greater because of greater observed number of pods per node. In both the WR and conventionally farmed plots, soybean plants in 1992 typically had 3 to 5 pods per node, as opposed to 1 to 3 pods per node in 1991. The overall cooler temperatures in 1992 caused fewer aborted flowers and subsequently greater pod production. The yield difference was much greater in 1991 which indicates that the soybeans in the WR plots were protected from hot dry winds, had fewer aborted flowers and produced more pods. In 1992 under cooler winds, the effect was less as evidenced by a smaller yield difference. Soybeans, other legumes and other alternative crops with lower stress tolerance may exhibit the greatest benefits from WR farming during average to hot summers.

Conclusions

The use of wheel ridges in place of one row out of three increased total two-year, corn and sorghum grain production by 13.8 percent (alpha = 0.23) compared to conventional farming. Skip-row planting alone reduced grain yields 18.4 percent (alpha = 0.12) compared to conventional farming. Soybeans and possibly other low stress tolerant crops appear to have the greatest potential to increase grain production with the use of wheel ridges. Corn yields were maximum at plant populations of 33333 pl/ha (13333 pl/ac) on a total area basis. Sunflower seed yields were comparable to conventionally farmed sunflowers.

The wheel ridges can be constructed with a tractor-mounted grader blade or by using other standard farm implements such as moldboard plows, border dikers, or bedders. A ridge shaper was built to reshape the wheel ridged once per year. Deep chiseling of the cropped area is necessary to break up the compaction that occurs as a result of the ridge construction.

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Table 1. Crops grown in the two sets of plots.

Year	SPC Area	WR 3-crop production area
1990	grain sorghum	---------- none ----------
1991	corn	corn (w/popula. plots), sunflowers, soybeans
1992	grain sorghum	corn (w/popula. plots), sunflowers, soybeans

Table 2. Grain yields for the Surface Profile Comparison plots for 3 years, expressed on a total area basis.

Year	Crop	Farming Practice W4	R4	F4	F6	L.S.D.	Alpha
		Grain Yield (kg/ha)					
1990	Sorghum	2985[a]	3475[bc]	3287[ab]	3795[c]	490	0.10
1991	Corn	3242[a]	2553[ab]	2187[b]	2009[b]	882	0.10
1992	Sorghum	2847[ab]	2937[a]	2182[b]	3341[a]	732	0.10

Note: yield values superscripted by the same letter are not statistically different at the designated alpha level.

Table 3. Combined 1991 corn and 1992 sorghum grain yields for the SPC plots on a total area basis.

	Farming Practice					
	W4	R4	F4	F6	L.S.D.	Alpha
	Grain Yield (kg/ha)					
1991 Corn and 1992 Sorghum	6089 [a]	5490 [a]	4369 [b]	5351 [ab]	1040	0.10

Note: yield values superscripted by the same letter are not statistically different at the designated alpha level.

Table 4. Corn grain yields on a total area basis for four populations on the wheel ridge production plots for 1991 and 1992.

	Plant Populations (plants/ha)					
Year	20000	26667	33333	40000	L.S.D.	Alpha
	Total Grain Yield (kg/ha)					
1991	2314	2741	2873	2866	N.S.	0.10
1992	4678	5079	5193	4909	N.S.	0.10

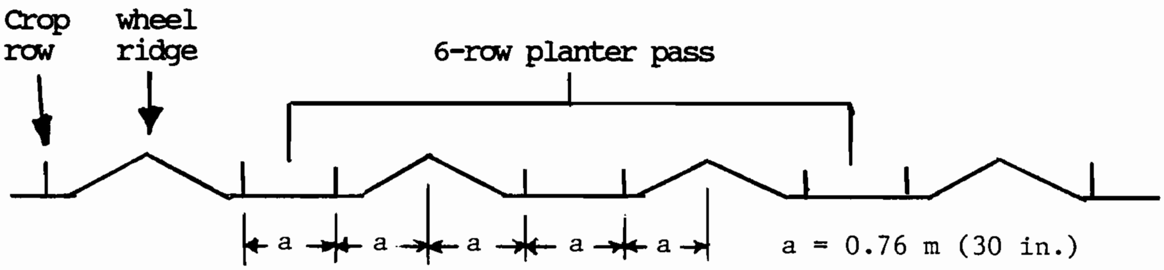

Figure 1. Cross sectional profile of wheel ridges, crop rows and planting pattern for a six row planter.