A USE OF SKIP-ROW PLANTING AS A STRATEGY FOR DROUGHT MITIGATION IN THE WEST CENTRAL GREAT PLAINS

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ABSTRACT

Skip-row planting of corn and sorghum has recently developed as a strategy for mitigating drought in the dryland regions of the western Central Great Plains. Here we compare 16 site-years of no-till feed grain yields when planted skip-row and when planted conventionally in Eastern Colorado and Western Kansas (over half of the locations were on farm replicated trials. The idea is that a wider row arrangement forces a change in the timing of soil-water availability and use, which may mitigate drought stress during the critical flowering period. Three alternative planting schemes were investigated and compared to planting in conventional 0.76m rows (30 inch rows). These were plant 2 rows, skip 2 rows (P2S2); plant 1, skip 1 (P1S1); and a plant 2, skip 1 (P2S1). Corn plots were seeded with roundup ready hybrids in 2004, 2005, 2006 and 2007. Sorghum was generally concept protected seed. Some of the sites included variable plant population in combination with alternative planting arrangements. There exists a trend for the alternative planting arrangements to yield higher than conventionally planted corn and sorghum when yields are less than 3500 kg ha^{-1} (50-60 bushels/acre). The effect is not always statistically significant. We did not observe either a disadvantage or an advantage if yields potentials are greater than this up to at least 5000 kg ha-1 (80 bushels/acre). An analysis of these data would suggest, that the alternative planting arrangements show potential for greater yields in dryer areas and/or in dry years where yields are less than 3500 kg ha-1 (56 bushel).

INTRODUCTION

The Central Great Plains Region (CGPR) is a net importer of feed-grains (corn, sorghum). Last year (2007) north eastern Colorado imported over 50 million bushels of corn to support existing beef feedlots. With the growth in the ethanol industry this shortfall for high energy feed grains in the region will be even greater. These markets provide incentive to develop stable dryland feed-grain production systems for the region. Because both corn and sorghum are sensitive to drought during reproductive development "the critical period" and because in the semi-arid west we are nearly always in a moisture deficit, lack of moisture during the critical period will reduce final yield. The lack of adequate moisture during silking/pollen shed, then becomes a major limitation to dryland feed-grain production in the region. In this study, we evaluate the skip-row strategy as a method to circumvent the water limitation during silking/pollen shed for corn and sorghum.

The idea behind "skip-row" is: water stored in the soil of the "skipped-row area" serves as a water reserve for drought periods later in the season. Because of the distance between the skip-row center and the planted row of corn or sorghum, the soil water in the skip-row is not positionally as available to the young plants until they are at the reproductive stage of development (silking/pollen shed). A second facet of this technique is that the same plant population in a conventional planting, is twice as dense "in the row" in the skip-row planting. For example, a 12,000 plant per acre planting using the skip-row method, would have a plant density in the row, equivalent to a 24,000 plants per acre planting in a conventional planting. This "high population" in the row makes up for no plants in the skip-row.

MATERIALS AND METHODS

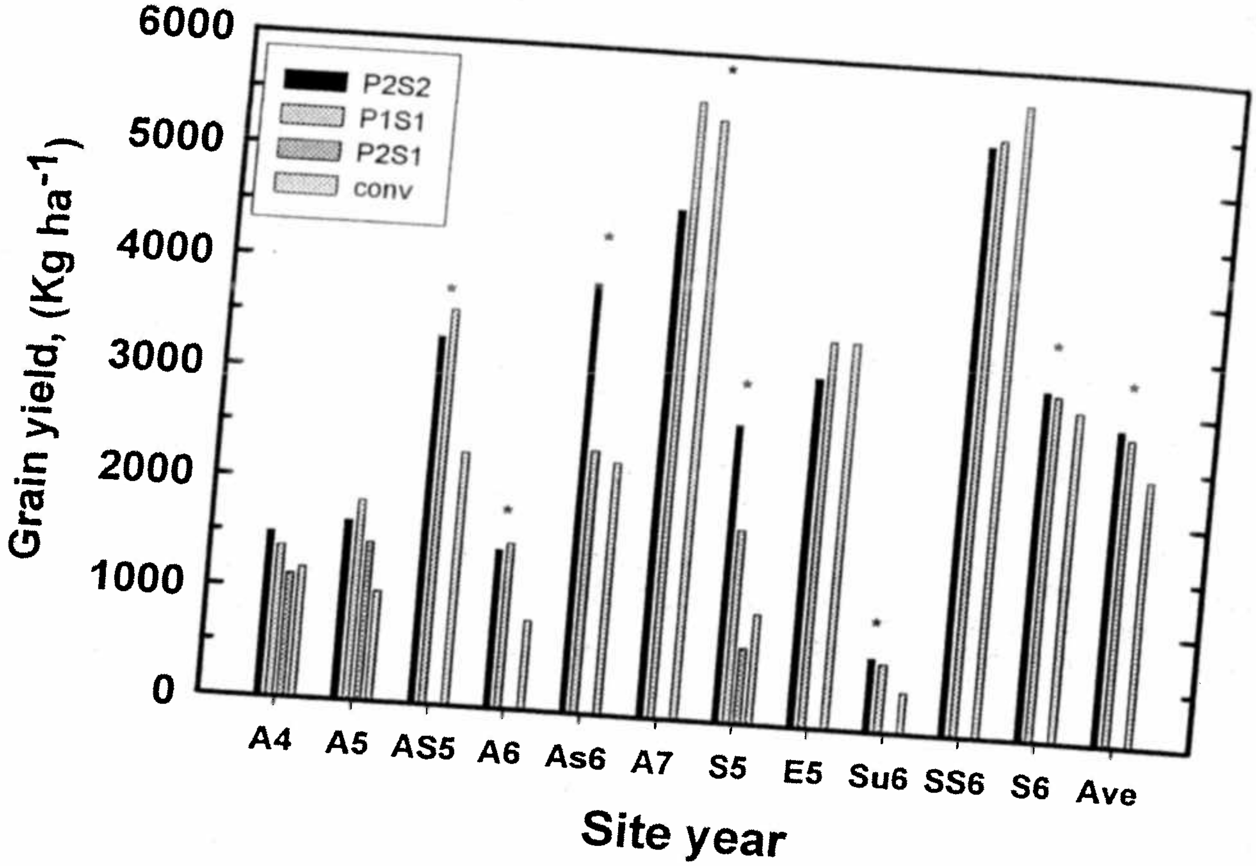
Four planting arrangement treatments (replicated four times) are being evaluated in these experiments. The treatments are: plant 2 rows, skip 2 rows (P2S2); plant 1, skip 1 (P1S1); plant 2, skip 1 (P2S1); and conventional 30-inch rows. All planting schemes were seeded at three plant populations of 8,000 12,000 and 16,000 plants per acre in 2005, 2006 and 2007. In 2004, only 2 populations of 12 and 16 thousand were included in the study. All are seeded with a roundup ready hybrid (LAZER L45-F3 in 2004 and 2005 and N42-m2 in 2006, and P38H66 in 2007) into barley stubble in 2004 and into stripper head wheat stubble in 2005, 2006 and 2007. Planting is with a John Deere Maximerge air seeder on or with in a day or two of May 25 each year. The sites are sprayed with ½ lb a.i atrazine and glyphosate just prior to planting. Plots are fertilized with 60-70lbs of N top dressed 2 inches to the side of the seed opener using UAN (32-0-0) and 20 lbs of P (P_2O_5) as ammonium polyphosphate, (10-34-0) was applied with the seed at planting. Roundup was sprayed at V-8 stage of development for weed control. Grain sorghum was seeded at 20,000 and 40,000 plants per acre using P2S2, P1S1 and compared with conventionally planted grain sorghum on 30-inch centers in 2005 and 2006. In addition to the replicated small plot studies for corn and sorghum in 2005, and 2006 three bulk fields on the station each year were split in half, with one half planted in the P2S2 arrangement at 12,000 plants per acre and the other half planted at the same population in conventional 30 inch rows.

Several on farm experiments were also conducted near Scott City, Kansas. In these experiments Dryland corn was planted in randomized replicated blocks with strips 16 to 32 rows wide across whole 40 and 80acre fields. Each 16 or 32 row strip was planted in one of three arrangements and replicated 4 times. The three planting arrangements tested were P2S2, P1S1 and conventional planting. We dropped P2S1 because it was so similar in response in our other research to conventional planting that we felt the treatment was redundant.

RESULTS AND DISCUSSION

Skip-row planting does tend to mitigate yield reductions due to drought. This is most apparent in those experiments where yields were average to low (Fig 1). Both P2S2 and P1S1 increased corn and sorghum yields at Akron where "overall" yields are minimal and limited by drought (less than 56 bushel/acre or 3500 kg ha^{-1}). On the other hand, skip-row plantings tended to produce yields equal to or slightly less than conventional planting when yields were high for the region (80 to100 bushels/acre or 4000-5000 kg ha^{-1}). In these data sets, the alternative planting arrangements especially P2S2 and P1S1 produced 500-1800 more kg of grain ha^{-1} (8-28 bushels/acre) than conventionally planted corn and sorghum. A fitted regression equation of the yield increase from skip-row planting was regressed on the average conventional yield for each experimental site (Fig 2). This equation indicates that yield-increases due to skip-row planting decline as conventional yields increase above 3500 kg ha^{-1} (56 bu/acre).

Fig 1 Corn and Sorghum grain yields as affected by planting arrangement averaged across population. The A4, A5,A6,A7 is corn at Akron in 2004, 2005, 2006 and 2007. AS5 and AS6 is sorghum at Akron in 2005 and 2006. The other sites are farmer fields in Kansas.



We suspect the advantage with skip-row occurs when first the crop is limited by dry conditions. The advantage results from a timing of water use. In other words, the crops planted in skip-row are not able to get to the water in the skip-row area when they are small, so that water is left as a reserve for later in the season (when plants have reached flowering and are larger). Because these crops are sensitive to drought during flowering, the "water reserve" in the skip-row area tends to counteract the drought that commonly occurs during flowering in the CGPR. In a conventional planting, where the plants are more evenly distributed in the field, soil water is used as the plants grow and is depleted earlier in the season (plants just don't plan for the future very well).

We measured water in the skip-row middles of P2S2 and in the furrow of conventionally planted corn at 29.6 thousand plants ha^{-1} population. We found more water was left at the end of the season in P2S2 than in conventionally planted corn in the middle of the skip (the furrow). This suggests the system needs further refinement with respect to optimal skip-row width.

In the 11 experiments we conducted, the skip-row managed corn averages 6-bushel greater corn yield than the conventionally planted corn. The increase in yield is statistically significant in 2005 and 2006, and is significant when all of the data is included in the analysis of variance. (Fig 1). At Scott City, Kansas, we measured significantly more corn with skip-rc 2005 but only one location out of 5 did we see an increase in corn yields at Scott City in 2 Because population has not influenced yields in these experiments we averaged ac population to evaluate planting architecture effects. In whole split field comparisons, the P planted corn had higher yields in each field (Table 1). The increase ranged from 8 to 27 bus. in favor of the P2S2 corn over the conventionally planted corn. Drew Lyon, Alex Pavlista, I Klein and Alan Schlegel conducted similar experiments, at Trenton, Ogalala, and Scottsbl Nebraska and at Tribune Kansas in 2005. In those studies, the skip-row corn in the P2S2 a P1S1 arrangements were 10-12 bushels better than the conventionally planted corn. Yields w between 64 and 74 bushels (averaged across 4 replications) for the skip row corn and about bushel for the conventional corn at Trenton and at Ogalala. At Tribune and at Scottsbluff yiel were between 80 and 92 bushels with no trend for an advantage or disadvantage with plantin arrangement. In a preliminary analysis it seems as though the alternative planting arrangemen are more likely to show an advantage if yields are less than 70 bushel but the effect is nc consistent. With grain sorghum both P2S2 and P1S1 had significantly greater yields than th conventionally planted grain sorghum at either population of 20,000 or 40,000 plants/acre ir 2005. However in 2006 only P2S2 showed a yield advantage over conventionally planted grain sorghum (Table 2).

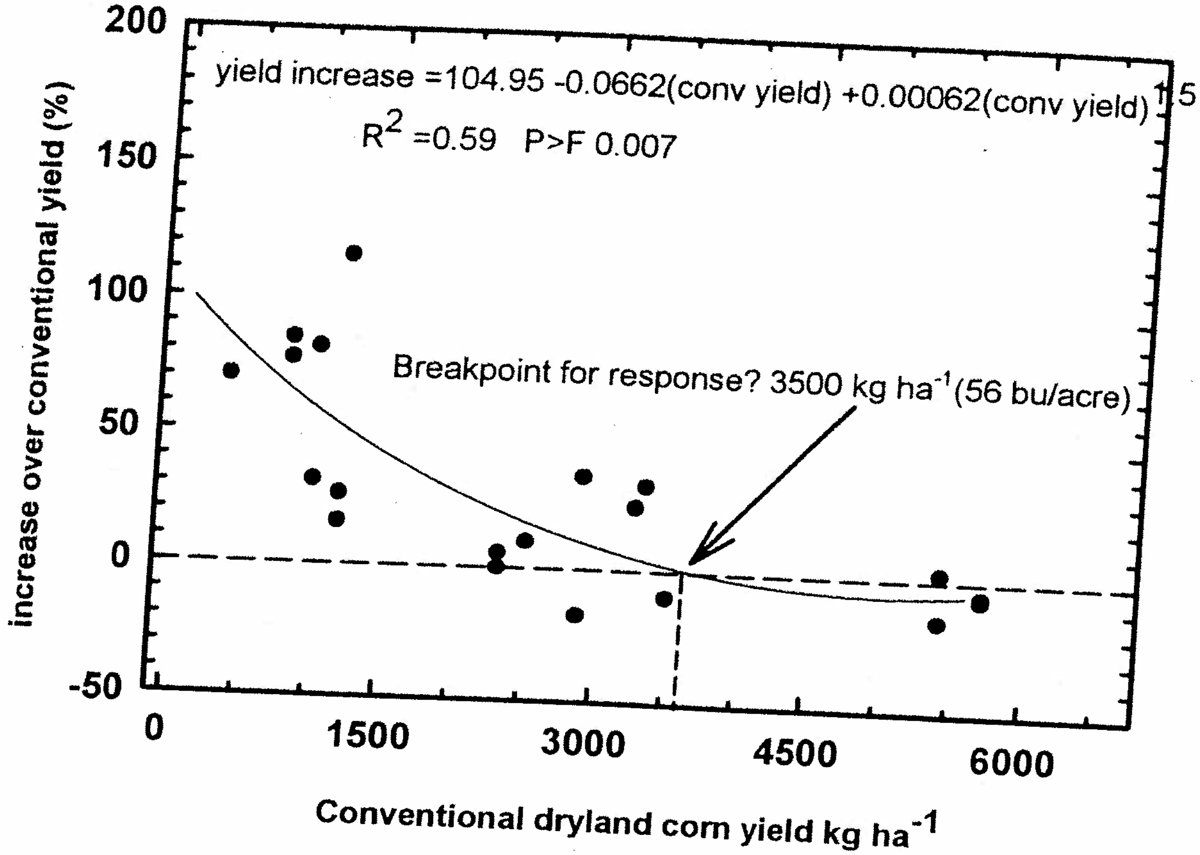
Table 1. Dryland corn yields in whole fields planted in the P2S2 arrangement as compared to conventionally planted corn at the USDA-ARS CGPRS, Akron Colorado. These fields are 4 to 15 acres in size with 3 fields used each year.

Treatment	2005	2006	2 year average
	Bushels/acre		
P2S2	41	44	43
Conventional	19	40	30
P>F	0.13	0.37	0.23

Table 2. Skip-row Grain sorghum at the USDA-ARS CGPRS Akron, Colorado and at Scott city Kansas.

Treatment	2005 Akron	2006 Akron	2006 Scott City	Average
	Bushels /acre			
P2S2	53	62	85	67
P1S1	57	38	86	60
Conventional	19	46	91	52
P>F	0.0001	0.02	0.54	---

Fig 2. Increase in corn or sorghum yields above conventional planting from skip-row planting as a function of overall conventional yields.



CONCLUSIONS

Many times the skip-row planting arrangements result in significantly greater yields. For corn the average increase across all site years is about 6 bushel. The yield advantage with skip-row is more likely seen under conditions of low yield due to drought, when yields are less than 60-70 bushel, (Figure 1). When yields are greater than 70 but not greater than say 100 bushel there is less likelihood of either observing an advantage or disadvantage with skip-row planting. In Figure 2, we see a greater response to skip-row planting as yield potential in the conventionally planted corn is less. For example compare the yield as a percentage increase at 20 bushels versus at 60 or 70 bushel. There is some concern regarding the "plant two skip two arrangement" in that you have 90 inches of space for weeds to grow. Weed Control and the best methods for fertilizer placement in skip-row are unresolved issues. What is the best method of placement for fertilizing skip-row corn? We also question what should be the optimal distance to skip between the paired rows. What is "magic" about a 90 inch gap?

When skip-row does provide an advantage why does it happen? We suspect that it has to do with the timing of water availability to the crop. You don't have more water in a skip-row field at planting time than in a conventionally planted field. All you have changed with the skip-row technique is the timing of water use. The small plants in the planted rows, in the skip-r field, will use all of the water that is in the immediate vicinity of where they are growing, but a not "big enough" (don't have the root development yet) to get to the water in the skip area wh they are small. However, as they mature, the plants are large enough to get to the reserve water in the middles of the skip-row area. The key point here is the critical moisture deman period for corn development is silking/pollination. Because these crops are sensitive to droug during flowering the water reserve in the skip-row area tends to counteract the drought th commonly occurs during flowering in the CGPR. In a conventional planting, where the plants ar more evenly distributed in the field, soil water is used as the plants grow and is depleted earlie in the season (corn and sorghum plants just don't plan for the future very well). The skip-row method ensures that some water will still be left in the soil profile for the crop during that critical period at pollination. That extra water reserve then can result in better yields with the skip-row technique at yield potentials common for the dryer portions of the CGPR.