Final Report – 2021 (for Wyoming Bean Commission)

Effect of Reduced-Tillage, Deficit Irrigation, and Cultivar on Conventional and Direct Harvested Yield of Dry Bean

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Introduction

This is an on-going long-term project within a barley-beet-dry bean rotation. Agronomic research and producer testimonials have shown that reduced tillage has the potential to save water especially in semi-arid environments. That is, by reducing disturbance of the soil surface we reduce evaporative loss from soil. Although this concept of moisture savings from reduced tillage is widely recognized, there is little information for producers in the Bighorn Basin regarding the yield of dry bean under reduced tillage systems regardless of irrigation management.

In the past, our primary focus has been on comparing the results of reduced-till under deficit irrigation to conventional tillage under full irrigation to see if yields would be comparable. In the 2020 version of this project, this scenario appeared to play out with one of the dry bean cultivars tested. That cultivar had similar yield under the combination of deficit irrigation and reduced tillage as it did with full irrigation and conventional tillage. The year 2020 was extremely hot and maybe a good year for reduced tillage so we should not automatically assume that deficit irrigation and reduced tillage will work in every situation. Of course, our research also included the two converse combinations of treatments to attain a full understanding of the dry bean response across all four of these management practices side-by-side.

Another aspect of reduced tillage systems involves soil quality. Recent research at UW has shown that reduced-till systems have increased soil organic matter. However, until producers can capture tangible and/or financial benefits from that improved soil quality, conventional tillage will be a standard by which we compare alternative soil management practices.

A more recent theme associated with this reduced-tillage research is to see if using direct harvest of dry bean can be employed and further reduce end-of-season soil disturbance. Oftentimes, dry bean harvest includes undercutting and windrowing which obviously disturbs the soil surface but is very efficient at gathering a high percentage of the beans that are present. However, if direct harvest can be employed profitably, the soil surface can remain undisturbed during the fall. In this project and related projects, our research has shown that the efficiency of direct harvest is greatly affected by cultivar selection. Upright cultivars that produce a greater percentage of pods above the combine-cutting-height have shown to result in a greater percentage of grain being captured by the combine than prostrate cultivars. For that reason, we often compare contrasting dry bean varieties in this reduced-till research.

Objectives

The primary objective of this project is to see if reduced-tillage saves enough soil moisture to allow dry bean to have optimal yields under 75% irrigation compared to conventional tillage yields under full-irrigation. A second objective is to see if the response varies among early- and late-maturing

cultivars as well as upright vs. prostrate cultivars. The third objective is to compare yields using conventional harvest vs. direct harvest.

Methods

For the 2021 dry bean component of this research, we used a 1.6-acre field with 48 plots (0.033 acres each) that followed 2020 sugar beet. The design included reduced-tillage vs. conventional tillage, full irrigation vs. deficit irrigation (75%), four dry bean cultivars, and three replicate plots per tillage-irrigation-cultivar treatment. Conventional harvest (aka, indirect cut) and direct harvested yield was collected. The four cultivars were: Monterrey (late-upright), Nez Perce (late upright), Poncho (early prostrate), and Windbreaker (mid-maturity and mid-stature). The study was sown on 26 May 2021 and plots were six-rows, 135-feet long, 22-inch spacing, and 90K seeding rate. The area was fertilized with 80 N, 130 P, 80 K, 70 S, and 8 Zn.

The study was conducted with sprinkler irrigation. Once the crop was established (late June 2021), differential irrigation was imposed. This was typically achieved by applying 1.0 inch per week to the fully-irrigated plots and 0.7-inch per week to the deficit-irrigation plots. At maturity, we collected yield by indirect and direct harvest for each of the 48 plots.

Photos of the irrigation system, reduced-till planting, conventional tillage, and two harvest systems are provided in Figures 1 and 2.

Figure 1. Photo of the lateral irrigation system used for imposing differential irrigation.

Figure 2. Examples of our reduced-till planting (top left), conventional tillage (top right), simulation of indirect harvest (bottom left) and direct cut harvest (bottom right).

Results

Yields for the different managements are presented several different ways in order for the reader to find specific treatment combinations of interest.

In the first set of four tables, we compare the two tillage approaches. It needs to be noted beforehand that weed control within the reduced-tillage system was very challenging this 2021 season. The reduced-tillage required much hand-weed control and in several plots, we did not achieve the control we usually do.

Using indirect harvest, conventional tillage outyielded reduced-tillage within the deficit-irrigation treatment across three of the cultivars (Table 1). The percent difference ranged from 12% for Monterrey to 41% for Poncho. Several of the Windbreaker plots in reduced-tillage area were abandoned due to weeds. Also using indirect harvest but under full irrigation, conventional tillage outyielded reduced-tillage across all four cultivars (Table 2). Under this full irrigation, the decline in reduced-tillage yields was much steeper than for the deficit irrigation with a 44% decline for Nez Perce and 70% for Windbreaker.

Using direct harvest, we also observed a yield decline due to reduced-tillage. Under

deficit irrigation and using direct harvest, yield decline associated with reduced tillage ranged from 12% for Nez Perce to 41% for Poncho (Table 3). Under full irrigation and using direct harvest, yield decline associated with reduced-tillage ranged from 27% for Nez Perce to 56% for Monterrey (Table 4).

Table 1. Dry bean yield of four cultivars using the indirect harvest method as affected by tillage under deficit irrigation in 2021. Values are the average across three plots.

Cultivar	Conventional Tillage	Reduced Tillage
	---------- lbs/a ----------	
Monterrey	951	838
Nez Perce	1661	1223
Poncho	2277	1331
Windbreaker	1336	-
Average	1556	1131

Table 2. Dry bean yield of four cultivars using the indirect harvest method as affected by tillage under full irrigation. Values are the average across three plots.

Cultivar	Conventional Tillage	Reduced Tillage
	---------- lbs/a ----------	
Monterrey	1844	991
Nez Perce	1940	1086
Poncho	2614	1152
Windbreaker	2556	773
Average	2238	1913

Table 3. Dry bean yield of four cultivars using the direct harvest method as affected by tillage under deficit irrigation. Values are the average across three plots.

Cultivar	Conventional Tillage	Reduced Tillage
	---------- lbs/a ----------	
Monterrey	1126	888
Nez Perce	1385	1219
Poncho	1721	809
Windbreaker	1010	--
Average	1310	972

Table 4. Dry bean yield of four cultivars using the direct harvest method as affected by tillage under full irrigation. Values are the average across three plots.

Cultivar	Conventional Tillage	Reduced Tillage
	---------- lbs/a ----------	
Monterrey	2487	1095
Nez Perce	1895	1387
Poncho	1558	836
Windbreaker	2111	987
Average	2013	1076

For the next set of comparisons, we contrast the two harvest methods. For deficit irrigation and conventional tillage, yield from Poncho was greatly reduced when direct harvested vs. indirect cut (Table 5). Yields from Monterrey and Nez Perce were also reduced upon direct harvest but less so. For full irrigation and conventional tillage, yield from Monterrey was increased by direct harvest vs. indirect cut (Table 6). Yield of Nez Perce was unaffected but yields of Poncho and Windbreaker were reduced by direct harvest. For deficit irrigation and reduced-tillage, yield of Monterrey was slightly higher when direct harvested but yield of Poncho was sharply reduced (Table 7). For full-irrigation under reduced-tillage, Monterrey, Nez Perce, and Windbreaker showed a yield increase when direct harvested but yield of Poncho was greatly reduced when direct harvested (Table 8). The overall loss/gain to direct harvest showed that Monterrey averaged better yields when direct harvested vs. indirect cut (Table 9). Yield of Poncho was consistently reduced when direct harvested.

Table 5. Effect of indirect vs. direct harvest on yield of four dry bean cultivars under deficit irrigation and conventional tillage.

Cultivar	Indirect Cut	Direct Harvest	Percent Loss to Direct
	---------- lbs/a ----------		
Monterrey	951	888	+ 7
Nez Perce	1661	1219	+ 27
Poncho	2277	809	+ 64
Windbreaker	1336	--	

Table 6. Effect of indirect vs. direct harvest on yield of four dry bean cultivars under full irrigation and conventional tillage.

Cultivar	Indirect Cut	Direct Harvest	Percent Loss to Direct
	---------- lbs/a ----------		
Monterrey	1844	2487	- 35
Nez Perce	1940	1895	- 2
Poncho	2614	1558	+ 40
Windbreaker	2556	2111	+ 17

Table 7. Effect of indirect vs. direct harvest on yield of four dry bean cultivars under deficit irrigation and reduced tillage.

Cultivar	Indirect Cut	Direct Harvest	Percent Loss to Direct
	---------- lbs/a ----------		
Monterrey	838	888	- 6
Nez Perce	1223	1219	+ 1
Poncho	1331	809	+ 39
Windbreaker	--	--	--

Table 8. Effect of indirect vs. direct harvest on yield of four dry bean cultivars under full irrigation and reduced tillage.

Cultivar	Indirect Cut	Direct Harvest	Percent Loss to Direct
	---------- lbs/a ----------		
Monterrey	961	1095	- 10
Nez Perce	1086	1387	- 27
Poncho	1152	836	+ 27
Windbreaker	773	987	- 27

Table 9. Overall loss to direct harvest averaged across all irrigation/tillage treatments.

Cultivar	Indirect Cut	Direct Harvest	Percent Loss to Direct
	---------- lbs/a ----------		
Monterrey	1156	1399	- 21
Nez Perce	1577	1537	+ 2
Poncho	1844	1231	+ 33
Windbreaker	1640	1367	+ 17

Our third presentation of the yields focused on averages across the four cultivars (Table 10). For indirect cut, deficit irrigation reduced yield under conventional tillage but yields were similar for reduced-till. Yields were lower due to reduced-till as shown in previous tables. For direct harvest, deficit irrigation reduced yield as previously shown above and reduced-till also yielded lower.

Table 10. Comparison of yields averaged across the four cultivars in 2021.

Irrigation	**Indirect Cut**		**Direct Harvest**	
	Conventional-Till	Reduced-Till	Conventional-Till	Reduced-Till
	---------- lbs /a ----------			
75% ET	1556	1104	1310	901
Full	2238	1004	2012	1014

For a final presentation of the yield data, we compared yield loss due to direct harvest among the four management practices. We realize that the cultivars varied substantially for this trait but a summary table indicates that deficit irrigation increased the percent loss to direct harvest and reduced-till reduced the percent loss to direct harvest (Table 11).

Table 11. Yield loss due to direct harvest when compared across irrigations and the two tillage systems. Values are averaged across the four cultivars.

Irrigation	**Percent Loss Due to Direct Harvest**	
	Conventional-Till	Reduced-Till
75% ET	33	11
Full	5	- 9

Although yield reduction due to deficit irrigation was apparent, we were also able to document slight differences in canopy temperature between irrigations (Table 12). The temperature differences were less than expected.

Table 12. Canopy temperature on 11 August 2021 averaged across the four cultivars.

Irrigation	**Fahrenheit**		**Celsius**	
	Conventional-Till	Reduced-Till	Conventional-Till	Reduced-Till
	---------- °F or °C ----------			
75% ET	75.2	77.9	24.0	25.5
Full	78.4	78.6	25.8	25.9

As for seed size and seed per pound, several differences were found due to the treatments and cultivars. Seed size of conventionally-tilled plots was greater than for reduced-till across both irrigations (Table 13). Likewise, the number of seed per pound was greater within the reduced-tillage plots compared to conventionally-tilled plots. Seed from Monterrey, Poncho, and Windbreaker were heavier than seed from Nez Perce. Likewise, there were more seed per pound for Nez Perce than the other three cultivars. The significance of the tillage and cultivar effects are shown by the P-values presented at the bottom of Table 13. There did not seem to be any profound differences in seed size or the number of seed per pound when seed from indirect cut plots was compared to seed from direct harvested plots. Irrigation showed not effect on seed size or the number of seed per pound.

Regarding maturity dates, the effects of irrigation and tillage were relatively minor. There was a significant tillage-by-cultivar interaction but it was unclear what values contributed to this interaction. Poncho was the earliest maturing cultivar across all four irrigation-tillage combinations and Monterrey was the latest maturing cultivar (Table 14). Upright stature was also affected by a tillage-by-cultivar interaction. Poncho, a cultivar already-known to be quite prostrate, showed even further prostrate stature under reduced-tillage than it did under conventional tillage. Monterrey showed the highest upright stature values whereas Nez Perce and Windbreaker ranked in the middle.

Discussion and Summary

Overall, there appears to be a yield disadvantage with reduced-till for dry bean, which we mostly attribute to weed pressure. As for the percentage of yield lost to direct harvest, we found that Poncho lost an average of 33% across all of the treatments whereas Monterrey showed a very slight increase in yield upon direct harvest. There were also strong trends for deficit irrigation to increase the loss upon direct harvest presumably due to lower pod heights within the water-stress canopies. Concurrently, conventional tillage increased the percent loss to direct harvest and we do not have an explanation for that.

Going forward, these results have emphasized important considerations needed before conversion to reduced tillage. These considerations include additional attention to weed management and cultivar selection within the reduced-till system. Moreover, it stands to reason that within a reduced-tillage system, eliminating the undercutting, finding greater efficiency for direct harvest, and possibly reducing fuel use could improve net profit.

Table 13. Effect of irrigation rate, tillage practice, and cultivar on seed size, number of seed per pound, and maturity date. The headings with "A" are associated with indirect cut and headings with "B" are associated with direct harvest.

Irrigation	Tillage	Cultivar	Seed Size A	Seed Size B	Seed per Pound - A	Seed per Pound - B
			mg	mg	no.	no.
75% ET	Conv.	Monterrey	395	406	1148	1120
		Nez Perce	314	314	1445	1445
		Poncho	369	374	1232	1214
		Windbreaker	410	389	1106	1165
		Average †	359	365	1275	1260
	Reduced	Monterrey	360	356	1260	1276
		Nez Perce	298	305	1520	1485
		Poncho	360	377	1260	1210
		Windbreaker	--	--	--	--
		Average †	339	346	1347	1324
100% ET	Conv.	Monterrey	389	381	1166	1192
		Nez Perce	322	316	1411	1435
		Poncho	386	382	1176	1190
		Windbreaker	394	396	1151	1145
		Average †	366	360	1251	1272
	Reduced	Monterrey	358	365	1267	1245
		Nez Perce	295	319	1540	1423
		Poncho	357	361	1274	1256
		Windbreaker	366	402	1238	1131
		Average †	337	348	1360	1308
P-values						
Irrigation			0.8664	0.8659	0.9337	0.6860
Tillage			0.0001	0.0634	0.0009	0.0425
IrrByTill			0.5476	0.5316	0.4350	0.4596
Cultivar			0.0001	0.0001	0.0001	0.0001
IrrByCult			0.4243	0.7113	0.5234	0.7369
TillByCult			0.7490	0.2459	0.7005	0.3161
IrrByTillByCult			0.6399	0.1792	0.6899	0.2362

† None of the averages include Windbreaker due to missing values with Windbreaker in the deficit irrigation-reduced tillage combination.

Table 14. Effect of irrigation, tillage, and cultivar on maturity and upright stature of dry bean in Powell during 2021.

Irrigation	Tillage	Cultivar	Maturity	Upright Stature
			dap	no.
75% ET	Conv.	Monterrey	98	9.7
		Nez Perce	92	8.7
		Poncho	90	8.7
		Windbreaker	90	9.0
		Average †	92	9.0
	Reduced	Monterrey	96	9.0
		Nez Perce	95	9.0
		Poncho	90	4.7
		Windbreaker	93	7.0
		Average †	93	7.4
100% ET	Conv.	Monterrey	97	8.7
		Nez Perce	95	8.3
		Poncho	90	6.3
		Windbreaker	90	8.0
		Average †	93	7.8
	Reduced	Monterrey	96	9.7
		Nez Perce	93	8.3
		Poncho	92	5.3
		Windbreaker	93	8.0
		Average †	93	7.8
P-values				
Irrigation			0.7670	0.4064
Tillage			0.4965	0.1085
IrrByTill			0.7670	0.1085
Cultivar			0.0001	0.0001
IrrByCult			0.8754	0.5647
TillByCult			0.0323	0.0007
IrrByTillByCult			0.0399	0.0852