Final Report

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Determination of optimal planting configuration of low input and organic barley and wheat production in Arizona

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Summary

Markets for organic barley and wheat are expanding. A major problem growing organic barley and wheat is controlling the weeds. Organic barley and wheat were grown in conventional 6-inch drill spacing but also in 20 inch spacing so weeds could be cultivated in a study at the Larry Hart Farm near Maricopa. The weed pressure was slight and the weed biomass averaged about 1% of the crop biomass, 20-in rows accounted for 0.84% while the 6-in drill spacing showed a higher concentration of weeds (1.14%). The primary weed in both crops was mallow. We found statistically different differences in grain yields in both wheat (durum) and barley showing higher yields for the 6-inch drill planting system.

Introduction

The demand for organic food in general and food products derived from organic barley and wheat in particular is increasing. The price premium received by the grower to produce organic wheat and barley can be 50 to 100% of conventional crops depending to market trends. However, the price premium for growing organic grains may be offset by lower yields as a result of not be able to apply chemical fertilizers and pesticides.

Weed control is one of the biggest challenges facing producers of organic barley and wheat in Arizona. Barley and wheat are very competitive with weeds in conventional production due to more vigorous growth as a result of chemical fertilizers, and if weeds do become a problem, chemical herbicides can be applied. To suppress weeds, organic producers can plant in drill rows or sow seeds at a higher rate than in conventional production. Another option is the use of cultivation, which requires that the seed be planted in rows about 20 inches wide so that a cultivator and tractor can pass through the crop. Planting barley or wheat in 20-inch rows would certainly decrease yield in conventional production compared to the typical 6-inch drill rows (Ottman, 2004). However, in organic production the yield potential is less than when using conventional practices, and the yield loss in wide rows may not be as great as expected. Furthermore, the ability to cultivate and control weeds in the 20-inch spacing may compensate for any yield loss in the wider rows. Other advantages of wider rows are reduced seed costs and decreased lodging (Ottman, 2004), and possibly savings in irrigation water.

Objectives: Determine if planting in 20-inch rows combined with cultivation reduces weed pressure compared to 6-inch drill rows in organic barley and wheat production. This is the third year of the study.

Procedure

A row spacing study with organic barley and durum was conducted at Hart Farms, about 5 miles west of Maricopa, AZ. The crop was grown using organic methods which do not allow the use of chemical fertilizers or pesticides. The study was located in two 5-acre, level basin fields (205 ft wide x 1200 ft long). The previous crop was forage sorghum, which came after forage oats. Manure was applied in early December at a rate of 10 ton/A. On January

10, 2014, 'Baretta' barley and 'Kronos' durum were dry planted separately in each 5-acre field. First irrigation took place on January 11, 2014. Two planting methods were used: 1) grain drill with 6 inch row spacing and a seeding rate of about 145 lbs/acre for barley and 138 lbs/acre for durum, and 2) row planter with 20 inch row spacing and a seeding rate of 74 lbs/acre for barley and 95 lbs/acre for durum. The seed was planted in strips the length of the field (1200 ft) and a width of 20 ft from the plot edges and 17.5 ft from the first to last row of each plot. The number of rows planted was 38 rows with the grain drill and 12 rows with the planter. The experimental design was a complete block design with 2 treatments (6 and 20 inch row spacing) and 5 blocks repeated for two crops (barley and durum).

Irrigation scheduling was managed by the grower. A total of five irrigation events were registered on the following dates: January 11, January 28, February 26, March 30, and April 22, 2014. The mechanical operations of planting (both drill and row planter) and cultivation were carried out with a 120 HP tractor equipped with an auto-pilot system enhanced with RTK quality GPS of sub-inch accuracy. To achieve vehicle navigation repeatability in these jobs we used the same A-B reference line saved in the internal memory of the computer display. To minimized implement side-drift during mechanical operations we closed the gap of the tractor sway-blocks and restrained the play of the 3-point hitch implement connections.

Weed pressure was very low for the most part of the growing season. Barley and durum strips on 20-in rows were cultivated twice on February 10, and March 10, 2014. The front toolbar was equipped with flat knives of 1/4" thickness, positioned 5 inches away from the seed-line. 6-inch wide "duck-feet" sweeps were used in the front tool-bar to cultivate the middles. Tooling depth was set to 3 inches for aggressive weed control. Rear tool-bar was equipped with two flat coulters for implement stability.

During the growing season, weed density and crop growth were measured between irrigations for a total of three sampling times. The measurements consisted of two samples of 18 inches of row for 2 rows for 6 inch spacing (3 ft^2) and for the 20 inch spacing (7.5 ft^2). Weed density was determined by weighing weeds from the sampled areas. Crop growth was determined by 1) weighing plants sampled from the sampled areas, and 2) measuring light interception by the crop within 1 hr of solar noon.

Harvest was carried out on June 12 with a conventional combine of 20 feet wide header. This grain combine was retrofitted with a yield monitor for electronic recording of instantaneous yield across the field. A differential-correction GPS was connected to the computer display of the yield monitor to geo-reference yield data. At harvest, grain yield, test weight, yellow berry (durum only), and protein content were determined.

Discussion

Weed pressure was not very severe this year and weed biomass was around 1 % of the crop biomass (Table 1). Nevertheless, cultivation in the 20 inch row spacing was effective in reducing the weed populations to low levels, although light interception and crop growth were delayed in the 20 inch row spacing (Table 1).

At the first sampling time on March 13 (for light) at the jointing stage, light interception in the 6 inch row spacing was 73.3% of incident for barley and 61.7% for durum, compared to 35% for barley and 38.8% for durum in the 20 inch row spacing. Light interception showed a slight increase at the second sampling time on April 11. By the third sampling time on May 1at heading stage, light interception in the 6 inch spacing was 60.6% for barley and 46.8% for durum compared to 45.9% for barley and 30.2% for durum in the 20 inch row spacing. The 20 inch row spacing intercepted only 39.6% of the incoming light at solar noon, compared to 63% for the 6 inch spacing averaged over crops for the three measurement time.

Plant biomass at the March 13 sampling at tillering was greatly reduced by about a 76% in the 20 inch compared to the 6 inch row spacing. This reduction in yield is undoubtedly related to the reduction in light interception in the wider rows. At the last two sampling dates, the biomass yield reduction in 20 inch rows was 18.5% averaged for barley and wheat. The dynamics of plant biomass are visually presented in Figure 1. As the growing season approached maturity, durum wheat in 20-in rows grew at a faster rate than 6-in drill; but barley showed a sustained trend of higher biomass production in the 6-in drill planting system

Cultivation in the 20 inch rows reduced the weed biomass substantially, generally to about 41% to the weed biomass in the 6 inch spacing. At the March 13 sampling time, the weeds population was very small, so the effect of cultivation on weed biomass had not been realized by this time. However, by the April 11 sampling time, weed biomass increased and had been reduced in the 20 inch row spacing by cultivation. The primary weed was mallow with some Palmer amaranth.

Planting in 20 inch rows resulted in a reduction in yields to 6 inch row spacing for wheat and barley (Table 2). In the first year of the study, the rows were 30 inches rather than 20 inches, and the yield reduction for barley in rows was 25 to 35%, but no yield reduction was measured in the wheat. Most grain quality parameters were not affected by row spacing, only protein content and HVAC of durum wheat showed a positive response to increased row spacing.

The yield maps show clear strips for the barley and wheat planted in different row spacing (Figs. 2-3). The ends of the field, particularly on the north, had lower yield potential than the middle. The yield maps show a clear advantage of the 6-in row spacing for barley and to a lesser degree for durum.

Acknowledgments

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References

Ottman, Mike. 2004. Planting Methods for Small Grains in Arizona. AZ 1333. The University of Arizona College of Agriculture and Life Sciences, Tucson, AZ 85721.

Sullivan, Preston. 2003. Organic small grain production. www.attra.ncat.org.

Table 1. Row spacing effect on light interception and plant and weed biomass at several sampling dates for barley and durum crops grown organically at the Larry Hart Farm in Maricopa, AZ in 2014.

Sampling Date	Crop	Row Spacing	Light interception	Plant biomass	Weed biomass
		inches	% of incident	lbs/acre	lbs/acre
Mar 13	Barley	6	73.3	5030	16.9
		20	35.0	758	11.7
			**	**	NS
	Durum	6	61.7	3005	21.1
		20	38.8	1008	8.2
			**	*	NS
Apr 11	Barley	6	73.2	6714	8.4
		20	48.2	4406	22.8
			NS	**	NS
	Durum	6	62.7	4634	119.3
		20	39.5	4641	39.9
			**	NS	NS
May 1	Barley	6	60.6	10336	131.6
		20	45.9	8065	34.9
			*	NS	NS
	Durum	6	46.8	7768	127.3
		20	30.2	7165	50.0
			**	NS	NS

NS, *, ** = Not significant at the 5% probability level, and significant at the 5%, and 1% probability levels, respectively.

Table 2. Row spacing effect on grain yield, test weight, grain protein, and HVAC for barley and durum crops grown organically at the Larry Hart Farm in Maricopa, AZ in 2014.

Crop	Row spacing	Grain yield	Test weight	Grain protein	HVAC
	inches	lbs/acre	lbs/bushel	%	%
Barley	6	2828	47.06	11.93	--
	20	2304	46.62	12.30	--
		**	NS	NS	--
Durum	6	2884	62.75	13.74	96.75
	20	2688	62.82	14.64	98.97
		*	NS	*	*

NS, * = Not significant at the 5% probability level, and significant at the 5% probability levels, respectively.

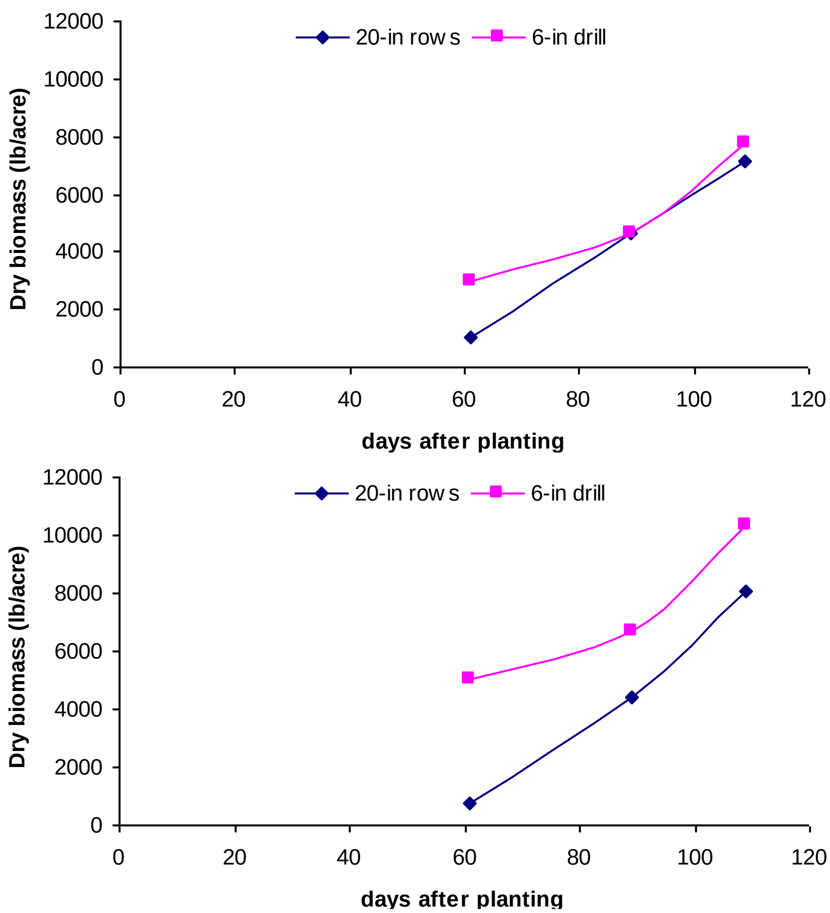


Figure 1. Dynamics of plant growth in wheat (top plot) and barley (bottom plot) in low input organically grown grain production in Maricopa, AZ 2014

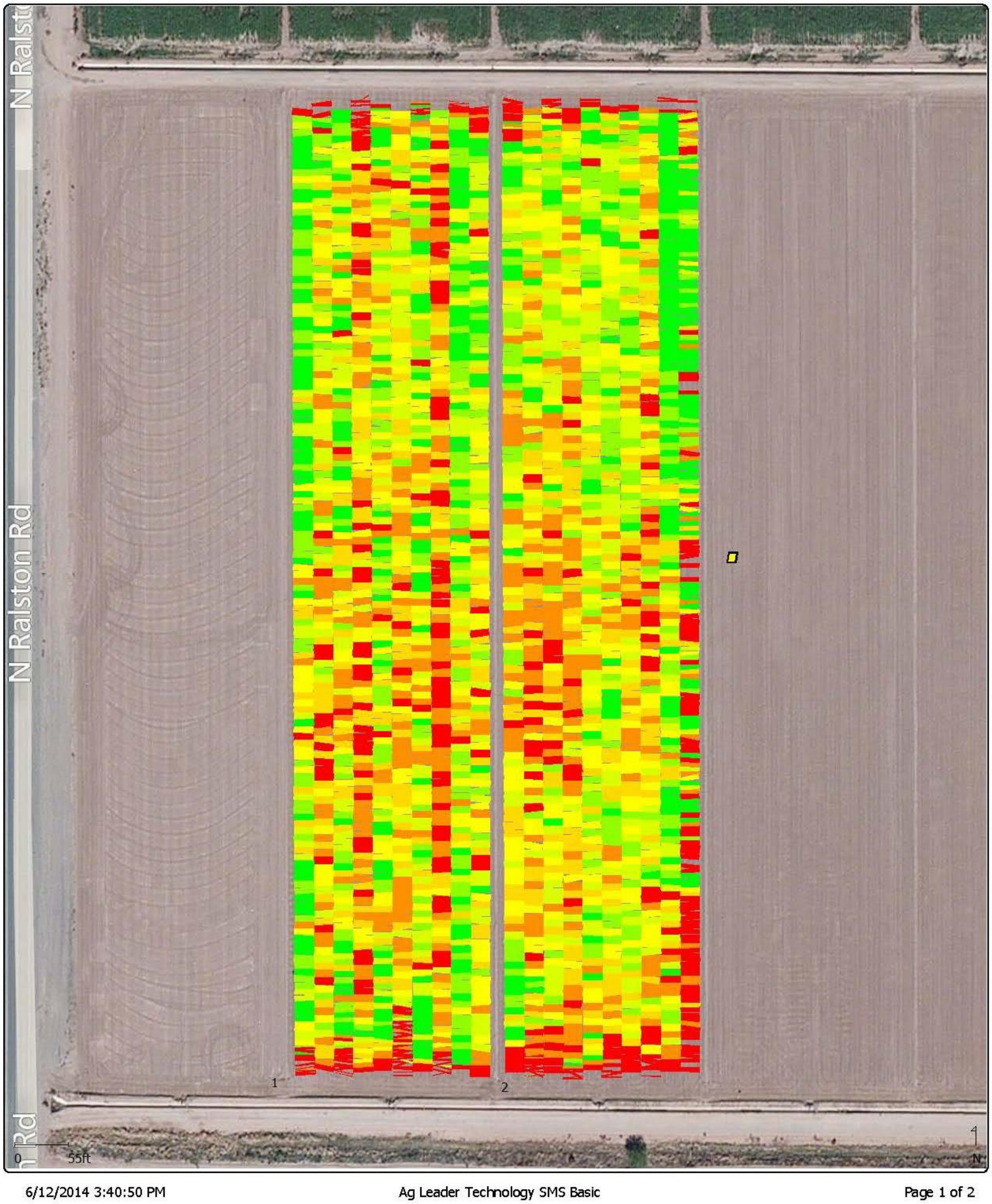
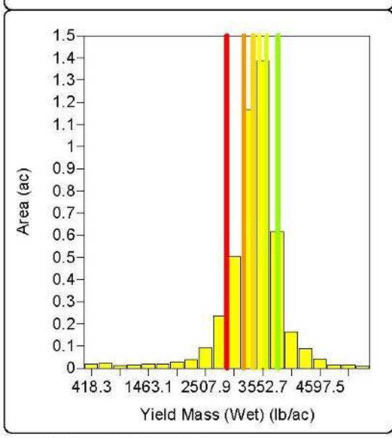


Fig. 2. Grain yield map for barley (left) and durum (right) grown organically at the Larry Hart Farm in Maricopa, AZ in 2014. The vertical strips represent different row spacing starting with 6 inch on the left (west) alternating with 20 inch.

Grower : Hart	Grower : Hart
Farm : Maricopa	Farm : Maricopa
Field : 2014wheat	Field : 2014Barley
Year : 2014	Year : 2014
Operation : Grain Harvest	Operation : Grain Harvest
Crop / Product : WHEAT	Crop / Product : BARLEY
Op. Instance : Harvest - 1	Op. Instance : Harvest - 1
Area : 4.520 ac	Area : 4.521 ac
Avg. Yield : 60.71 bu/ac	Avg. Yield : 69.38 bu/ac
Avg. Moisture : 6.059 %	Avg. Moisture : 6.865 %
Yield Mass (Wet) (lb/ac)	Yield Mass (Wet) (lb/ac)
3,826.99 - 7,166.81 (0.56 ac)	3,893.52 - 6,370.59 (0.62 ac)
3,617.07 - 3,826.99 (0.67 ac)	3,551.28 - 3,893.52 (0.65 ac)
3,490.71 - 3,617.07 (0.70 ac)	3,274.15 - 3,551.28 (0.67 ac)
3,371.93 - 3,490.71 (0.70 ac)	2,964.24 - 3,274.15 (0.68 ac)
3,207.21 - 3,371.93 (0.71 ac)	2,660.49 - 2,964.24 (0.70 ac)
2,892.62 - 3,207.21 (0.69 ac)	2,224.58 - 2,660.49 (0.69 ac)
287.68 - 2,892.62 (0.49 ac)	237.50 - 2,224.58 (0.51 ac)
Notes - Spatial Note Type	
General Note (1)	



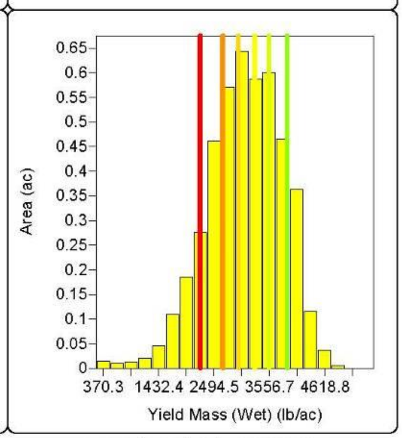


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Fig. 3. Description of grain yield map in Fig. 2.