

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 30 inch spacing so weeds could be cultivated in a study at the Larry Hart Farm near Maricopa. The weed pressure was moderate and the weed biomass was about 16 to 26% of the crop biomass near maturity. The primary weed was canarygrass and the secondary weed was malva. Grain yields of the wheat (durum) were similar regardless of row spacing, but the barley grain yields were 4327 lbs/acre in the 6 inch spacing and 3330 lbs/acre in the 30 inch spacing.

Introduction

The demand for organic food in general and food products derived from organic barley and wheat in particular is increasing. Organic barley is used primarily to feed cows whose milk is organically produced and organic wheat is processed into bread or pasta. Organic wheat production in Arizona has increased from about 250 acres in 2000 to over 1600 acres in 2004 (USDA, Economic Research Service, based on information from USDA-accredited State and private organic certifiers.)

The market for organic wheat and barley in Arizona is expected to increase in the future by nearly 20% over the next 5 years according to Lackawanna Products Corp., an organic grain buyer. 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 according to Dick Sickler of Lackawanna Products Corp. 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 (Sullivan, 2003) 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 30 inches wide so that a cultivator and tractor can pass through the crop. Planting barley or wheat in 30-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 30-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 30-inch rows combined with cultivation reduces weed pressure compared to 6-inch drill rows in organic barley and wheat production.

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 1100 ft long). The previous crop was sorghum silage. The ground was prepared by chopping the sorghum silage stubble, applying 10 tons/acre of manure in December, disking, ripping with crumbler to 7-8 inches, disking with cultipacker before planting. Manure was applied at a rate of 10 tons/a to the previous sorghum silage crop in June 2010. The crop before the sorghum silage was barley, and 20 T/a of manure was applied before that crop in December, 2009. On December 18, 2011, 'Cochise' barley and 'Kronos' durum were planted separately in each 5-acre field. Two planting methods were used: 1) grain drill with 6 inch row spacing and a seeding rate of about 120 lbs/acre for barley and 132 lbs/acre for durum, and 2) row planter with 30 inch row spacing and a seeding rate of 70 lbs/acre for barley and 81 lbs/acre for durum. The seed was planted in strips the length of the field (1050 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 36 rows with the grain drill and 8 rows with the planter. The experimental design was a complete block design with 2 treatments (6 and 30 inch row spacing) and 5 blocks repeated for two crops (barley and durum).

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 minimize 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.

Weeds were cultivated on the following dates using the following methods:

January 24, 2011. Frame with front toolbar equipped with flat knives of 1/4" thickness, positioned 2.5 inches away from the seed-line. Tooling depth was set to 2 inches. Rear tool-bar was equipped with rolling (Lilliston) cultivators for soil conditioning and two flat coulters for implement stability.

March 1, 2011. 6-inch wide "duck-feet" sweeps were added to the front toolbar to cultivate the middles. Flat knives were positioned at 3 inches away from the seed-line. The tooling configuration of the rear toolbar was not changed.

March 29, 2011. The only change to the tooling configuration was the use of thicker (3/8") flat knives spaced 5 inches away from the seed-line. The depth setting was increased to 3.5 inches. The configuration of sweeps in the front toolbar and rear bar tooling was not changed.

During the growing season, weed density and crop growth were measured between irrigations for a total of four sampling times. The irrigation dates and amounts were: Dec 22 (6.9 inches), Feb 5 (10.6 inches), Mar 14 (9.3 inches), and Apr 8 (7.8 inches) for a total of 34.7 inches. The measurements consisted of two samples of 18 inches of row for 2 rows for 6 inch spacing (3 ft²) and for 1 row for the 30 inch spacing (7.5 ft²). 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 May 25 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

Cultivation in the 30 inch row spacing was effective in reducing the weed populations to low levels, although light interception and crop growth were delayed in the 30 inch row spacing (Table 1).

At the first sampling time on February 15 at the tillering stage, light interception in the 6 inch row spacing was 30% of incident for barley and 18% for durum, compared to 1% for barley and 3% for durum in the 30 inch row spacing. Full cover had been reached by the second sampling time on March 27 near heading, and light interception in the 6 inch spacing was 85% for barley and 90% for durum compared to 58% for barley and 49% for durum in the 30 inch

row spacing. Similar results were obtained for light interception measurements on April 16 during the grain fill stage. The 30 inch row spacing intercepted only 48 to 58% of the incoming light at solar noon, compared to 84 to 90% for the 6 inch spacing.

Plant biomass at the Feb 15 sampling at tillering was reduced by about half in the 30 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. By the Mar 27 sampling, plant biomass of barley in the 30 inch row spacing was still reduced compared to the 6 inch spacing, by the plant biomass for the durum was essentially the same at this time. At the later sampling dates on Apr 16 and May 7, we were not able to detect differences in plant biomass due to row spacing for either barley or durum.

Cultivation in the 30 inch rows reduced the weed biomass substantially, to about a quarter or less of the weed biomass in the 6 inch spacing. At the Feb 15 sampling time, the final cultivation had not been completed, so the effect of cultivation on weed biomass had not been realized by this time. However, by the Mar 27 sampling time, weed biomass had been substantially reduced in the 30 inch row spacing by cultivation, and the reduction in weed biomass in the 30 inch row spacing was maintained through the end of the season.

The relative composition of the weed species was not affected by row spacing for either barley or durum, except the 6 inch row spacing of durum had more sheperdspurse than the 30 inch spacing (Table 2). The primary weed was canarygrass, which comprised 83-85% of the weed mixture for barley and 56-75% for durum. Malva was the only other weed species of consequence. Some sheperdspurse was present and a small amount of miscellaneous weed species. Canarygrass is very competitive with wheat and barley, and can reduce yields of these crops. Heads of canarygrass were evident above the wheat and barley canopy and appeared in patches of various levels of severity across the field.

Planting in 30 inch rows resulted in a yield reduction of about 25% for barley, but resulted in similar yields to 6 inch row spacing for wheat (Table 3). Plant height was increased by planting in 30 inch rows for durum, but no increase in plant height was detected for barley. Test weight was also increased by planting in 30 inch rows in durum, but not increase in test weight was detected for barley. Grain protein was increased by planting in 30 inch rows compared to 6 inch rows by 1.3 percentage points for barley and 1.7 percentage points for durum. Planting in 30 inch rows compared to 6 inch rows also resulted in a dramatic increase in HVAC for durum. The increase in protein and HVAC in the 30 inch rows probably was the result of eliminating weeds which compete with the crop for nitrogen.

The barley produced more grain yield than wheat in 6 inch relative to 30 inch rows possibly because 1) the barley in 6 inch rows either had less weed pressure or was more competitive with weeds, 2) the barley has a lower nitrogen requirement than wheat and elimination of weed in the 30 inch spacing for competing for nitrogen was not as much of an advantage for barley compared to wheat.

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References

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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 2011.

Sampling Date	Crop	Row Spacing	Light interception	Plant biomass	Weed biomass
		inches	% of incident	lbs/acre	lbs/acre
Feb 15	Barley	6	30	657	86
		30	1	372	67
				**	*
	Durum	6	18	544	226
		30	3	278	79
				+	**
Mar 27	Barley	6	85	4460	813
		30	58	3271	242
				**	**
	Durum	6	90	2575	1023
		30	49	2343	228
				**	NS
Apr 16	Barley	6	88	6374	1502
		30	57	6126	200
				**	NS
	Durum	6	84	8024	1346
		30	48	6066	248
				**	NS
May 7	Barley	6	---	8126	1305
		30	---	6157	339
				---	NS
	Durum	6	---	9047	2405
		30	---	9114	445
				---	NS

NS, +, *, ** = Not significant at the 10% probability level, and significant at the 10%, 5%, and 1% probability levels, respectively.

Table 2. Row spacing effect on the relative composition of weed species sampled on May 7 for barley and durum crops grown organically at the Larry Hart Farm in Maricopa, AZ in 2011.

Crop	Row Spacing	Canarygrass	Malva	Sheperdspurse	Miscellaneous
	inches	%	%	%	%
Barley	6	85	15	0	0
	30	83	10	0	7
		NS	NS	---	NS
Durum	6	56	32	12	0
	30	75	25	0	0
		NS	NS	*	---

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

Table 3. Row spacing effect on grain yield, plant height, test weight, grain protein, and HVAC for barley and durum crops grown organically at the Larry Hart Farm in Maricopa, AZ in 2011.

Crop	Row spacing	Grain yield	Plant height	Test weight	Grain protein	HVAC
	inches	lbs/acre	inches	lbs/bushel	%	%
Barley	6	4327	22.8	49.7	9.4	---
	30	3330	24.2	50.2	10.7	---
		**	NS	NS	*	---
Durum	6	3455	27.4	63.2	11.3	32
	30	3683	29.6	63.8	13.0	82
		NS	*	**	**	**

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

Fig. 1. Grain yield map for barley and durum (wheat) crops grown organically at the Larry Hart Farm in Maricopa, AZ in 2011. The vertical strips represent different row spacing starting with 6 inch on the left (east) alternating with 30 inch.

