ARIZONA COOPERATIVE EXTENSION
THE UNIVERSITY OF ARIZONA
College of Agriculture and Life Sciences

AZ1523 August 2010

Minimum tillage for wheat following winter vegetables

Kurt Nolte, Mike Ottman, Trent Teegerstrom and Guangyao (Sam) Wang

The advantages of minimum tillage

Wheat is typically grown after cotton or other field crops in most of Arizona except for Yuma County where wheat is planted after winter vegetables. About half the wheat and most of the winter vegetables (lettuce, cabbage, broccoli, or cauliflower) in Arizona are grown in Yuma County. For wheat grown in the region, the conventional tillage sequence prior to planting can be tied to as many as six field operations (Table 1). As costs for labor and resources continue to increase, and with a better understanding of the benefits obtained from conservation tillage methods, alternatives to conventional tillage practices could be attractive to some producers. In addition to the reduction of inputs, minimum tillage has been shown to reduce oxidation of soil organic matter and increase soil microbial activity, which are among the most important factors for soil productivity and sustainability (Mitchell et al., 2004). Minimum tillage could also save valuable time and potentially extend the wheat planting period in winter vegetable – wheat rotations, since less time is required for ground preparation. However, switching from conventional to minimum tillage may require changes in management practices to maximize the benefits of reduced tillage.

Table 1. A comparison of common ground preparation operations, estimated machine and labor hours and approximated fuel usage, and costs prior to seeding wheat in Yuma, AZ.

Conventional Tillage				
	Hours*		Operating Costs* ($/acre)	
Tillage Operation	Machine	Labor	Fuel/Oil/Repairs	Labor
Roll Beds	0.15	0.17	4.19	1.60
Disk #1	0.23	0.25	3.40	2.39
Chisel #1	0.23	0.25	11.19	2.39
Chisel #2	0.23	0.25	11.19	2.39
Disk #2	0.23	0.25	13.40	2.39
Float	0.15	0.17	4.05	1.60
Drill	0.23	0.25	6.62	2.39
Total	1.45	1.59	64.04	15.15

Minimum Tillage				
	Hours*		Operating Costs* ($/acre)	
Tillage Operation	Machine	Labor	Fuel/Oil/Repairs	Labor
Roll Beds	0.15	0.17	4.19	1.60
Cultivate	0.23	0.25	10.76	2.39
Herbicide Application	0.01	0.01	0.34	0.14
Drill	0.23	0.25	6.62	2.39
Total	0.62	0.68	21.91	6.52

*NOTES: Machine and labor hours and operating cost are for one time over the designated acreage and were calculated in 2008.

Figure 1. A representative lettuce field after harvest prior to ground preparation for wheat seeding (A) , wheat seedbed prepared using minimum tillage practices (B) or conventional methods (C). Minimum till fields typically have two tillage operations prior to planting while wheat grown conventionally can have up to six field operations prior to seeding.

Field preparation

In conventional tillage systems, wheat following lettuce or other winter vegetable crops is typically planted where the previous crop has been either ring rolled or mechanically chopped to crush unharvested plant residues. The field is then disked, chiseled with a short shank in two directions, disked again, and then land-leveled prior to wheat seeding (Table 1). It is estimated that over 1.5 hours/acre is needed for the seven operations with costs totaling almost $80/acre for these operations.

When minimum tillage is used, harvested fields are either ring rolled or chopped to minimize crop residue effects, and then cultivated once before planting. The combination of ring rolling followed by cultivation severs the stem portion of harvested plants, significantly preventing plant grow-back and reducing the likelihood of a weed outbreak due to regrowth of the previous crop. The operation also flattens the ground for greater seeding efficiency on bed tops and within the furrow (Fig. 1). Reducing ground preparation in minimum tillage wheat production to two tillage operations lowers fuel usage by almost 70%, and could represent a $50/acre saving when compared to conventional tillage schemes.

Planting

In Yuma County, wheat is commonly planted from late December to early March, immediately following the harvest of a vegetable crop. Conventional grain drills can be used to plant both conventional and minimally tilled fields at typical seeding rates of 150 to 250 pounds/acre. Wheat grown conventionally is solid seeded using a grain drill with a spacing that may vary from 6 to 7.5 inches. For planting on raised beds using minimum tillage, 3 to 4 rows are planted on the bed surface, and if furrows are not intentionally seeded, grain drills should to be adjusted accordingly to assure desired planting rates. It has been shown previously that wheat yields derived from fewer planted rows on a bed can be similar to those solid seeded in Ohio (Beuerlein, 2001), Oklahoma (Freeman et al., 2007) and Indiana (Kline et al., 2003) and the results of our tests conducted in the desert southwest are consistent with these observations. Moreover, our work suggests that sunlight penetration through the fully developed crop canopy does not differ when wheat is grown under conventional and minimum tillage conditions indicating plant growth compensation to different planting patterns (Table 2).

Table 2. Plant density measured as a function of photosynthetically active radiation (PAR) penetration through crop canopy. PAR measurements were determined at the bed surface and within furrows in minimum tilled wheat and at the soil level in conventionally grown wheat. Overall data or data within a location that share the same letter are not significantly different at p=0.05.

		PAR (µmol photons/ m²/sec)		
Location	**Tillage Method**	**Bed Surface Minimum Tillage**	**Furrow Minimum Tillage**	**Soil Surface Conventional**
Somerton, AZ	Conventional			149.0 a
Somerton, AZ	Minimum Till	134.8 a	178.2 a	
Yuma Ag Center, AZ	Conventional			147.9 a
Yuma Ag Center, AZ	Minimum Till	212.1 a	177.9 a	
Winterhaven, CA	Conventional			279.3 a
Winterhaven, CA	Minimum Till	291.0 a	305.8 a	
Summary	Conventional			185.9 a
	Minimum Till	212.5 a	214.6 a	

Stand establishment

A chief area of concern related to the adoption of minimum tillage is the grow-back of a previously harvested crop (volunteers), which can result in a subsequent weed issue in the wheat crop (Fig. 2). It seems clear that, when producing wheat following vegetables on raised beds using minimum tillage schemes, specific and careful control of the former crop is essential. Regrowth of the preceding crop will decrease wheat yield potential and could affect the health of subsequent crops if, for example, pathogens such as *Fusarium* and *Schlerotinia* are carried over from the lettuce crop (Koike and Davis, 2009). Therefore, elimination of the previous crop by either herbicide application or cultivation prior to seeding is imperative. The control of regrowth could be achieved by the use of post emergent broadleaf herbicides or cultivation prior to seeding as suggested previously.

Wheat growth and yield

We compared the effects of conventional and minimum tillage on durum wheat establishment, growth and yield in three replicated trials at two locations in Arizona and one location in California during the 2007 growing season. All locations included durum following either head lettuce or Romaine hearts planted on 42-inch beds. Wheat growth, measured as either plant height at heading or days to heading, was determined to be similar with wheat grown conventionally and under minimum tillage. And, while irrigation water moved to the end of furrowed minimum till fields quicker than in conventional treatments (data not shown), water application rates and timing in this study were similar. Wheat yield, grain moisture, and test weight was also not different between conventional and minimum tillage practices (Table 3). Viewed broadly, we were not able to detect differences in grain

Figure 2. (A) Significant regrowth of lettuce during wheat germination can be problematic during stand establishment if not controlled adequately. The control of regrowth (B) by the use of a broadleaf herbicide or light cultivation prior to seeding can significantly assist in stand establishment.

Table 3. Wheat yield and quality parameters as influenced by tillage practice. Overall data or data within a location that share the same letter are not significantly different at p=0.05.

Location	Tillage Method	Moisture (%)	Test Weight (lb/bu)	Yield (tons/acre)
Somerton, AZ	Conventional	9.15 a	61.25 a	3.64 a
Somerton, AZ	Minimum Till	8.80 a	61.50 a	3.78 a
Yuma Ag Center, AZ	Conventional	9.07 a	61.00 a	3.35 a
Yuma Ag Center, AZ	Minimum Till	9.07 a	62.00 a	2.98 a
Winterhaven, CA	Conventional	10.10 a	61.50 a	2.57 a
Winterhaven, CA	Minimum Till	11.20 a	61.25 a	2.21 a
Summary	Conventional	9.39 a	61.25 a	3.21 a
	Minimum Till	9.43 a	61.58 a	2.94 a

yield and quality due to tillage practice in these studies. This indicates that, when using minimum tillage, growers have the potential to produce wheat equivalent to that of conventional tillage methods while significantly conserving fuel, labor and time in typical winter vegetable to wheat rotations

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THE UNIVERSITY OF ARIZONA • COLLEGE OF AGRICULTURE AND LIFE SCIENCES

The University of Arizona
College of Agriculture and Life Sciences
Tucson, Arizona 85721

Kurt Nolte
Area Associate Agent

Mike Ottman
Agronomy Specialist

Trent Teegerstrom
Associate Specialist

Guangyao (Sam) Wang
Assistant Specialist

Contact:
Kurt Nolte
knolte@cals.arizona.edu

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