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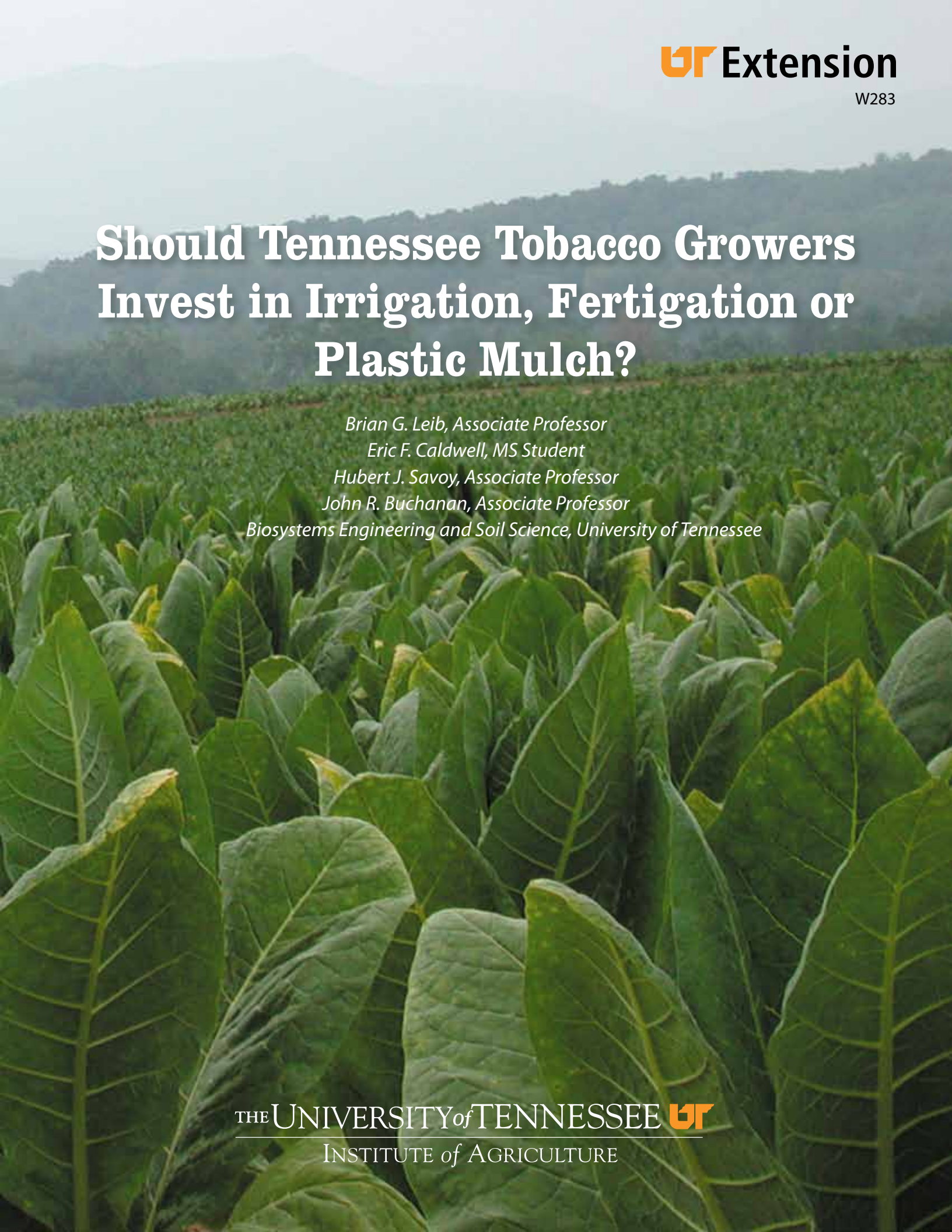

Should Tennessee Tobacco Growers Invest in Irrigation, Fertigation or Plastic Mulch?

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THE UNIVERSITY of TENNESSEE
INSTITUTE of AGRICULTURE

INTRODUCTION

The desire to grow high-yielding, high-quality burley and dark fire-cured tobacco has not changed, but the market in which tobacco is sold has changed. The increasing competition from inexpensive foreign leaf, coupled with shrinking U.S. demand, calls for greater efficiency in growing practices that take into account the leaf quality desired in market contracts. Irrigation has long been considered insurance against dry seasons, but recent research has shown it to be of greater benefit. By optimizing soil-water levels, plants increase their ability to efficiently use soil and fertilizer nitrogen. By avoiding dry periods between rainfall events, yield and quality can be improved even in average-to-good precipitation seasons.

This factsheet uses the results from multi-year University of Tennessee irrigation studies in a cost-benefit analysis to help determine if investing in an irrigation system will be profitable. Tobacco yield and quality benefits provided by irrigation, fertigation (fertilizer applied through the irrigation system) and black plastic mulch are also evaluated, with tobacco quality being measured by the Grade Index (GRI) and tobacco-specific nitrosamine (TSNA) concentration of the leaf. TSNAs are of interest to buyers because they are considered one of the more potent carcinogens in cigarettes, and decreasing TSNAs fits corporate objectives of providing safer products. TSNAs form during the curing process and the level of TSNA is increased by higher nitrate content in the leaves, while nitrates accumulate in the leaves during periods of slow growth, like during dry periods. These nitrates constitute a 'waste,' as they are not used for growth, and are 'food' for bacteria that form TSNAs.

TOBACCO IRRIGATION TEST RESULTS

Tobacco irrigation recommendations are based on seven site-years for dark fire-cured (TN D950) and 10 site-years for burley (TN 90) tobacco, as shown in Table 1. This long period of testing insured that results were representative of Tennessee conditions. In the dark fire-cured tobacco trials, rainfall was above average for two years, below average for three years and near average for two years. For burley, rainfall was above average for four years, below average for four years and near average for two years. The soils used for these tests were also representative of Tennessee tobacco-growing regions: a Dickson silt loam at Springfield and a Lindside silt loam at Greeneville.

In these trials, irrigation was applied based on weekly rainfall using drip tape placed beside every tobacco row. Irrigation supplemented rainfall so that the total of rain and irrigation equaled at least 1 inch of water per week, starting at tobacco's rapid growth stage (approximately four weeks from transplanting). Even though 1 inch per week is less than tobacco's water-use rate, this irrigation rate produced the highest yields in the tests (several other rates were studied) and is a widely accepted guideline used by producers. The highest irrigation amount occurred in 2007 with 9 inches applied, and the least in 2004 with only 0.5 inches of irrigation applied. The average amount applied was less than 4 inches per year. The greatest response to irrigation was a yield increase of more than 50 percent and a GRI increase of 16 points in burley during 2007. On average, the increase was around13 percent for dark and 16 percent for burley, accompanied by a 4-point GRI increase.

BENEFIT OF TOBACCO IRRIGATION

The average yield increase was 373 lb/acre per year for the dark fire-cured and 402 lb/acre per year in the burley as shown in Table 2. These increases had an estimated value of 933 $/ac-yr in dark fire-cured and 683 $/ac-yr in burley, based on a fixed price of $2.50 per lb and $1.70 per lbs, respectively. Though GRI was higher with irrigation, the effect on price is not clear, so no price adjustment was made on this basis. In some years, irrigation increased gross return by more than $2,000 per acre (2007), while in other years irrigation provided very little gain (2004).

Table 1. Rainfed versus Irrigated Yield & Quality of Dark Fire-Cured and Burley Tobacco
(Rainfall & Irrigation between June 1 and August 31 - Historic Plant Water Use is 11.2")

SPRINGFIELD, TN (Historic Rainfall is 11.8")

				YIELD	YIELD	GRI	GRI
		Rain	Irrig	Rainfed	Irrigated	Rainfed	Irrigated
DARK		(inch)	(inch)	(lb/ac)	(lb/ac)	(#)	(#)
2000		7.5	-	2632	3050	57	61
2001		12.3	2.0	3102	3363	38	46
2002		9.1	3.0	2900	3402	50	49
2003		14.5	2.0	3327	3466	60	65
2004		14.2	0.5	3435	3400	57	54
2005		16.9	3.7	Hurricane	Damage	-	-
2006		12.7	3.6	3036	3385	60	71
2007		4.9	9.0	2422	3396	63	64
Average		11.5	3.4	2979	3352	55	59

SPRINGFIELD, TN (Historic Rainfall is 11.8")

				YIELD	YIELD	GRI	GRI
		Rain	Irrig	Rainfed	Irrigated	Rainfed	Irrigated
BURLEY		(inch)	(inch)	(lb/ac)	(lb/ac)	(#)	(#)
2000		7.5	?	2271	2998	64	69
2001		12.3	2.0	3153	3417	71	68
2002		9.1	3.0	2427	3039	75	81
2003		14.5	2.0	3089	3190	74	74
2004		14.2	0.5	3182	3233	71	73
2005		16.9	3.7	Hurricane	Damage	-	-
2006		12.7	3.6	1923	1976	72	73
2007		4.9	9.0	1709	2802	34	50
Average		11.5	3.4	2536	2951	66	70

GREENEVILLE, TN (Historic Rainfall is 12.7")

				YIELD	YIELD	GRI	GRI
		Rain	Irrig	Rainfed	Irrigated	Rainfed	Irrigated
BURLEY		(inch)	(inch)	(lb/ac)	(lb/ac)	(#)	(#)
2005		14.8	3.5	2525	2679	59	60
2006		16.5	3.2	3096	3154	58	56
2007		10.1	5.0	1786	2693	61	65
Average		13.8	3.9	2469	2842	60	60

COST OF TOBACCO IRRIGATION

Several irrigation systems are suitable for tobacco production.

1. **Stationary Gun** – a large, high-pressure (50 to 70 psi) sprinkler on a non-moving stand that is manually transported from one location to another location after each irrigation set and is supplied by flexible, lay-flat hose.
2. **Traveling Gun** – a large, high-pressure sprinkler (50 to 100 psi) that is slowly pulled on a wheeled cart by a hard hose supply line toward a reel or by a cable that drags the hose during each irrigation set.
3. **Drip Tape** – thin-walled, low-pressure (8 to 15 psi), usually 5/8" diameter, disposable polyethylene tubing with closely spaced internal emitters that is laid along or between tobacco rows and wets a narrow strip during irrigation sets. Pressure regulation and filtration are often required. Drip tape should be replaced every year.
4. **Solid-Set Sprinklers** – medium-pressure sprinklers (30 to 50 psi) on risers spaced 40 to 60 feet apart connected to above ground aluminum or PVC pipe. Enough pipe and sprinklers are located to cover the entire field and they remain stationary for the entire growing season.
5. **Hand-Line Sprinklers** – medium-pressure sprinklers (30 to 50 psi) spaced 30 to 40 feet apart on aluminum or PVC laterals in sections that are easily disconnected and reconnected. The lateral sections are moved 40 to 60 feet and reconnected to a header line after each irrigation set, requiring multiple moves to complete a single irrigation of a field.

The capital cost, operating cost and total cost of each system are shown in Table 3. The initial capital cost was converted to an annual cost based on a 7 percent interest rate that is amortized over a seven-year payback period. This is a conservative figure, because the equipment is expected to last longer than seven years. Also, the initial capital cost does not include the cost of developing a water source, because this cost can be highly variable. The calculation assumes that a stream, pond or well is already accessible and in close proximity to the tobacco field. While some systems are more expensive, such as the solid set sprinklers, there is potential for this system to be used for frost protection of high-value crops like strawberries, thus reducing the capital cost applied to tobacco irrigation. Also, drip tape costs were based on yearly replacement of one drip line for each tobacco row. Placing drip tape in every other row could reduce the $225 per acre per year cost by half (this has not yet been successfully tested

photo by Ronnie Barron

Stationary Sprinkler with Riser Stand

Traveling gun irrigation in tobacco with close-up of sprinkler and cart

Drip tape irrigation in tobacco

Table 2. Average Tobacco Irrigation Benefit (2000 to 2007)

	RAINFED Yield (lb/ac)	IRRIGATED Yield (lb/ac)	Yield Increase (lb/ac)	Price ($/lb)	Gross Return I ($/ac-yr)
DARK	2979	3352	373	2.50	933
BURLEY	2516	2918	402	1.70	683

Table 3. Irrigation System Cost for Tobacco in a Humid Region

IRRIGATION TYPE	Capital Cost		Operating Cost			Total Cost
	Initial $/ac	Annual $/ac-yr	Labor $/ac-yr	Electric $/ac-yr	Maintain $/ac-yr	$/ac-yr
Stationary Gun	600	109	25	45	6	185
Traveling Gun	650	118	11	50	19	198
Drip Tape	404	72	10	35	245	361
Solid-Set Sprinkler	1,900	344	12	40	19	415
Hand-Line Sprinkler	550	100	28	40	6	174

1. Hours of labor are based on the amount of water applied and the type of irrigation system at $8/hr.
2. Electric cost is based on applying 4 inches of water and a 100-foot lift plus the pressure required for each irrigation system.
3. The standard maintenance cost for each system is reduced by 50 percent due to less use of equipment in humid regions.
4. Drip tape maintenance includes $225 for replacing drip tape each year.
5. The Hand-Line Sprinklers require a spray row every 40 feet in order to move pipe in a tobacco field.

in Tennessee). Since the range of total cost to own and operate these systems ($174 to $415 ac/yr) is lower than the gross annual return, irrigating a high-value tobacco crop in Tennessee should be profitable, even though yield increases were only around 15 percent on average.

TOBACCO IRRIGATION, FERTIGATION & PLASTIC MULCH TEST

Because of the positive results from the tobacco irrigation study, it was decided to test the effects of fertigation, reduced nitrogen application and plastic mulch on yield, GRI and TSNA concentration. Irrigation plots used the same irrigation method as in the previous study. All preplant N fertilizer was ammonium nitrate. In the fertigation plots, half the total N was preplant and the other half was split injected into the irrigation water at 4, 6 and 8 weeks after transplant using soluble urea. The plastic mulch plots used the same irrigation and fertigation program as the fertigated plots, but utilized a double row of tobacco (same number of plants per acre) planted into a single raised-bed covered by black plastic. Irrigation amounts were the same in all plots. As shown in Table 4, irrigation produced

Check Valve, Injector, Screen Filter, and Batch Tank for Fertigation

Plastic Mulch in Tobacco Production

Table 4. Benefit of Irrigation, Fertigation and Plasticulture in Burley and Dark Tobacco

2006-2007	DARK			
SPRINGFIELD, TN	Yield (lb/ac)	GRI (#)	TSNA (ppm)	Return ($/ac-yr)
Rainfed - 200 lbs N/ac	2729	61	-	0
Irrigated - 200 lbs N/ac	3390	64	-	1651
Irrigated - 100 lbs N/ac	3368	69	-	1596
Fertigated - Irrigated - 200 lbs N/ac	3321	66	-	1480
Fertigated - Irrigated - 150 lbs N/ac	3343	68	-	1535
Fertigated - Irrigated - 100 lbs N/ac	3299	68	-	1424
Plastic - Fertigated - Irrigated - 200 lbs N/ac	3393	68	-	1660
Plastic - Fertigated - Irrigated - 100 lbs N/ac	3164	67	-	1086

2005-2006-2007	BURLEY			
SPRINGFIELD & GREENEVILLE, TN	Yield (lb/ac)	GRI (#)	TSNA (ppm)	Return ($/ac-yr)
Rainfed - 200 lbs N/ac	1976	57	1.43	0
Irrigated - 200 lbs N/ac	2216	61	1.01	408
Irrigated - 100 lbs N/ac	2110	56	0.67	228
Fertigated - Irrigated - 200 lbs N/ac	2281	57	0.99	519
Fertigated - Irrigated - 150 lbs N/ac	2196	58	0.71	375
Fertigated - Irrigated - 100 lbs N/ac	2119	52	0.52	244
Plastic - Fertigated - Irrigated - 200 lbs N/ac	2364	60	1.04	661
Plastic - Fertigated - Irrigated - 100 lbs N/ac	2109	54	0.56	227

Combined Benefit of Irrigation, Fertigation and Plastic Mulch in Tobacco Production

the main benefits in yield and quality, including the reduction of TSNA by 30 percent in burley tobacco, while fertigation and plastic mulch added marginal benefit. Reduced nitrogen application also reduced TSNA but at a slight loss in yield and GRI quality. Recommendations from the combined studies are as follows:

RECOMMENDATIONS

1. Irrigation will increase the yield and quality of dark fire-cured and burley tobacco. Even though the average yield increase may only be around 15 percent, the added value of the tobacco is sufficient to make irrigation a profitable practice unless excess costs are incurred to develop a water supply for the irrigation system. In addition, the variation in yield from year to year was much less with irrigation, a great advantage under contract marketing. Irrigation also reduced TSNA by an average of 30 percent, a quality aspect that may increase the price for tobacco in the future.
2. Fertigation produced slightly higher yields than irrigation alone in burley tobacco. However, the degree of improvement was not enough to warrant a strong recommendation for fertigation of tobacco. What fertigation does offer is increased control over the field at little cost if drip irrigation is to be used. If fertigation can be incorporated into your operation in such a manner as to save time and the number of tractor passes across a field, it will be more cost effective.
3. Reduction of N from 200 to 150 or 100 lbs/ac with fertigation gave yield and quality losses in burley tobacco in some growing seasons, while in other growing seasons these lower N levels were

sufficient. During these trials, the savings from applying less N could not be justified even as N prices rose with increased energy costs. Lower N application in combination with irrigation did reduce TSNA formation in burley tobacco by more than 60 percent. However, lower N rates for reducing TSNA cannot be recommended at this time because tobacco price is not adjusted for TSNA content.

4. Plastic mulch on raised-beds increased the yield of burley and dark fired-cured tobacco, but the increase may not be enough to offset the cost of new equipment ($7500 for a bedder and water wheel planter) and annual mulch replacement ($185 per acre each year). Therefore, plastic mulch is not recommended unless it fits into your particular operation. For instance, plastic mulch warms the soil and would promote earlier tobacco production. This could allow better use of tobacco-curing facilities and better distribute labor requirements. It could also create the ability to follow tobacco with another high-value crop in the same growing season. It should be noted that additional water applications might have improved production under plastic mulch and that plastic mulch was not tested during wet/cold conditions early in the growing season.

Acknowledgements

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More Detailed Articles Describing UT Tobacco Irrigation Experiments

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W-283 10/11 12-0036

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