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

(An Extension Fact-Sheet based on recent research)

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Abstract. *U.S. tobacco growers are competing in a recently deregulated market with greater supply coming from abroad and shrinking U.S. demand for their product. Tobacco production based on preplant fertilization and reliance on natural precipitation has become less profitable under current conditions. This fact sheet combines the results of two studies that tested the benefit of irrigation, fertigation, and plasticulture to produce higher tobacco yield and quality while reducing carcinogens, tobacco specific nitrosamines (TSNA). Eight years of study and two sites formed the basis for tobacco irrigation recommendations that were representative of Tennessee conditions.*

Even though tobacco is drought tolerant and Tennessee is a high rainfall region with many good water-holding soils, both Burley and Dark Fire-Cured tobacco were profitably irrigated with only a 15% average yield increase due to the high value of the crop. In addition, irrigation and reduced N rates with irrigation (fertigation) reduced TSNA formation in Burley tobacco by 30% and 60%, respectively.

Keywords. Burley tobacco, Dark fire-cured tobacco, Drip irrigation, Cost-benefit, Fertigation, Plasticulture, Nitrosamine.

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INTRODUCTION

The desire to grow high yielding, high quality Burley and Dark Fire Cured tobacco has not changed. What has changed is the market in which tobacco is sold. The increasing competition from inexpensive foreign leaf, coupled with shrinking US 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 uptake and utilize nitrogen toward growth. By simply avoiding dry periods between rainfall events, yield and quality benefits are accrued in even average to good precipitation seasons. Recently, the 2007 drought and warnings that global warming will disrupt precipitation patterns have increased interest in irrigation systems.

This fact-sheet will provide a basis for a cost-benefit analysis to help determine if investing in an irrigation system will be profitable over the life of that system. We will also discuss irrigation, fertigation, and plastic mulch use in tobacco production to determine the benefits they provide in improving yield and quality. Quality considerations will consist of the Grade Rated Index (GRI) and tobacco specific nitrosamine (TSNA) concentration of the leaf. TSNA's are of interest to buyers because they are considered one of the more potent carcinogens in cigarettes and decreasing TSNA's fits corporate objectives of providing safer products. TSNA's form during anaerobic periods of the curing process from residual nitrates in harvested leaves and nitrates accumulate in the plant during periods of sub-optimal growth conditions. These nitrates constitute a 'waste' as they are not utilized toward growth, and are 'food' for nitrosating bacteria that form TSNA's.

TOBACCO IRRIGATION TEST RESULTS

Tobacco irrigation recommendations are based on 7 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, helped the results to be representative of Tennessee conditions. In Dark Fire-Cured Tobacco, rainfall was above average for 2 years, below average for 3 years, and close to average for 2 years, and for Burley, above average for 4 years, below average for 4 years, and close to average for 2 years. The soils used for these tests were also representative of Tennessee tobacco growing regions: the Springfield site was a Dickson silt loam and the Greeneville site was a Lindside silt loam. For this comparison, fertilizer was applied at recommended rates while irrigation, via drip tape placed beside every tobacco row, was applied based on weekly rainfall. 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 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 while the average amount applied was less than 4 inches per year. The highest response to irrigation was a yield increase of over 50% and a GRI increase of 16 points in Burley during 2007 but on average the increase was around 13% for Dark and 16% for Burley accompanied by a 4 point GRI increase.

COST/BENEFIT OF TOBACCO IRRIGATION

The average yield increase was 373 lb/acre per year in the Dark Fire Cured and 402 lb/acre per year in the Burley as shown in Table 2. As for gross return on investment, the result was \$933 \$/ac-yr in Dark Fire Cured and \$683 \$/ac-yr in Burley based on a fixed price of \$2.50 per lbs

Table 1. Rainfed versus Irrigated Yield & Quality of Dark-Fire Cure 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")

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

SPRINGFIELD, TN (Historic Rainfall is 11.8")

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

GREENEVILLE, TN (Historic Rainfall is 12.7")

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

Table 2. Summary of Tobacco Irrigation Benefit (2000 to 2007)

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

and \$1.70 per lbs, respectively. These prices represent expected averages at the end of the trials since GRI is no longer tied to price and it is uncertain whether the GRI difference will create a price difference. Again, gross return was an average. In some years, irrigation made more than \$2,000 per acre (2007) while in other years irrigation provided very little gain (2004).

Several irrigation systems are thought to be compatible with 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), 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 ever year.
4. Solid-Set Sprinklers – medium pressure sprinklers (30 to 50 psi) spaced 40 to 60 feet apart on aluminum or PVC pipe and risers. 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.

Table 3. Irrigation System Cost Analysis for Tobacco in a Humid Region (\$/ac-yr)

Irrigation Type	Capital Cost		Operating Cost			Total Cost
	Initial	Annual	Labor	Electric	Maintain	
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. Annual Capital Cost is based on a 7-year payback at 7% interest and a stream, pond, or well is already accessible.
2. Hours of Labor are based on the amount of water applied and the type of irrigation system at \$8/hr.
3. Electric Cost is based on applying 4 inches of water and a 100 foot lift.
4. The standard Maintenance Cost for each system is reduced by 50% due to less use of equipment in humid region.
5. Drip Tape Cost is based on lines in every row. Drip tape in every other row would reduce cost, labor, and maintenance.
6. Drip Tape Maintenance is \$20 and includes \$225 for replacing drip tape each year.
7. The Solid-Set Sprinklers are portable with possible multiple uses for split cropping with high value crops in need of frost protection, such as strawberries. This would reduce capital costs for tobacco by 50%.
8. The Hand-Line Sprinklers requires a spray row every 40 feet in order to move pipe in the Tobacco

The capital cost, operating cost, and total cost of each system is shown in Table 3. The initial capital cost was converted to an annual costs based on a 7% interest rate that is amortized over a seven-year payback period as 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. Also, drip tape costs were based on yearly replacement of one drip line for each tobacco row and 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 in Tennessee). Since the range of total cost to own and operate these systems (\$174 to \$415 ac/yr) is lower than the gross return, irrigating a high value tobacco crop in Tennessee should be profitable even though yield increases were only around 15% on average.

TOBACCO IRRIGATION, FERTIGATION & PLASTIC MULCH TEST

Because of the positive results from the tobacco irrigation study, it was decided to test tobacco production with the addition of fertigation, reduced nitrogen application and plastic mulch to determine the effect on yield, GRI, and TSNA concentration. In the irrigation plots, the same irrigation method and protocol was used as in the previous study. Also, all preplant fertilizer was ammonium nitrate. In the fertigation plots, half the total N was preplant and the other half was split injected at 4, 6, and 8 weeks after transplant using liquid urea. The plasticulture plots used the same irrigation and fertigation protocol but a double row of tobacco was planted into a single raised-bed covered by black plastic mulch. As shown in Table 4, irrigation again produced the main benefits in yield and quality including the reduction of TSNA by 30% in Burley tobacco. 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-Fired and Burley Tobacco. Even though the average yield increase may only be around 15%, 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. Irrigation also reduced TSNA by an average 30%, 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 and little cost to implement once irrigation is established. 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 application from 200 to 150 or 100 lbs/ac with fertigation incurred yield and quality losses in Burley Tobacco in some growing seasons while in other growing season these lower N levels were sufficient. During these trials, the savings from applying less N could not be justified even as nutrient prices rose with increased energy costs. Lower N application in combination with irrigation did reduce TSNA formation in Burley Tobacco by over 60%. However, lower N rates for reducing TSNA cannot be recommended at this time because neither a premium can be obtained nor a discount avoided by producing lower TSNA in tobacco.
4. Plastic mulch on raised-beds increased the yield of Burley and Dark-fired Tobacco but the increase may not be enough to profitably offset the cost of new equipment (\$7500 for a bedder and water wheel planter) and annually replacing the mulch (\$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 could have improved production under plastic mulch and that plastic mulch was not tested during wet/cold conditions early in the growing season.

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

2006-2007 SPRINGFIELD, TN	DARK			DIFFERENCE			VALUE		
	Yield (lb/ac)	GRI (#)	TSNA (ppm)	Yield (lb/ac)	GRI (#)	TSNA (%)	Price (\$/lb)	Return (\$/ac-yr)	above Irrig (\$/ac-yr)
Rainfed - 200 lbs N/ac	2729	61		0	0		2.50	0	
Irrigated - 200 lbs N/ac	3390	64		661	3		2.50	1651	0
Irrigated - 100 lbs N/ac	3368	69		639	7		2.50	1596	-55
Fertigated - 200 lbs N/ac	3321	66		592	5		2.50	1480	-171
Fertigated - 150 lbs N/ac	3343	68		614	7		2.50	1535	-116
Fertigated - 100 lbs N/ac	3299	68		570	7		2.50	1424	-228
Plastic - 200 lbs N/ac	3393	68		664	7		2.50	1660	9
Plastic - 100 lbs N/ac	3164	67		435	6		2.50	1086	-565

2005-2006-2007 SPRINGFIELD, TN & GREENEVILLE, TN	BURLEY			DIFFERENCE			VALUE		
	Yield (lb/ac)	GRI (#)	TSNA (ppm)	Yield (lb/ac)	GRI (#)	TSNA (%)	Price (\$/lb)	Return (\$/ac-yr)	above Irrig (\$/ac-yr)
Rainfed - 200 lbs N/ac	1976	57	1.43	0	0	0	1.70	0	
Irrigated - 200 lbs N/ac	2216	61	1.01	240	4	30	1.70	408	0
Irrigated - 100 lbs N/ac	2110	56	0.67	134	-1	54	1.70	228	-180
Fertigated - 200 lbs N/ac	2281	57	0.99	306	0	31	1.70	519	111
Fertigated - 150 lbs N/ac	2196	58	0.71	221	1	51	1.70	375	-33
Fertigated - 100 lbs N/ac	2119	52	0.52	143	-5	63	1.70	244	-165
Plastic - 200 lbs N/ac	2364	60	1.04	389	3	27	1.70	661	252
Plastic - 100 lbs N/ac	2109	54	0.56	133	-3	61	1.70	227	-182

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