Effects of High and Low Management Intensity on Profitability for Three Watermelon Genotypes

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ABSTRACT

A replicated, small plot study on watermelon [*Citrullus lanatus* (Thunberg) Matsumura and Nakai] in 1997, 1999, and 2000 revealed that production management intensity affected yields and profitability of watermelon, in Oklahoma. Management intensity was based on a combination of cultural practices and levels of use of production methods. Low intensity management (LM) consisted of use of soil fertilization and weed control. High intensity management (HM) included the same weed control and fertilization as LM but also included use of plastic mulch, drip irrigation, insect pest control, and plant disease control. Cost and return analyses were based on the range of actual prices during the cropping season and the range of yields during the three years. Yields from the seedless triploid genotype 'Gem Dandy' consistently resulted in greater positive net revenue under HM than the diploid open pollinated 'Allsweet' or the hybrid diploid 'Sangria'. Under LM, yields from the seedless triploid also resulted in greater net revenues when conditions were favorable or lost less money than the open pollinated 'Allsweet' or the hybrid diploid 'Sangria' when conditions were unfavorable.

INTRODUCTION

Watermelon, *Citrullus lanatus* (Thunberg) Matsumura and Nakai, is an important crop in Oklahoma. It has been stated that watermelon production is usually more profitable when managed at a high level of intensity (Clough, 1992; Robinson and Decker-Walters, 1997; Hochmuth et al., 2001; Bolin and Brandenberger, 2001). Management intensity is characterized by a combination of cultural practices at different levels of usage. Cultural practices such as irrigation, cultivation, genotype selection, and control of weeds, insect pests, and plant diseases play important roles in determining production costs as well as yields and net returns. Questions frequently asked by watermelon growers are "What difference does the level of management intensity have on yields?" and "How is the expected net return affected when increased expenditures are required for high level management cultural practices?

A replicated small plot experiment was conducted contrasting high and low production intensity management in 1997, 1999, and 2000, (Lu et al., 2003). They found that the combined effect of several cultural practices on watermelon yield was significant, producing a 100% increase in weight and number of marketable fruit per area in two out of three years when compared with production at low production management intensity (Lu et al., 2003). This paper addresses the second question of whether management intensity affects profitability of watermelon production. Profitability was measured as the dollar net revenue per acre.

The objectives were to 1) characterize and estimate the expected net returns of two production management intensity strategies for each of three watermelon genotypes (open-pollinated diploid, hybrid diploid, and seedless triploid) using actual costs of production and actual market prices during the time of the experiment, and 2) examine the change in expected net revenue in response to variation in a) market price, and b) yield.

Although studies evaluating production management intensity are common, most of them emphasize only one or two cultural practices. There is a paucity of studies on the profitability of watermelon involving multiple cultural practices. Brown (1987) found that the use of plastic mulch and row covers when using watermelon transplants did not increase net return. Increasing watermelon transplant density can increase the potential for greater gross return per area (NeSmith, 1993). Pier and Doerge (1995) evaluated the economics of drip-irrigated watermelon in addition to the agronomic and environmental aspects. Pest management and use of technology increase costs and affect pest economic thresholds of watermelon production (Barrientos and Anciso, 1996). Kumar et al. (1997) estimated the cost/benefit ratio associated with managing rodent pests of watermelon. Intercropping with watermelon increased value per area compared with monocrop of papaya (Aiyelaagbe and Jolaoso, 1992). Irrigation practices can be managed to achieve a higher net return within a range of watermelon market prices regardless of electrical energy cost (de Andrade et al., 2001). Using a tandem model, Epperson and Fletcher (1985) predicted market price of watermelon with high probability when compared with the 30-year records of price in the United States, but did not relate price to net revenue.

There is also information on yield differences among watermelon genotypes. Some previous studies revealed yield variation among genotypes due to rates of calcium application (Scott et al., 1993) or methods of vine training (Watanabe et al., 2001). The effect of management intensity on yield varies among watermelon genotypes of different ploidy (Lu et al., 2003): a triploid genotype showed the greatest differences in yield between high management intensity (HM) and low management intensity (LM) in all three years, producing at least 50% more weight and 30% greater number of marketable fruit per area under HM than LM. However, no one has related yield to profit or net revenue. In an investigation of the relationship between yield, profitability, and risk for corn production, it was found that technology (cultural practices) improved profitability and choice of corn genotypes reduced risk (Chavas et al., 2001). High intensity production management using different technologies often provides benefits over a traditional low input production system. However, the extra investments in HM are not always offset by net return (Purvis et al., 1995). Previous research has indicated that weather conditions can result in highly variable watermelon yields among years (Snyder et al., 1991; Fernandez-Bayon et al., 1993; Gimeno et al., 1999; Fumagalli et al., 2001; Korkmaz and Dufault, 2001; Lu et al., 2003).

MATERIALS AND METHODS

A 3-year study was conducted to compare yield under high production management intensity (HM) and low production management intensity (LM). Low management intensity (LM) included only use of soil fertilizer and weed control in the 3-year study. High intensity management (HM) included the use of the same fertilizer levels and weed control as the LM plots. HM additionally included use of black plastic mulch on raised beds, drip irrigation, insecticides, and fungicides. Three genotypes were selected for the study based on differences in ploidy and seed price: open-pollinated diploid ‘Allsweet’ ($2/1,000 seeds), diploid hybrid ‘Sangria’ ($35/1,000 seeds), and triploid ‘Gem Dandy’ ($170/1,000 seeds). A split plot design was used in the experiment to evaluate effects of two treatment factors. Management intensity and genotype and treatments were assigned to whole plots (18.3×5.5m) and subplots (6.1×5.5m), respectively. The two levels of management intensity (HM and LM) were randomly applied to whole plots in each block. The three genotypes were randomly assigned among the three subplots in each whole plot. The experimental unit consisted of one subplot containing 30 transplants of each genotype. The experiment was replicated in six, four, and six blocks in 1997, 1999, and 2000, respectively. The production schedules for HM and LM were the same among genotypes within each year. Although not planned, insecticides had to be used in LM plots in 1997. Considering this would be the case for commercial production if density of insect pests reached the economic threshold under LM, these costs were included in the budgets. Harvest occurred in July and August of each year. Weeds were managed using both chemical and mechanical control in both HM and LM so that the effects of plastic mulch and drip irrigation used in HM would be restricted to soil temperature and moisture, thus, weeds were eliminated as a factor in marketable yields. Fertilizer levels were identical in both HM and LM plots. The market prices used for the analysis for each year were averages of prices from 1 July to 31 August at Dallas, TX (USDA Agricultural Marketing Service, 1997; 1999; 2000). Yields were determined by picking all fruit, culling the unmarketable fruit, then weighing the marketable fruit for each plot, and then extrapolating from plot size to one-acre units.

RESULTS

Net Return Expectations Utilizing Actual Prices, Yields and Costs of Production

Utilizing actual costs of production, market prices at the time of harvest, and plot yield data (extrapolated to pounds per acre), cost and return budgets were developed for each of the three genotypes under high level management (HM) and low level management (LM) for each of the three years of the study. To simplify comparisons among the evaluations, the individual budgets for each year were combined into a single spreadsheet. This included the yields of three genotypes produced under both HM and LM for each year, the actual costs of production and the actual market price at Dallas (Table 1.). Given actual prices, costs, and yields for each year the seedless genotype 'Gem Dandy' was the only genotype that consistently yielded positive net revenue during the three-year study.

In 1997 yield from all three genotypes resulted in positive net revenue ranging from a high of $2,772 per acre for 'Gem Dandy' under HM to a low of $41 per acre for 'Gem Dandy' under LM. 'Allsweet' yield resulted in net return of $962 per acre under HM and $105 per acre under LM. 'Sangria' yield resulted in a positive net return of $295 and $242 per acre under HM and LM, respectively.

In 1999 both ‘Allsweet’ and ‘Sangria’ yields resulted in net losses in both HM and LM management while ‘Gem Dandy’ yields resulted in a positive net return of $995 per acre under HM and $469 per acre under LM. ‘Sangria’ yield resulted in a net loss, the greatest being -$950 per acre under HM and -$534 per acre under LM. ‘Allsweet’ yield resulted in losses of -$711 and -$353 per acre under HM and LM, respectively.

In 2000 ‘Allsweet’ yields resulted in a net loss of -$26 and -$404 per acre for HM and LM respectively. ‘Sangria’ yields resulted in positive net revenue of $383 per acre under HM but a net loss of $277 per acre under LM. ‘Gem Dandy’ yields resulted in positive net revenue under both levels of management. Revenue was $1,485 and $673 per acre for HM and LM, respectively.

Prices and yields varied between years and within years. Using actual yields and actual prices, the one constant result was that yields consistently were higher under HM than LM for each genotype for all three years and that the yields from the seedless watermelon ‘Gem Dandy’ consistently resulted in a positive net return under both levels of management intensity during all three years. This value ranged from the high of $2,772 per acre under HM to the low of $41 per acre under LM. These two extremes occurred during the 1997 crop season. ‘Allsweet’ yields resulted in net losses under both HM and LM during two of the three years. ‘Sangria’ yields resulted in net losses during two of the three years under LM. ‘Sangria’ yields resulted in positive net revenue in two of the three years under HM.

SENSITIVITY ANALYSES

Six different scenarios were evaluated to determine the sensitivity of net return to a change in either the market price or marketable yields. These scenarios were 1. actual market prices and actual yields, 2. average prices and average yields, 3. high prices and high yields, 4. low prices and low yields, 5. low prices and high yields, 6. high prices and low yields. All data used in the sensitivity analyses were within the range of data observed during the experiment. Both the high prices and the low prices were actual prices recorded at the Dallas market during the time of the experiment. The expected net return results from actual prices and yields were described above. Table 3 contains a summary of the expected net revenue for all six scenarios.

Net Return Expectations Utilizing Three Year Average Prices and Average Yields

Since prices and yields varied considerably between and within years, average yields and prices for the three years were calculated (Table 2.) to determine if different results would occur if average values were utilized rather than actual values, to reflect a more likely scenario. These average prices and yields per acre were utilized with actual annual costs of production for the six scenarios per year.

Utilizing actual production costs for each year and average prices and yields (during the three years of the experiment) the yields of the hybrid seeded watermelon genotype 'Sangria' resulted in losses under both HM and LM for all three years. These losses ranged from a low of -\$61 under HM during 2000 to a high of -\$355 under LM during 2000.

Yields from the diploid genotype 'Allsweet' resulted in losses in all three years under LM ranging from a loss of -\$171 per acre in 1997 to -\$368 per acre in 2000. This -\$368 per acre loss was the greatest loss of any of the genotypes over the three years. Under HM, yields of 'Allsweet' resulted in a -$39 loss in 1999 but a positive net return of $3 and $102 per acre in 1997 and 2000, respectively.

Yields of the seedless triploid genotype 'Gem Dandy' resulted in a positive net return in all three years under both HM and LM. In all three years the HM scenario provided a higher net return than under LM. These net returns ranged from a low of $447 per acre under LM in 2000 to a high of $1,903 per acre under HM in 2000.

Net Return Expectations Utilizing <u>High Prices and High Yields</u>

Utilizing high yields and high prices provided results indicating that in only one case ('Allsweet' in 2000) were net revenues negative. In all other cases the net revenues were positive. The higher net revenue for all three genotypes occurred under HM. These ranged from $306 per acre for 'Sangria' to $3,892 per acre for 'Gem Dandy'.

Net Return Expectations Utilizing <u>Low Prices and Low Yields</u>

Under conditions of low prices and low yields all three genotypes lost money under LM. Under HM, yields from 'Allsweet' and 'Sangria' resulted in negative net revenues while yields from 'Gem Dandy' resulted in positive net revenue ranging from $354 in 1999 to $496 per acre in 2000.

Net Return Expectations Utilizing <u>Low Prices and High Yields</u>

Under high yields and low prices yields form all three genotypes resulted in positive net revenues under HM. These ranged from a low of $18 per acre for 'Sangria' to a high of $1,485 per acre for ‘Gem Dandy’. Under LM yields from ‘Allsweet’ resulted in losses all three years. Yields for ‘Sangria’ resulted in a positive net revenue for two of the three years and those from ‘Gem Dandy’ resulted in a positive net revenue for all three years.

Net Return Expectations Utilizing High Prices and Low Yields

Under these conditions yields from both ‘Allsweet’ and ‘Sangria’ resulted in losses under LM and HM in all three years. These losses per acre were greater under HM than under LM. Yields form ‘Gem Dandy’ resulted in a positive net revenue all three years under HM but under LM resulted in a loss in 2000. The other two years resulted in positive net revenues of $41 and $57 per acre for 1997 and 1999, respectively.

CONCLUSIONS

Based on the results from these small plot experiments, yields from the seedless, triploid genotype ‘Gem Dandy’ consistently resulted in a greater positive net revenue under HM than the diploid open pollinated ‘Allsweet’ or the hybrid diploid ‘Sangria’. Under LM, yields from ‘Gem Dandy’ resulted in greater net revenues per acre when conditions were relatively favorable. The triploid also lost less money per acre when conditions were unfavorable.

Marketable yields from the experiments varied greatly within a genotype between the three years studied. These differences from low to high in the three years ranged from 61 percent under HM to 135 percent under LM for ‘Gem Dandy’. ‘Allsweet’ had a yield range of 220 percent under LM to 481 percent under HM. ‘Sangria’ had the largest yield differences between the three years. They were 1,307 percent for HM and 1,934 percent for LM. Conditions at an experiment station often are different from those found in a farmer’s field. To be able to extrapolate to make recommendations to producers, a similar three-year type of experiment should be developed on farmer's fields utilizing large acreages.

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Table 1. Costs and Returns for Three Watermelon Genotypes under High and Low Management Practices in Oklahoma, 1997, 1999, and 2000.

Actual Yields, Prices, And Costs of Production

			HM 'Allsweet'	HM 'Sangria'	HM 'Gem Dandy'	LM 'Allsweet'	LM 'Sangria'	LM 'Gem Dandy'
1997	Price per lb 1997		$0.1012	$0.1012	$0.1823	$0.1012	$0.1012	$0.1823
	Yield in lbs/acre		24,839.00	16,827.00	25,462.00	8,280.00	10,862.00	5,520.00
	Gross Revenue		2,513.71	1,702.89	4,641.72	837.94	1,099.23	1,006.30
	Basic Cost of Production less H,G,S,M		922.47	981.87	1,224.87	522.60	582.00	825.00
	Harvest, Grade, Shed, Market - per pound	$0.0253	628.43	425.72	644.19	209.48	274.81	139.66
	Total Costs per acre		1,550.90	1,407.59	1,869.06	732.08	856.81	964.66
	Net Return per Acre		962.81	295.30	2,772.66	105.85	242.43	41.64
1999	Price per lb 1999		$0.0848	$0.0848	$0.1393	$0.0848	$0.0848	$0.1393
	Yield in lbs/acre		4,273.00	1,246.00	19,854.00	2,582.00	534.00	11,218.00
	Gross Revenue		362.35	105.66	2,765.66	218.95	45.28	1,562.67
	Basic Cost of Production less H,G,S,M		965.45	1,024.85	1,267.85	507.24	566.64	809.64
	Harvest, Grade, Shed, Market - per pound	$0.0253	108.11	31.52	502.31	65.32	13.51	283.82
	Total Costs per acre		1,073.56	1,056.37	1,770.16	572.56	580.15	1,093.46
	Net Return per Acre		(711.21)	(950.71)	995.51	(353.61)	(534.87)	469.21
2000	Price per lb 2000		$0.0975	$0.0975	$0.1070	$0.0975	$0.0975	$0.1070
	Yield in lbs/acre		11,040.00	17,539.00	31,961.00	4,362.00	6,944.00	20,744.00
	Gross Revenue		1,076.40	1,710.05	3,419.83	425.30	677.04	2,219.61
	Basic Cost of Production less H,G,S,M		823.41	882.81	1,125.81	719.24	778.64	1,021.64
	Harvest, Grade, Shed, Market - per pound	0.0253	279.31	443.74	808.61	110.36	175.68	524.82
	Total Costs per acre		1,102.72	1,326.55	1,934.42	829.60	954.32	1,546.46
	Net Return per Acre		(26.32)	383.51	1,485.40	(404.30)	(277.28)	673.14

Table 2. Prices and Yields of Three Watermelon Genotypes under High and Low Management Practices in Oklahoma, 1997, 1999, and 2000.

		HM 'Allsweet'	HM 'Sangria'	HM 'Gem Dandy'	LM 'Allsweet'	LM 'Sangria'	LM 'Gem Dandy'
1997	Price per lb 1997	$0.1012	$0.1012	$0.1823	$0.1012	$0.1012	$0.1823
1999	Price per lb 1999	$0.0848	$0.0848	$0.1393	$0.0848	$0.0848	$0.1393
2000	Price per lb 2000	$0.0975	$0.0975	$0.1070	$0.0975	$0.0975	$0.1070
	Range Between High & Low Years	$0.0164	$0.0164	$0.0753	$0.0164	$0.0164	$0.0753
	Average Price per Pound	$0.0945	$0.0945	$0.1429	$0.0945	$0.0945	$0.1429
	Percentage Change in Price from High to Low	19.34%	19.34%	70.37%			
1997	Yields in 1997	24,839	16,827	25,462	8,280	10,862	5,520
1999	Yields in 1999	4,273	1,246	19,854	2,582	534	11,218
2000	Yields in 2000	11,040	17,539	31,961	4,362	6,944	20,744
	Range Between Years from Highest to Lowest	20,566	16,293	12,107	5,698	10,328	15,224
	Average Yield over Three Year Study	13,384	11,871	25,759	5,075	6,113	12,494
	Percentage Range of Yields from Lowest to Highest	481.30%	1307.62%	60.98%	220.68%	1934.08%	135.71%

Table 3. Summary of Net Returns per Acre for Three Watermelon Genotypes under High and Low Management Practices in Oklahoma,
(All Prices and All Yields - 1997, 1999, 2000)

	HM 'Allsweet'	HM 'Sangria'	HM 'Gem Dandy'	LM 'Allsweet'	LM 'Sangria'	LM 'Gem Dandy'
1997 Actual Prices and Actual Yields (Table 3)	$962.81	$295.30	$2,772.66	$105.85	$242.43	$41.64
1999 Actual Prices and Actual Yields (Table 3)	(711.21)	(950.71)	995.51	(353.61)	(534.87)	469.21
2000 Actual Prices and Actual Yields (Table 3)	(26.32)	383.51	1,485.40	(404.30)	(277.28)	673.14
1997 Average Prices and Average Yields (Table 4)	3.70	(160.40)	1,804.39	(171.41)	(158.98)	644.29
1999 Average Prices and Average Yields (Table 4)	(39.28)	(203.38)	1,761.41	(156.05)	(143.62)	659.65
2000 Average Prices and Average Yields (Table 4)	102.76	(61.34)	1,903.45	(368.05)	(355.62)	447.65
1997 High Prices and High Yields (Table 5)	962.81	349.34	3,793.01	105.85	242.43	2,431.81
1999 High Prices and High Yields (Table 5)	919.83	306.36	3,750.03	121.21	257.79	2,447.17
2000 High Prices and High Yields (Table 5)	1,061.87	448.40	3,892.07	(90.79)	45.79	2,235.17
1997 Low Prices and Low Yields (Table 6)	(668.23)	(907.73)	397.20	(368.97)	(550.23)	(371.57)
1999 Low Prices and Low Yields (Table 6)	(711.21)	(950.71)	354.22	(353.61)	(534.87)	(764.71)
2000 Low Prices and Low Yields (Table 6)	(569.17)	(808.67)	496.26	(565.61)	(746.87)	(568.21)
1997 Low Prices and High Yields (Table 7)	555.45	61.70	1,386.34	(29.94)	64.29	869.78
1999 Low Prices and High Yields (Table 7)	512.47	18.72	1,343.36	(14.58)	79.65	885.14
2000 Low Prices and High Yields (Table 7)	654.51	160.76	1,485.40	(226.58)	(132.35)	673.14
1997 High Prices and Low Yields (Table 8)	(598.15)	(887.30)	1,892.21	(326.63)	(541.47)	41.64
1999 High Prices and Low Yields (Table 8)	(641.13)	(930.28)	1,849.23	(311.27)	(526.11)	57.00
2000 High Prices and Low Yields (Table 8)	(499.09)	(788.24)	1,991.27	(523.27)	(738.11)	(155.00)