Technical Report No. 36

Comparative Yields and Costs of Teepee-, Clothesline-, and Non-Trellised Cucumber Productionin American Samoa

October - December 1999

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ABSTRACT

This study was conducted to compare yields and to determine the cost of producing teepee-trellised, clothesline-trellised and non-trellised cucumbers using galvanized steel posts as an alternative to posts from native rainforest trees. Marketable yields of the cultivar 'Delight Green' (including US Fancy, US Nos. 1 & 2 and offgrade) were 42.6, 28.8 and 28.5 $Mg \cdot ha^{-1}$ for the teepee, clothesline and non-trellised systems respectively. The yield of US Fancy, US No. 1 and 2 (Grade A) for the teepee-trellised system was significantly greater than both the clothesline-trellised and non-trellised systems. Breakeven prices, based on total marketable yields, were $0.88 for teepee-trellised, $1.00 for clothesline-trellis and $0.80 US per kilogram for the non-trellised system. There were higher returns to management and labor & management for the teepee-trellised system at a selling price of $1.10 per kilogram. In addition to the galvanized steel posts used for trellises, a less labor intensive cultivation system was developed. Our current goal is to develop a management system that requires less labor and inputs without reducing yields thereby increasing returns to the farmer.

INTRODUCTION

Cucumber, *Cucumis sativus* L., is one of the preferred vegetables cultivated and eaten by a typical Samoan family on a regular basis. Locally, cucumbers are either grown on the ground, without any supports (non-trellised) or on trellises (teepee style or clothesline). Management practices differ greatly for these two methods. There is also great diversity between farmers who use the same cultural method. Some farmers apply chemical fertilizers, some use only manures, while others rely on the soil's natural fertility. Pesticides are used by some, while others rely on nature's checks and balances to control pests and diseases. Irrigation is practiced only by a few. The harvest period ranges from 3 – 6 weeks.

In American Samoa, there are no grades or standards for any of the locally produced agriculture commodities. Cucumbers are no exception: high quality US Fancy and US Nos. 1 & 2 are often mixed together with misshapen off-grade cucumbers and sold at the Fagatogo Farmers Market (FFM) or at family operated roadside stands by the pile. Because few farmers own scales, produce sold at the FFM or roadside stands is not weighed. One large cucumber, two small ones or a bag of misshapen fruits would normally cost $1.00 US. In a market price survey at the FFM in November 1999 where piles of vegetables were randomly selected and weighed, cucumbers were sold at $1.28 US per kilogram. Cucumbers were purchased by retailers at $1.10 for ungraded fruits and $1.32 per kilogram for US Fancy and US No. 1. The School Lunch Program purchases US Fancy and US No. 1 quality cucumbers for $1.65 per kilogram.

Most American Samoa farmers do not keep production records, so the amount spent on fertilizer, seed, fuel, and labor is not recorded. Because produce is not weighed,
crop yield is unknown. Consequently, breakeven prices cannot be calculated and whether or not a crop was profitable cannot be determined. In their analysis of total costs vs. yield of cucumbers, Hirata and Tilialo (2000) calculated breakeven prices of $0.94 and 0.57 per kilogram for the teepee-trellised and non-trellised systems, respectively, at the Tauiliili Research Facility at the American Samoa Community College. Although the teepee-trellised had a 55% greater marketable yield, it was more profitable to grow cucumbers untrellised because of the high cost of the one-time-use wood trellis posts. The recommendations of this study were to find alternative trellis support methods along with identifying a cultivation system that required less labor. They also recommended that price surveys be conducted to determine if there are price differentials between US Fancy, US No. 1, US No. 2 and culls in the marketplace.

In American Samoa, Navarro and Misa (1986) tested two cucumber varieties, 'Giant Climbing' (Takii Seed Co. Ltd.) and 'Marketer No. 2' (Known You Seed Co. Ltd.). The marketable yields for the non-trellised trial were 13.2 and 19.2 $Mg \cdot ha^{-1}$ (5.9; 8.6 tons/acre) for 'Giant Climbing' and 'Marketer No. 2', respectively. Kuo et. al. (1990) tested eight varieties from Known You Seed Co. Ltd. Yields ranged from 26.2 - 47.3 $Mg \cdot ha^{-1}$ (11.7 - 21.1 tons/acre) for the clothesline-trellised cucumbers, with 'Delight Green' identified as a high producer. In October 1998, 'Delight Green' produced marketable yields of 74.2 and 47.8 $Mg \cdot ha^{-1}$ using teepee-trellised and non-trellised methods, respectively (Hirata and Tilialo 2000). In the studies conducted by Navarro (1986) and Misa and Kuo et al (1990), no definition of marketable yields was provided. In Hirata and Tilialo's study, marketable yields included US Fancy, US No. 1, US No. 2 and culls (off-grade) to reflect the situation in American Samoa all grades are marketed.

MATERIALS AND METHODS

LAND PREPARATION

The trial was conducted at the Tauiliili Research Facility Research Block # 2, American Samoa Community College. The field was sprayed with glyphosate (Roundup Ultra, Monsanto) at the rate of 8 ml/liter of water for initial weed control. The soil was tilled four times to a depth of 20 cm with a 5-horsepower rear-tined tiller before planting. Aged chicken manure was incorporated into the soil at the rate 15.8 $Mg \cdot ha^{-1}$ during final field tilling. Ten grams of 10-20-20 fertilizer was incorporated into each planting hole before transplanting seedlings.

FIELD LAYOUT

The trial was laid out in complete randomized block and replicated 4 times. Each block was 11.89 x 3.04 m, with each treatment area measuring 3.96 x 3.04 m. Each treatment comprised three raised beds 0.2 m high, 0.9 m wide and 3.04 m long with 0.3 m between beds. An irrigation furrow, 10 cm deep and 15 cm wide, was cut down the length of the bed.

In the teepee-trellised treatment, galvanized steel pipes 2.5 cm in diameter and 2.2 m long were pounded 30 cm into the soil in pairs to form the "teepee". Each set of teepees was spaced 1.5 m apart. Used 10 cm eye fish netting obtained without charge from CASAMAR – Samoa, a local business, was draped over the rows of trellis to form a "tent". Seedlings were transplanted in double rows 61 cm apart in each bed with 45.7 cm between plants within each row.

In the clothesline-trellised treatment individual galvanized pipes the same dimensions as those used above were pounded perpendicular into the soil 30 cm deep at
1.5 m intervals. One edge of fish netting was attached to the tops of these pipes and draped down. A single row of seedlings was transplanted 23 cm apart alongside the irrigation furrow.

In the non-trellised treatment, a single row of cucumber plants was transplanted along one side of the irrigation furrow 30 cm apart. Distance between rows was 1.2 m.

SEEDLING PREPARATION

The cultivar, 'Delight Green' identified by Kuo et al. (1990) as a high yielder and used by Hirata and Tilialo (2000) was also selected for this trial.

Soil heated in an electric sterilizer for 6 hours (71° C) was used as the planting media. Seeds were sown in 237 ml styrofoam cups with six 3 mm drainage holes. Used cups from a prior trial, sterilized with sodium hypochlorite were utilized to reduce costs.

Twelve days after sowing, seedlings were transplanted to the field and watered in with 473 ml of starter solution (15-30-15 soluble fertilizer at the rate of 4 ml/liter of water) followed by an additional 473 ml of water. Because of low germination, randomized blocks 1, 2 and 3 were

transplanted on October 19, while block 4 was transplanted on November 2, 1999. The trellised plants were tied to the netting until they grew over the top of the trellis.

MANAGEMENT PRACTICES

All plants were side-dressed with 10 grams of 10-20-20 fertilizer 14, 28 and 42 days after transplanting. Weeding in the initial week after transplanting consisted of raking newly emerged weeds to uproot them. A second weeding using a hand held cultivator was eliminated, thereby necessitating a second more labor intensive weeding with hoes. No supplemental irrigation was necessary as total rainfall for any seven consecutive days was not less than 25 mm. On November 11, aphids (*Aphis gossypii*) and melon thrips (*Thrips palmae)* were observed, along with many of their natural predators, ladybird beetles and immature lacewings. On December 1, using a 15 l knapsack sprayer, Malathion 50 was applied at a rate of 3.9 ml per liter of water to control the aphid and thrips population. When the thrips population was not reduced significantly, Diazinon 25 was applied, without success. Randomized block 4, two weeks younger than the other three blocks, was so severely infested that there was no harvest. The health of the crop declined quickly because of the heavy infestation. During that time, powdery mildew was present but deemed not serious enough to begin a chemical control program. Belly Rot caused by *Rhizoctonia solani* Kuhn, resulted in rotted fruits only in the non-trellised blocks. Gummy stem blight caused by *Mycosphaerella melonis* was present but did not pose an economic problem.

HARVESTING

Beginning 27 days after transplant, the blocks were harvested twice weekly for the first three weeks. During the 4th and 5th weeks, plots were harvested once a week due to the severe decline in plant health attributed to the thrips infestation. There were eight harvests over the 5-week period.

After harvesting, fruits were washed, graded and weighed. Since there are no grading standards in American Samoa, the two grades developed and used by Hirata and Tilialo (2000) - Grade A and off-grade - were employed. In American Samoa and for the purpose of this study, off-grade produce was considered a marketable commodity. Severely misshapen, spoiled fruits and those damaged by pests were considered unmarketable.

MARKETING

Although the produce was not sold, BCTC-Samoa Inc., a garment factory was used as the "marketing outlet" for the cost of production analysis. Daily, the company purchased 225 kg of any vegetable and paid a flat $1.10/kg for ungraded produce. The marketing costs included round trip mileage (at $.19/km) and labor charges for each of the deliveries.

CLEARING THE FIELD

This was the last step in obtaining cost information - the amount of time it took to remove the netting and poles.

WEATHER CONDITIONS

According to ASCC-AHNR climatological data collected on site, rainfall from October 19 – December 17, 1999 totaled 737 mm, ranging from a low of 25 to a high of 242 mm for any seven consecutive day period. The temperature range for that period October – December is 25 - 32.2 º C (NOAA 1999).

COST OF PRODUCTION

Cost of production considerations were based on Cox et al. (1988), Cox (1996) and Barber (1998). *Variable costs.* Start and finish times for each operation were recorded and the cost of labor calculated using the territory's minimum wage for the miscellaneous category - $2.45 per hour plus 9.15 % (employer contribution to social security, medicare and workmen's compensation insurance). All material inputs were purchased from local vendors. Machinery costs included the operation of the 5-horsepower tiller was assessed at $1.50 per hour to cover fuel, oil and repairs, mileage for the 10-year-old vehicle used assessed

at $0.19/km and electricity costs for the electric soil sterilizer.

Fixed Costs. For the purposes of this study, land was considered a fixed cost. Equipme depreciated during this study included a 5-horsepower rear-tined tiller and a 15 liter hand-pump knapsack sprayer. Multiple-use tools such as shovels, bush knives, rakes, hoes, water hoses, sprinklers, etc. were depreciated as were the irrigation system and electric soil sterilizer. Steel posts, as an alternative to native trees used for trellis posts, were depreciated over a period of six years with three uses per year. All fixed costs were included in the category of other costs. No overhead costs were charged.

All yields and cost of production analyses are projected to one hectare. All monetary values are expressed as US dollars.

RESULTS

In determining cucumber yields in American Samoa, three methods: teepee-trellis, clothesline-trellis and non-trellis, were compared using the cultivar, Delight Green (Known-You Seed Co. Ltd.). As shown in Table 1 below, the yield of Grade A fruits for the teepee-trellised treatment showed a significant difference over the clothesline-trellised and the non-trellised treatments. Although the total marketable yields of the teepee-trellised system was almost 50% greater than the clothesline and non-trellised systems, there was no significant difference.

There was a significant reduction in labor, material and machinery costs (table 2). Other costs were greater due to a better accounting of depreciation of tools such as water hoses, hand spades, bushknives, water sprinkler heads etc. For the 1999 teepee-trellis system, depreciation of the galvanized steel posts used for trellis support over a 6 year period was included.

In the effort to develop a more cost-effective management system, labor inputs were reduced. Even the labor-intensive operation of trellis/staking the vines to the netting was reduced significantly for the teepee-trellised system (table 3). Overall there was a dramatic reduction in overall labor costs for both non-trellised and teepee-trellised methods between the 1998 and the 1999 study.

Material costs were reduced substantially due to the shorter cropping season and the effort to develop a more cost-effective management system (table 4).

Total machinery costs decreased slightly despite the inclusion of electricity costs for the soil sterilizer as shown in table 5.

Fixed costs (table 6) included in the 1999 study are substantially higher due to the inclusion of the depreciated costs of the galvanized steel posts, the soil sterilizer, the irrigation system and the miscellaneous items such as shovels, hoes, water hoses, and hand spades etc.

The breakeven prices (table 7) for the teepee-, clothesline-, and non-trellis systems were $.88, $1.00 and $.80 per kilogram respectively. Although total costs were lower in the 1999 cost-of-production study, the breakeven prices were higher because of the lower yields. The return to management per hectare at a selling price of $1.10/kg was greater for the teepee-trellis system ($9,457) than for either the non-trellis ($8,038) or clothesline-trellis ($2,944) systems.

DISCUSSION

The yield of Grade A cucumber and total marketable yield for the teepee-trellised cultivation system was greater than either the clothesline- or non-trellised methods. Surprisingly, though plant density for both the teepee- and the clothesline-trellised systems

was the same, 35,864 plants per hectare, the yield for the teepee-trellised system was 66% and 48% higher for Grade A and total marketable fruits, respectively. Although total marketable yield for both clothesline- and non-trellised system were similar, the clothesline trellised system produced a greater yield of Grade A fruits. This supports Hirata and Tilialo's (2000) finding that staked cucumbers had a greater yield of Grade A fruit. In the non-trellised system, there were more fruit culls due to belly rot, and rat and insect damage than for either teepee- or clothesline-trellised systems. The November 1999 market price survey showed that retailers paid $1.10 and $1.32 per kilogram for ungraded and Grade A fruits, respectively. This pricing information should support a farmer's decision to trellis his cucumbers.

In the 1998 trial (Hirata and Tilialo, 2000), trellis posts were cut from the forest at a cost of $1.50 each. Because of the high amount of rainfall, the bases rotted after one cropping season. Therefore, in this study, galvanized steel posts were used as an alternative to wooden posts. The costs were shifted from material costs to other costs and depreciated over a 6-year period with 3 crops per year.

In the 1998 trial, labor hours were assessed at $2.45 per hour. In this trial, labor was assessed at $2.67 per hour which includes 9.15% fringe benefits. In trying to develop a more cost-effective management system for growing cucumbers in American Samoa, we made a conscious effort to reduce labor inputs, especially in the area of trellising and staking. Labor costs were reduced in all operations except for weeding and clearing the field (Table 3). To reduce labor costs even further, the second weeding operation using a hand held cultivator was eliminated. However, a longer, more time consuming hoeing operation was needed at a later date, increasing labor costs for weeding. In the 1999 trial, because of the shorter cropping season with reduced harvests, labor costs for harvesting and marketing were lower. Clearing the field took longer in this trial because the galvanized trellis posts had to be pulled out of the ground. In the 1998 trial, most of the posts rotted off at the base making pole removal easier and faster.

Total material costs in the 1999 trial was lower than the 1998 study for several reasons: 1) the field used was cropped prior to the trial and was relatively "cleaner" and required less glyphosate, 2) the planting cups were recycled, 3) the pesticides used to control the aphids and thrips were less expensive than the product used in the 1998 study, 4) the amount of fertilizer used was less because of the shorter harvest period - five weeks vs. seven weeks, 5) the cost for the trellis posts was shifted to other costs, and 6) no supplemental irrigation was applied because of sufficient rainfall,.

In the 1998 study, only land, the 5-horsepower tiller and knapsack sprayers were included as other costs. In the 1999 study, costs increased because depreciation of other equipment, tools and galvanized steel posts were included. Land costs were lower because of the shorter cropping season.

Although the breakeven price for the non-trellised system was lowest, the greatest return to management at a $1.10 per kilogram selling price was from the teepee-trellised system, $9,457 compared to $8,038 and $2,944 for the non-trellised and clothesline-trellised systems respectively. If family labor was used where wages paid for labor would go back to the farmer and his family, the return to labor and return to management was greatest for the teepee-trellised system - $32,198 compared to $20,580 and $20,520 for clothesline-trellised and non-trellised systems respectively. If the Grades A and offgrade were sold at $1.28 and $1.10 per kilogram respectively, the returns for the teepee-trellised system would be greater still.

CONCLUSIONS

1) Marketable yields and the amount of high quality Grade A cucumbers were greater with a teepee-trellised system that with clothesline- or non-trellised systems resulting in higher returns.
2) When higher prices are paid for better quality produce as in American Samoa, growing cucumbers using a teepee-trellised system translates into increased returns.
3) While reducing the cost of inputs still netted higher returns for the teepee-trellised system, future cost of production studies are recommended utilizing only the teepee-trellised cultivation system coupled with being cognizant of the effort to reduce labor and other input costs.

Whether or not a farm family provides all the labor required for the cultivation of cucumbers, the teepee-trellised system (using galvanized steel posts depreciated over 6 years) should be recommended as it is the most profitable.

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Table 1: Yield of Cucumbers in American Samoa 1999

Method	Grade A[1]	Off-Grade[1]	Marketable Yield[1]
	$Mg \cdot ha^{-1}$	$Mg \cdot ha^{-1}$	$Mg \cdot ha^{-1}$
Non-Trellised	14.9[b]	13.6[a]	28.5[a]
Clothesline-Trellis	21.1[b]	7.7[a]	28.8[a]
Teepee-Trellis	35.1[a]	7.5[a]	42.6[a]

[1] *Yields in column followed by different letters are significantly different at P =0.05.*

Table 2: Comparative Cost of Cucumber Production Per Hectare in American Samoa

	1998	1999			
	N[1]	T[1]	N[1]	C[1]	T[1]
	Amount	Amount	Amount	Amount	Amount
Labor	$17,823	$32,427	$12,482	$17,636	$22,741
Materials	6,282	34,086	4,428	4,986	5,858
Machinery	1,222	1,231	1,123	1,137	1,137
Other	2,209	2,305	3,510	5,586	7,913
Total Costs	$27,536	$70,049	$21,543	$29,345	$37,649

[1] N = *Non-trellis,* C = *Clothesline-trellis,* T = *Teepee-trellis.*

Table 3: Labor Costs of Cucumber Production Per Hectare in American Samoa

	1998		1999		
Operation	N[1]	T[1]	N[1]	C[1]	T[1]
Land Preparation	$3,090	$3,090	$2,981	$2,981	$2,981
Nursery	2,969	3,019	931	1,205	1,304
Field Planting	962	1,345	845	1,093	1,167
Weeding	275	175	1,813	1,726	1,788
Trellising/staking	0	13,551	0	4,583	8,383
Fertilizing	1,618	1,970	1,888	1,702	1,702
Spraying	330	533	273	323	410
Irrigation	797	797	0	0	0
Harvesting	4,761	4,101	1,813	1,192	1,714
Marketing	2,336	2,336	1,938	1,938	1,938
Clearing Field	335	970	0	894	1,354
Total Labor Costs	$17,473	$31,987	$12,482	$17,636	$22,741

[1] N = *Non-Trellis*, C = *Clothesline-Trellis*, T = *Teepee-Trellis.*

Table 4. Material Costs of Cucumber Production per Hectare in American Samoa.

	1998		1999		
	N[1]	T[1]	N[1]	T[1]	C[1]
Roundup Ultra	$940	$940	$580	$580	$580
Malathion 50	0	0	132	232	315
Diazinon 25	0	0	108	108	207
Safer's Soap	1,256	1,893	0	0	0
Chicken Manure	1,682	1,682	1,682	1,682	1,682
Fertilizer (10-20-20)	732	1,056	586	844	844
Miracle-Gro	126	188	126	188	188
Trellis Posts[2]	0	26,208	0	0	0
Water	160	160	110	110	110
Misc.	1,386	1,959	1,104	1,242	1,932
Total Material Costs	$6,282	$34,086	$4,428	$4,986	$5,858

[1] N = *Non-Trellis*, C = *Clothesline-Trellis*, *T = Teepee-Trellis.*

[2] *There were no material costs for the trellis posts in this study compared to the 1998 study because the galvanized posts used were depreciated over a period of six years and their costs are included in Table 5.*

Table 5: Machinery Costs of Cucumber Production per Hectare in American Samoa

1998		1999			
	N[1]	T[1]	N[1]	C[1]	T[1]
Tiller	636	636	684	684	684
Vehicle $0.19/km	586	595	280	305	305
Soil Sterilizer[2]	n/a	n/a	69	69	69
Total Machinery	$1,222	$1,231	$1,033	$1,058	$1,058

[1] N = *Non-Trellis*, C = *Clothesline-Trellis*, T = *Teepee-Trellis.*

[2] *In the 1998 study, electricity costs for the soil sterilizer were not included in the study.*

Table 6: Other Costs (Fixed) of Cucumber Production Per Hectare in American Samoa

	1998		1999		
	N[1]	T[1]	N[1]	C[1]	T[1]
Depreciation					
Tiller	$1,331	$1,331	$1,239	$1,239	$1,239
Sprayer	211	294	442	464	505
Irrigation system	0	0	792	792	792
Soil Sterilizer	0	0	91	91	91
Posts[2]	0	0	0	2,012	4,024
Land	988	988	741	741	741
Misc	0	0	205	247	521
Total Other Costs	$2,530	$2,613	$3,510	$5,586	$7,913

[1] N = *Non-Trellis*, C = *Clothesline-Trellis*, T = *Teepee-Trellis.*
[2] *Posts were a one-time use material cost in the 1998 study. In the 1999 study, they were depreciated and included here as a fixed cost.*

Table 7: Breakeven Analysis of Cucumber Production in American Samoa

	1998		1999		
	N[1]	T[1]	N [1]	C[1]	T[1]
Labor Costs	$17,823	$32,427	$12,482	$17,636	$22,741
Material Costs	6,282	34,086	4,428	4,986	5,858
Machinery Costs	1,222	1,231	1,123	1,137	1,137
Other Costs	2,530	2,613	3,811	5,912	7,992
Total Costs	$27,857	$70,357	$21,543	$29,345	$37,649
T/Marketable yield (kg/ha)[2]	47,898	74,398	26,794	29,437	42,986
Breakeven Price ($/kg)	$0.58	$0.95	$0.80	$1.00	$0.88
Breakeven Yield (kg)					
At $1.10/kg	25,325	63,961	19,585	26,677	34,226
Return to Mgt at					
$1.10/kg selling price	$24,907	$11,160	$8,038	$2,944	$9,457
Return to Mgt & Labor					
At $1.10/kg selling price	$42,730	$43,587	$20,520	$20,580	$32,198

[1] N = *Non-Trellis*, C = *Clothesline-Trellis*, T = *Teepee-Trellis.*
[2] *Marketable yields are calculated from the cumulative yields of each treatment.*