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# Comparative Cost of Teepee-Trellised vs. Non-Trellised Cucumber Production in American Samoa

Larry S. Hirata, Agriculture Economics Specialist

**Abstract**

This study was conducted to compare yields and to determine the cost of producing teepee-trellised and non-trellised cucumbers in American Samoa. Delight Green (Known You Seed Co. Ltd), a cultivar identified as a high producer in a cucumber evaluation trial conducted in the 1990, was the cultivar selected. The break even prices for teepee-trellised and non-trellised cucumbers were \$0.95 and \$0.58 per kilogram, respectively. Because of the cost of posts cut from the forest and the added labor costs for tying vines to the teepee-trellis, it was cheaper to produce non-trellised cucumbers. Even with the 55% greater yields of the teepee-trellised method, at a selling price of \$1.10 per kilogram for ungraded fruit, there was a higher return to management for non-trellised cucumbers. If family labor was used, the amount returned to management and labor was greater for the teepee-trellised cucumbers at a selling price greater than \$1.10 per kilogram.

More investigation needs to be conducted to determine alternate trellis support methods along with identifying a cultivation system that requires less labor without any negative effects on yields. Wholesale price surveys also need to be conducted to determine if there are price differentials between Grades A, B and Off Grade cucumbers in the marketplace.

## INTRODUCTION

Cucumber, *Cucumis sativus* L., is one of the preferred vegetables cultivated and eaten by a typical Samoan family on a regular basis. In Fiscal Year 1998, 26,102 kg of cucumber were sold at the Fagatogo Farmers Market. By comparison, 13,184 kg, 6,410 kg and 5,678 kg, of Chinese cabbage, long beans, and eggplant, respectively were sold there (American Samoa Department of Agriculture, 1999). These figures Jmarketable yields of cucumber worldwide average 11.7 $Mg{\cdot}ha^{-1}$ (12.88 tons/hectare.). In Hawaii, the average slicing cucumber yields are approximately 22.4 $Mg{\cdot}ha^{-1}$ (10 tons/acre) at a density of 6000 plants per acre (Valenzuela et al. 1994). Hanna and Adams (1991) in Florida reported average marketable yields of 61.8 $Mg{\cdot}ha^{-1}$ (25 T/acre) for staked (trellised) cucumbers and 40.5 $Mg{\cdot}ha^{-1}$ (16.4 T/acre) for unstaked (non-trellised) cucumbers over a three year period. Russo et al. (1991), employing ground culture (non-trellised) and two trellis systems, show average yields of 39.52 and 48.9 $Mg{\cdot}ha^{-1}$ (17.6 and 21.8 tons/acre) for non-trellised and trellised systems, respectively. Smith and Taylor (1995) in their annual *Production cost for Selected Vegetables in Florida, 1994 - 95* give average yields of 37.9 $Mg{\cdot}ha^{-1}$ (16.5 tons/acre).

The breakeven price for cucumbers in Hawaii was \$0.28USD/kg (\$0.13/pound) according to Marutani (1979), based on a marketable yield of 75 $Mg{\cdot}ha^{-1}$ (66,876 pounds/acre). His study divided the \$21,856 total costs/hectare as labor at 70%, materials at 21%, machinery at 6% and others at 3%. Smith and Taylor (1995) estimated the breakeven price for cucumber produced in Florida at \$0.28/kg (\$0.13/pound) based on a marketable yield of 37 $Mg{\cdot}ha^{-1}$ (33,000 pounds/acre). The total cost was \$10,412/hectare (\$4,213.79/acre) with labor at 69%, materials at 25%, machinery at 3%, and other costs at 3 %. In the recent COP study of cucumbers of two farms conducted in Hawaii (Petersen et al), the average total costs were \$19,808/hectare (\$8,016/acre) with a breakdown as follows: labor at 60%, materials at 29%, machinery at 5% and others (fixed costs) at 6%. The break even price was \$0.57/kg (\$0.26/pound) based on total costs and \$0.53/kg (\$0.24/pound) based on total variable costs. The break even yields were 18,224 kg and 17,140 kg, based on total costs and variable costs respectively at a selling price of \$1.19/kg.

The two cucumber variety trials give the only source of marketable yield for American Samoa. No cost of production studies have been conducted in the Territory.

This trial comparing yields and cost of production for teepee-trellised and non-trellised plots was conducted from October to December 1998.

## MATERIALS AND METHODS

**Land Preparation:**

The field was sprayed with glyphosate at the rate of 8 ml/liter of water for initial weed control. As this was relatively new agricultural land, soil was purchased to fill in low spots and leveled, stumps and rocks were removed. The soil was tilled four times to a depth of 20 cm with a 5-horsepower rear-tined tiller before planting. Aged chicken manure at the rate 15.8 $Mg{\cdot}ha^{-1}$ was incorporated into the soil during the final field tilling. Ten grams of 10-20-20 fertilizer was incorporated into each planting hole before the seedlings were transplanted.

**Field Layout:**

The trial was laid out in complete randomized block replicated 4 times. Each block was 6.1 x 7.9 m. with each treatment being 6.1 x 3.96 m Each of the non-trellised treatments comprised of three raised beds 20 cm high, 0.9 m wide and 6.1 m long. An irrigation furrow, 10 cm deep and 15 cm wide, was cut down the center of each bed. 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.

Each teepee-trellised treatment comprised of three raised beds 20 cm high, 0.9 m wide and 6.1 m long. As in the non-trellised treatment, an irrigation furrow was cut down the length of the bed. A double row of plants were transplanted 61 cm apart in each bed with 46 cm between plants within each row. Ten cm diameter branches or trunks of local trees were used for trellis posts. Native trees used for posts were Tavai (*Rhus taitensis*), Fuafua *(Kleinhovia hospita*), Maota (*Dysoxylum samoense*) and Fau (*Hibiscus tiliaceus*). 1.8 m long posts, placed teepee style leaving 1.5 m above the ground, were spaced 1.5 m apart in the rows. For additional stability, wooden poles 7.6 cm in diameter connected each teepee across the top. Used 10 cm eye fish netting obtained free from CASAMAR – Samoa, a local business, was draped over the rows of trellis to form a "tent". The trellis and netting were set up in the field before transplanting.

**Seedling Preparation:**

The cultivar, Delight Green (Known You Seed Co. Ltd., 26 Chung Cheng, 2nd Rd., Kaoshiung, Taiwan, ROC), identified by Kuo et al. (1990) was selected for this trial because of its high yields, low branching habit and high degree of tolerance to mosaic and mildews. Its low branching habit allowed for closer plant spacing and its tolerance to mosaic and mildews reduced the need for pesticides.

Sterilized soil was used as the planting media. Soil was heated in an electric sterilizer for six hours. Seeds were sown in 237 ml styrofoam cups with six 3 mm. drainage holes.

Eleven days after sowing, the 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. The trellised plants were tied to the netting until they grew over the top of the trellis.

**Management Practices:**

All plants are side dressed with 10 grams of 10-20-20 fertilizer on day 14, 28, 42 and 56 after transplanting. Weeding was limited to the initial week of transplant and consisted of raking newly emerged weeds to uproot them. Supplemental irrigation water was applied when the total rainfall for any seven consecutive days was below 25 mm. Aphids (*Aphis gossypii*) were present from the beginning along with their natural predators, ladybird beetles and lacewing. During the 3rd week after transplanting, the *A. gossypii* population exploded, resulting in severe leaf curling due to their heavy feeding. A chemical control program using potassium salts with fatty acids – 49% (20 ml/liter of water) was implemented. The blocks were sprayed twice, a week apart beginning from 20 days after transplanting. Powdery mildew was present but deemed not serious enough to begin a chemical control program. *Pythium* rot was a minor problem only in a few areas of the field where drainage was poor. Belly Rot caused by *Rhizoctonia solani* Kuhn, was a problem in only the non-trellised blocks. No control programs were effected for *Pythium* or *Rhizoctonia*.

**Harvest:**

Fields were harvested twice weekly beginning 27 days after transplant and lasted for seven weeks, until revenues generated from the daily sale of produce (at $1.10/kg) no longer covered the maintenance, harvesting and marketing costs.

After harvesting, the fruits were washed, graded and weighed. Since there are no grading standards in American Samoa, two grades were developed – Grade A and Off Grade. The grade A standard included fruit of the US Fancy, US No. 1 and US no. 2, following the United States Department of Agriculture Agriculture Marketing Service standards for grades of cucumbers (1958). The Off Grade standard included all misshapen and sunburned fruits, which are normally culled out in the US. In American Samoa and for the purpose of this study, Off Grade produce were considered a marketable commodity. Severely misshapen, spoiled fruits and those damaged by pests were considered unmarketable; they were removed from the field and discarded.

**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 cost included round trip mileage and the time expended 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 and spray the field with glyphosate, in addition to the cost of the herbicide used, was included in the cost of the operation.

**Climatological conditions:**

Rainfall from October 5 – December 24, 1998, totaled 837 mm, ranging from a low of 6 to a high of 203 mm. a week. When rainfall was less than 25 mm. for any consecutive 7 days, supplemental irrigation was applied. The average annual temperature range for October – December is 25.6 - 32.8 $^{o}$ C (NOAA 1998).

**Cost of Production:**

Cost of production considerations were based on Cox et al. (1988), Cox (1996) and Barber (1998).

Fixed Costs: For the purposes of this study, land was considered a fixed cost. Equipment depreciated during this study included a 5-horsepower rear-tined tiller and a hand-pump 15 liter knapsack sprayer. All fixed costs were included in the category of other costs.

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. All material inputs were purchased from local vendors. Operation of the 5-horsepower tiller was assessed at $1.30 per hour to cover fuel, oil and repairs. The 10-year-old pickup truck was not depreciated, instead vehicle use was assessed at $0.19/km for the purpose of this study. Fuel costs and mileage are included in the machinery costs.

All yields and cost of production analyses in the results are projected to one hectare.

## RESULTS

In determining cucumber yields in American Samoa, two methods: teepee-trellised and non-trellised, were compared using the cultivar, Delight Green (Known-You Seed Co. Ltd.). In the teepee-trellised treatment, although the yield of Grade A were substantially greater than that of the non-trellised treatment, the differences were not significant (table 1).

The yields of this study for both non-trellised and teepee-trellised are compared to research both field trials and surveys conducted elsewhere as shown in table 2.

Table 3 below provides the cost of

production by the categories of labor, materials, machinery and other costs. The table compares American Samoa with Hawaii (1979 and 1999) and Florida (1995).

Table 4 identifies the labor costs by operation. Outstanding is the $13, 551 for the teepee-trellised system for trellising and staking the vines.

Table 5 identifies the material cost of production per hectare. Outstanding is the $26,208 for the posts necessary for the trellises.

The break even analyses are provided in Table 6. In this table, reflecting the reality of the local situation where Off Grade fruits are a marketable commodity, they are included in the calculation of the break even price.

## DISCUSSION

Individual plant yields of the test plants were calculated and divided into two groups, Grades A and Off Grade. To obtain yields per hectare, these were multiplied by 26,910 and 35,880 plants for non-trellised and teepee-trellised respectively. The total yield for the teepee-trellised treatment was 55% greater than that of the non-trellised treatment. The difference in the results of this study, although not significant, support results from Florida (Hanna and Adams, 1984, 1987, 1991) and from Oklahoma (Russo et. al. , 1991) that trellised cucumbers had greater marketable yields. Many fruits harvested from the non-trellised treatment had belly rot caused by *Rhizoctonia solani* exacerbated by the high rainfall during the cropping period.

The yields obtained from field trials, as a rule, are generally higher than those obtained from the surveys. In research field trials where fertilizer, new cultivars, different cropping systems were being tested, would account for the higher yields. The yields cited in table 2 obtained from surveys are lower because of averaging. In these surveys, yields from progressive farms operated by the innovators, along with yields from poorer farms operated by the late adopters (Garforth, 1986) are averaged, resulting in lower yields. It would be interesting to conduct a survey locally to determine the average Territorial yield for purposes of comparison. However, because of a lack of record keeping skills of the local farmers in American Samoa, agriculture economic surveys of this nature are not possible at the present time. The yield results from this field trial will serve as a baseline for which to compare future field trials.

To obtain the projections per hectare for tables 3 - 5, results from this trial were multiplied by a factor of 112.12. The total marketable yields in table 6 is derived from the sum of the actual weights for each treatment multiplied by 112.12. The results from the Florida and the two Hawaii studies were multiplied by a factor of 2.47 to obtain the data per hectare. Although the cost of production surveys listed for Hawaii and Florida, were conducted at different times, and represent averages, the range of percentages for each cost category is important, i.e. labor: 59 - 70%, materials: 21 - 28%, machinery: 3 - 6% and other: 3 - 7% in serving as guidelines to an "ideal" breakdown of expenditures.

In this study, the expenditure breakdown for the non-trellised system was 65, 23, 4, and 8 percent for labor, materials, machinery and other costs respectively. The labor costs were somewhat high. This was due to the inexperience and inefficiency of the labor used. As experience and efficiency are gained, labor costs should be reduced in future studies.

For the teepee-trellised system, the percentage breakdown for labor, materials, machinery and other costs was 46, 49, 2, and 3 % respectively. All the percentages are skewed because of the high material costs due to the cost of the posts at $1.50 each. Because they lasted for only one cropping season, costs were not be depreciated and shared with several plantings. Alternate trellis methods need to be investigated to reduce this cost. Although accounting for only 46% of the total costs, labor at $32,337 per hectare is very high considering the wages at $2.45 an hour. It should have been comparable to the labor costs in for the Hawaii study (1979) when labor was paid $2.40 an hour. In this case study, because of the effort to make the teepee-trellised treatment to "look good", labor was used excessively in staking the vines to the netting. Labor needs to be more efficiently used. In future studies a more conscious effort needs to be made to reduce manpower resources and make each activity cost-effective. Machinery costs at 2% of total costs (($1,231) is considered acceptable. Other costs at $2,305 (2 % of the total costs) for this study is acceptable.

In looking at areas to reduce labor inputs; table 4 details the labor costs by operation. Field preparation costs at $3,090 per hectare for both non-trellised and teepee-trellised systems could be reduced, with the move to minimum tillage practices. The field was tilled 4 times which could be reduced. Nursery costs are high because of the amount of time to punch holes in each styrofoam cup. In the future as, these cups are recycled, the labor costs will drop. Labor for fertilizing is high and could be reduced if the fertilizer was not buried. A concerted effort to stake each vine, including laterals, to the netting caused the high trellising/staking labor cost of $13,551 per hectare for the trellised treatment. A conscious effort to reduce labor input for tying the vines to the netting must be made. It is interesting to note that it took less time to harvest the teepee-trellised system than the non-trellised due to the difficulty in locating the fruits in the latter treatment.

Outstanding in the material costs as shown in table 5, is the cost of the trellis posts at $26,208 per hectare. Because of the one time use of the posts, the cost could not be depreciated and spread over a number of plantings. Other trellising alternatives need to be investigated. To reduce the costs of the already expensive chemicals due to added shipping and duty fees, i.e. glyphosate @ $35.40 per liter, potassium salts of fatty acid @ $16.90 per liter, starter fertilizer @ $4.85 per kilogram and fertilizer at $0.71 per kilogram, these products could be purchased in larger containers and quantities. In the miscellaneous category, the cost of seeds and cups used for each treatment can be further reduced by purchasing seeds in larger quantities and the cups at wholesale prices. Perhaps direct seeding could be an alternative to transplanting.

At a selling price of $1.10/kg which is the norm for the Territory, if workers were hired to accomplish all of the fieldwork, the amount that would return to management would be $24,907 and $11,160 per hectare for the non-trellised cultivated and teepee-trellised systems respectively. It was more profitable for the farmer to grow non-trellised cucumbers in American Samoa using hired laborers. On the other hand, if family labor is used, $43,587 per hectare returned to management and labor for the teepee-trellised system which was $857 greater than the non-trellised system. If there was a price differential between Grades A and Off Grade, the difference could be greater. The price differential between the different grades need to be further investigated.

**CONCLUSION**

This trial contributes to the body of knowledge on cucumber cultivation in American Samoa. The yields obtained from this trial exceeds those of prior trials and opens the door for further investigations. Further yield and cost of production studies need to be conducted to determine 1) alternatives to one-time use trellis poles to reduce the cost of production, and 2) a more productive cultivation system with reduced labor inputs for American Samoa. Along this line a labor efficiency index (LEI), i.e. the amount of time in minutes to produce a kilogram of marketable fruit. With this index cultivation systems can be compared as to their overall labor efficiency. In addition, a market survey of prices need to be conducted to determine if price differentials between Grade A and Off Grade are real.

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**TABLE 1: YIELD OF CUCUMBER TRIAL IN AMERICAN SAMOA - 1998**

| Method | Grade A kg/ha | % | Off Grade kg/ha | % | Total kg/ha | Grade A $Mg \cdot ha^{-1}$ | Off Grade $Mg \cdot ha^{-1}$ |
|---|---|---|---|---|---|---|---|
| NonTrellised | 39,670 | 83 | 8,137 | 17 | 47,807 | 39.7 | 8.1 |
| Teepee Trellised | 63,522 | 86 | 10,713 | 14 | 74,235 | 63.5 | 10.7 |
| | n.s. | | n.s. | | n.s. | | |

**TABLE 2: COMPARATIVE YIELDS OF CUCUMBER PRODUCTION PER HECTARE**

| Location | Cultivation Method | Marketable Yields[1] $Mg \cdot ha^{-1}$ |
|---|---|---|
| American Samoa (1998) | Non-trellised | 39.7[2] |
| American Samoa (1998) | Teepee-Trellised | 63.5[2] |
| Florida (1995) average | | 37.0[3] |
| Hawaii (1994) average | | 22.4[3] |
| Florida (1991) | Trellised | 61.8[2] |
| Florida (1991) | Non-Trellised | 40.5[2] |
| Oklahoma (1991) | Non-Trellised | 39.5[2] |
| Oklahoma (1991) | Trellised | 48.9[2] |
| American Samoa (1990) | Trellised | 47.3[2] |
| World average (1989) | | 11.7[3] |
| American Samoa (1986) | Non-Trellised | 19.2[2] |

[1] Marketable yields excluding Off Grade
[2] Research field trials
[3] Surveys

**TABLE 3: COMPARATIVE COST OF CUCUMBER PRODUCTION PER HECTARE**

| | American Samoa Non-Trellised | | Teepee-Trellised | | Hawaii (1979) | | Florida (1995) | | Hawaii (1999) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Amount | % | Amount | % | Amount | % | Amount | % | Amount | % |
| Labor | $17,823 | 65 | $32,427 | 46 | $15,301 | 70 | $7,186 | 69 | $11,691 | 59 |
| Materials | $6,282 | 23 | $34,086 | 49 | $4,589 | 21 | $2,602 | 25 | $5,6[illegible]1 | 28 |
| Machinery | $1,222 | 4 | $1,231 | 2 | $1,312 | 6 | $311 | 3 | $1,038 | 5 |
| Other | $2,530 | 9 | $2,613 | 3 | $655 | 3 | $311 | 3 | $1,4[illegible]8 | 7 |
| Total | $27,857 | 100 | $70,357 | 100 | $21,857 | 100 | $10,410 | 100 | $19,[illegible]08 | |

**TABLE 4: LABOR COSTS OF CUCUMBER PRODUCTION PER HECTARE BY OPERATION AMERICAN SAMOA (1998)**

| | Non-Trellised | | Teepee-Trellised | |
|---|---|---|---|---|
| **Operation** | **Amount** | **%** | **Amount** | **%** |
| Field Preparation | $3,090 | 17 | $3,090 | 10 |
| Nursery | $2,969 | 17 | $3019 | 9 |
| Field Planting | $962 | 5 | $1,345 | 4 |
| Weed Control | $275 | 2 | $275 | 1 |
| Trellissing/staking | $0 | 0 | $13,551 | 42 |
| Fertilization | $1,618 | 9 | $1,970 | 6 |
| Spraying | $330 | 2 | $533 | 2 |
| Irrigation | $797 | 4 | $797 | 2 |
| Harvesting | $4,761 | 27 | $4,101 | 13 |
| Marketing | $2,336 | 13 | 2,336 | 7 |
| Clearing Field | $335 | 2 | $970 | 3 |
| Misc. | $350 | 2 | $350 | 1 |
| Total Labor | $17,823 | 100 | $32,427 | 100 |

**TABLE 5: MATERIAL COSTS PER HECTARE OF CUCUMBER PRODUCTION IN AMERICAN SAMOA (1998)**

| | Non-Trellised | | Teepee-Trellised | |
|---|---|---|---|---|
| | **Amount** | **%** | **Amount** | **%** |
| Chemicals | | | | |
| Glyphosate | 940 | 15 | 940 | 3 |
| Potassium salt of fatty acids | 1,256 | 20 | 1,893 | 5 |
| Chicken Manure | 1,682 | 27 | 1,682 | 5 |
| Fertilizer (10-20-20) | 732 | 12 | 1,056 | 3 |
| Miracle-Gro | 126 | 2 | 188 | 1 |
| Trellis Posts | 0 | 0 | 26,208 | 77 |
| Water | 160 | 3 | 160 | 0 |
| Misc | 1,386 | 21 | 1,959 | 6 |
| Total Material Costs | $6,282 | 100 | $34,086 | 100 |

**TABLE 6: BREAKEVEN ANALYSIS OF CUCUMBER PRODUCTION IN AMERICAN SAMOA (1998)**

| | **Non-trellis** | **Teepee-trellis** |
|---|---|---|
| Total Cost | $27,857 | $70,357 |
| Total marketable yield | 47,898 | 74,398 |
| Breakeven price | $.058 | $0.95 |
| Ret. To Mgt. @ $1.10/kg selling price | $24,907 | $11,160 |
| Ret. To Mgt. & Labor at $1.10/kg | $42,730 | $43,587 |
| Breakeven yield (kg) at $1.10/kg | 25,325 | 63,691 |