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Harvest Frequency, Yield, and Economics of Summer Squash

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Karen Strickler, Pollinator Paradise, Parma ID
Ariel Agenbroad, Canyon County Extension Educator, Caldwell, ID
Kevin Laughlin, Ada County Extension Educator, Boise, ID



Figure 1: Small squash on display at Pollinator Paradise booth, Nampa Farmers' Market



Figure 2: Squash harvest over a 3 day period. Large squash harvested 9/3, small squash harvested 9/3-5.

Summary

During the 2006 growing season in the Treasure Valley of Southwest Idaho four summer squash varieties were harvested, either daily at a small size, or every 2-3 days at a larger size. Squash harvested at the larger size yielded about 3 times more by weight than squash harvested when small, but 2-3 times as many squash fruits were produced by the plants when harvested more frequently at a small size. Both squash sizes sold well at the Nampa & Caldwell, Idaho Farmers' Markets, with less small squash than large squash left unsold at the end of market day most weeks. Large patty pan squash were the least popular. Customers preferred to buy squash by numbers rather than weight, even though they paid a premium price: Small squash when sold at 5-8 for \$1 brought in up to \$2.97 per pound and were more profitable than large squash.

Information from a vendor survey helped me formulate an enterprise budget for market squash production in which most costs are multiplied by the percentage of total garden that is planted in squash, or by the percentage of the total income that can be attributed to squash. The enterprise budget demonstrated that a yield of 600+ lbs of mini squash per year should be profitable if sold at Farmers' Market prices for mini squash. Squash growers on small acreages should consider increased production of baby summer squash. To increase the customer base for increased production, we will consider tasting and a value-added product such as grilled squash sold for consumption at the market.

Objectives

The goal of this study was to determine how harvest frequency and harvest size affect the yield and marketability of fruits produced by summer squash plants, *Cucurbita pepo*. In particular, I compared the yields from harvesting squash daily at a small size for mini squash vs. every 2-3 days at a larger size. I wondered if harvesting mini squash is worth the extra effort, and if it can be profitable for a small market gardener. Therefore the study also included a customer survey at two Farmers' Markets, a vendor survey and development of an enterprise budget for squash production aimed at market gardeners and small farmers.

Materials and Methods

This squash experiment got off to a late start in summer 2006 because of a family emergency in June, but I was able to accomplish much of what I set out to do.

I used four summer squash varieties: two zucchini (green: Cash Flow from Johnny's Selected Seeds¹, yellow: Butterstick from Territorial Seed Company²) and two patty pans (green: Starship from Territorial Seed Company² and yellow: Sunburst from Territorial Seed Company²). A total of 40 equally spaced hills were created in a sprinkler irrigated (K2 Smart Set gear drive sprinkler heads³) garden plot. Two gallons of commercial composted steer manure were added to each hill before planting.

The hills were randomly assigned a variety and harvest frequency so that there were 5 hills of each variety and harvest frequency combination. An extra hill of each variety was planted in case some hills were damaged or aberrant. The hills were arranged in 5 rows of 8 – 9 hills. Each hill was planted with 5 seeds of the same variety and thinned to 3 plants while the plants were young. The hills were planted on July 11 and 12.

Figure 3: By July 27 most of the seeds had germinated and the seedlings were ready to thin. This is the view looking west from the east end of the plot. Glass mason jars scattered through the plot were used to monitor water distribution.



Each hill was assigned a number. When the plants started blooming, flags were placed in each hill identifying the hill number and variety. Yellow flags marked hills that were harvested daily. Orange flags indicated harvests every 2 or 3 days.

Brown paper shopping bags were labeled with the hill number, variety, and harvest frequency of each hill, and were used to harvest the squash throughout the season. The squash were weighed individually after harvest each day.

Figure 4: August 8, flowering begins. Flags indicate harvest frequency. Note that the leaves of zucchini varieties (e.g., bottom left and bottom right) were more deeply divided than were the leaves patty pan varieties (e.g., bottom center). This photo was taken from the same vantage point as Fig. 3.



Results: Squash yields



Figure 5: Typical size of zucchini harvested every 2-3 days on left, daily on right. Stems were cut to about 1/2 inch on large squash, a little less on small squash, before weighing. Photo taken 8/23.

Interestingly, the size at which I harvested the squash decreased late in the season as temperatures dropped and day length shortened. Table 1 shows the average weight of fruits harvested prior to September 16 and after that date for the 4 varieties and two harvest frequencies. When harvesting daily I picked patty pan varieties at a size that was 40% smaller during the second half of the season as compared with the first half. Green squash picked every 2-3 days decreased much less in size over the

season, only 15%.

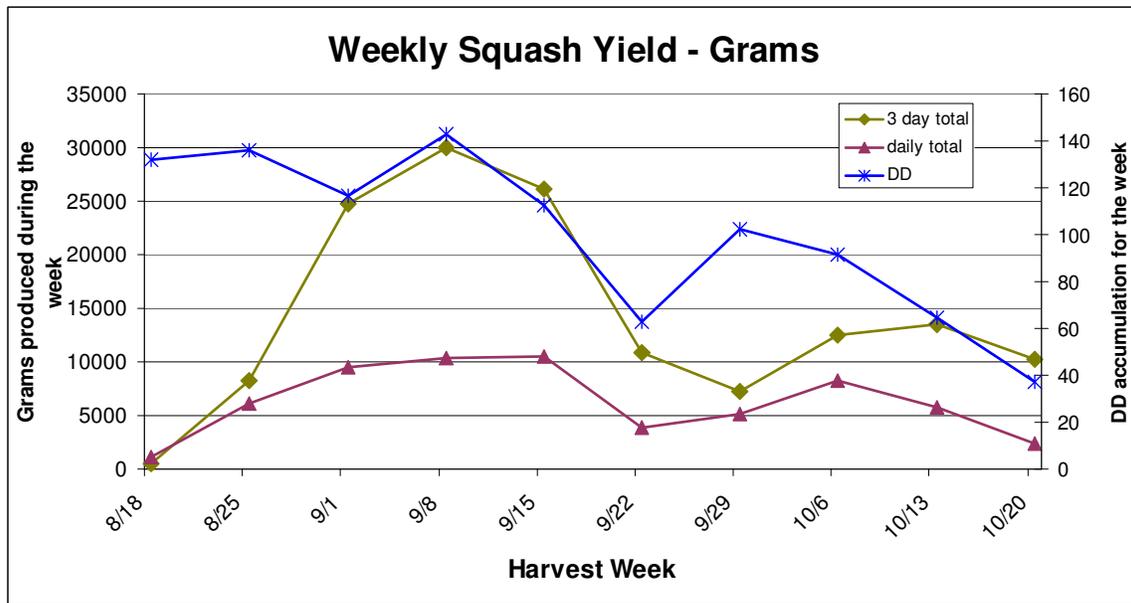
Table 1: Change in Average Weight (grams) of Harvested Squash during the first and second half of the 2006 season

Color Variety Harvest frequency	Green				Yellow			
	Patty Pan		zucchini		Patty Pan		zucchini	
	daily	2-3 days	daily	2-3 days	daily	2-3 days	daily	2-3 days
before Sept.16	33	223	45	215	35	240	41	246
after Sept. 16	19	187	32	184	20	178	31	183
% decline	44%	16%	29%	14%	42%	26%	25%	26%

Yield of squash harvested each week generally tracked fluctuations in temperature over the season, as one might expect. I obtained temperature and degree day (base 50°F) data for the UI Parma Research and Extension Center⁴ (about 3 miles from my squash plot) from the Agrimet (U.S. Dept. of Interior The Pacific Northwest Cooperative Agricultural Weather Network) web site⁵.

Yields reached a peak during week 3-5 (Figure 6). The weather turned cold during the week of September 15-22 (note the dip in the blue degree day DD line. DD =weekly degree day accumulations) and yields declined correspondingly. Note also that overall weekly yield in grams of squash harvested at the larger size was about 3 times the yield of small squash during peak production. The difference was less as yields declined late in the season.

Figure 6: Weekly squash yield in grams for squash harvested daily or every 2-3 days. Blue line indicates degree day accumulations for the week.



Although harvesting every 2-3 days at a larger size yielded more grams of squash than harvesting daily at a small size, the daily harvests yielded a greater number of fruits. In the case of yellow patty pans, more than 3 times more small fruit were produced by the end of the season than large fruits (Table 2), compensating for the greater yield in weight of harvesting less frequently. However, the other varieties only produced 1.5 to 2 times more fruit when picked small.

Table 2: Total Number of Squash Fruits Produced During the Season, and Ratio of Daily to 2-3 day harvests (%)

Color Variety Harvest frequency	Green				Yellow			
	Patty Pan		zucchini		Patty Pan		zucchini	
	daily	2-3 days	daily	2-3 days	daily	2-3 days	daily	2-3 days
Total number of squash harvested	438	213	392	196	743	232	335	225
<u>Daily number</u> <u>3 day number</u>	206%		200%		320%		149%	
Total Kg of squash harvested	12.0	33.2	16.2	39.1	22.3	27.8	12.4	44.0
<u>Daily weight</u> <u>3 day weight</u>	278%		241%		124%		355%	

Time to harvest the squash ranged from 15 to 45 minutes per day during peak production. Time to harvest per se was not a limiting factor in the harvest. Daily harvests do require dedication, however.

Results: Squash Sales and Pricing

Squash were sold at the Nampa Farmers' Market⁶ on Saturday mornings and the new Wednesday afternoon Caldwell Farmers' Market⁷. In addition, three large orders of squash were also filled during the season: for a local CSA (Eat Right Idaho⁸) and for Bon Appétit⁹, caterer for Albertson College of Idaho.

At the market, several different pricing schemes were tried. At Farmers Market large squash sold well at 2-4 for \$1.00. Small squash sold well at 5 – 8 for \$1.00. The number of small squash for \$1.00 increased as the size of the squash decreased late in the season. Baby squash were sold to Bon Appétit for \$1.75 per pound, which turns out to be a bargain price compared to the price per pound that I got at the farmers' market where 5-8 sold for \$1.00, which is usually between \$2 and \$3 per pound (Table 3).

Table 3: Approximate Weight of \$1.00 of Squash and Cost per Pound (based on weights in Table 1)

Color Variety Harvest frequency	Green				Yellow			
	Patty Pan		zucchini		Patty Pan		zucchini	
	daily	2-3 days	daily	2-3 days	daily	2-3 days	daily	2-3 days
before Sept.16	165 gm (5 fruits)	669 gm (3 fruits)	225 gm (5 fruits)	645 gm (3 fruits)	175 gm (5 fruits)	720 gm (3 fruits)	205 gm (5 fruits)	738 (3 fruits)
Price per lb	\$2.74	\$0.68	\$2.01	\$0.70	\$2.59	\$0.63	\$2.21	\$0.61
after Sept. 16	152 gm (8 fruits)	561 gm (3 fruits)	256 gm (8 fruits)	552 gm (3 fruits)	160 gm (8 fruits)	534 gm (3 fruits)	248 gm (8 fruits)	549 gm (3 fruits)
Price per lb	\$2.97	\$0.81	\$1.77	\$0.82	\$2.83	\$0.85	\$1.82	\$0.82

Large squash were clearly a better buy for the consumer. For small squash the zucchini varieties were a better buy than the patty pan varieties. Small squash were a much greater source of income per pound of squash. In most cases the cost per pound increased late in the season as the squash size decreased. However, small zucchini types decreased in price per pound, because their size decreased slightly but the number sold for a dollar increased considerably.

For comparison, most other vendors at the Saturday Farmers' Market sold squash the size of my larger squash at 3 – 4 for \$1.00, or at \$0.75 per pound. I was the only vendor selling baby squash at either of the Farmers' Markets. During peak season, 6 - 7 other produce vendors had squash for sale.

We kept track of the numbers of squash left over at the end of the Saturday market, and compared that with the number of squash that were harvested during the week. We found that we sold all but about 6% of the small squash that we harvested with green squash slightly more popular than yellow. An average of 17% of our large zucchini squash did not sell. Least popular were the large patty pan types: 28% did not sell. People frequently asked "What do you do with these?" Most people bought other squash varieties if they were available, even when we offered recipes.

Customer Survey

To get more information about customer preferences, we did three customer surveys during the season. Two were conducted at the Saturday market and one at the Wednesday market. For the

Figure 7: A survey table with samples of raw squash was set up next to our market booth on September 5.



Wednesday market survey and one Saturday market survey we hired a friend to grill squash so customers could taste the cooked squash before filling out the survey. The other Saturday market survey included tasting of raw squash.

A total of about 75 people filled out our market surveys from the three days combined. Overall, customers were equally willing to purchase baby squash compared with "medium" sized squash. Very few were interested in "huge" squash. Most preferred to buy squash by numbers (5-6 baby, 2-4 medium squash) (89% of respondents) than by the pound. When asked how much they would

pay per pound for squash, most chose \$1.00 or less, and many said they would not pay as much for baby squash per pound than for medium squash. This response surprised me, given that those who purchased squash paid \$2.00 or more per pound for them.

Vendor Survey

Six produce vendors who sell summer squash at the Nampa Farmers' Market filled out questionnaires concerning their cultural practices on August 5, 2006. Kevin Laughlin solicited responses from 5 additional squash vendor at the Capitol City Public Market¹⁰ in Boise. To these responses I added my own management practices. All of these vendors sell a diversity of produce, so squash is only a portion of their sales.

Some respondents did not answer all of the questions. Here is a summary of the responses:

Vendors planted between one and 14 varieties, with an average of 5 varieties.

Eight vendors reported that they planted squash seeds in rows, while three planted in hills. Those who planted in rows reported 75 ft, 120 ft, two rows of 150 ft each planted on two different dates, and 400 ft. Others reported planting 18, 22, 27 or 40 plants, or 6, 15 or 60 hills. One vendor planted half an acre in rows.

Ten respondents said that they use a rototiller to prepare the soil. Two respondents said that they also used a plow occasionally. Eleven respondents plant seeds by hand. No one indicated that they plant seedlings, although this was not explicitly asked.

One vendor claimed he did not fertilize his squash patch. Three vendors fertilized with compost and/or manure. One vendor uses a cover crop, one uses pelleted fertilizer, one an "all purpose" fertilizer. One organic grower uses Gardens Alive. One uses ammonium sulfate, added in amounts recommended for vegetables by a soil test. (Other respondents did not mention a soil test, but they were not specifically asked).

Five of the responding vendors do not use pesticides. One uses diatomaceous earth, one uses neem oil, and one hand picks squash bugs off of her plants. One uses the synthetic pyrethroid Warrior, when needed for squash bugs. One reported using rodent bombs.

I neglected to ask specifically about irrigation practices, but two vendors reported using drip irrigation, one uses flood irrigation and sprinklers and one reported using only sprinklers. One indicated that he irrigates 2-3 times per week, but did not specify method.

I also did not specifically ask about mulching, but one vendor volunteered that she used hay on top of newspaper but planned to switch to plastic, and one vendor reported using plastic. One was asked about mulching, and said that he avoids it because of squash bugs. I did not use mulch in 2006, but removed weeds with weekly hoeing. In 2007 I used hay as mulch, but this meant that weeds were not as well controlled as in 2006.

Two vendors reported that they stagger their squash plantings so that later plantings could replace older plantings when production decreased in the later plants due to disease and/or insect damage.

One vendor reported harvesting only once a week (presumably on Friday before market). Three vendors harvest 2-3 times a week. Two vendors harvest 4 or 5 times a week, and three harvest daily. Several people reported that it takes them 15 – 20 minutes to harvest.

I judged the size of squash sold for the Nampa vendors, while the Boise vendors were asked about the size of the squash that they sell. Five vendors sell primarily small to medium size squash. Two sell small to large squash, two sell large to huge squash. Only two reported selling baby squash and one was me. The other vendor, from the Boise market, said that most of their baby squash was sold to restaurants; baby squash does not sell well at the Boise market.

Six of the vendors used a cooler or refrigerator to store squash between markets. Three indicated that they do not cool their squash.

Asked how much squash they brought to market, two vendors gave a number of boxes (3 or 4) without indicating the size of the box. One indicated 10 gallons, with 5 pounds left over after market. Other vendors brought 10, 20-30, 35, 50 or 75 lbs to market. Three vendors indicated the number of squash brought to market: two brought about 100 individual squash. I brought 200 to 500, mostly baby squash to market.

All of the Boise vendors indicated that they sell out or almost sell out of squash most markets. Nampa vendors were more likely to have some left over, averaging about 85% sales. Overall the vendors typically sold 91% of their squash, on average.

12 vendors selling summer squash (and other produce) at 2 Farmers' Markets filled out a questionnaire on their management and marketing practices. Most of these vendors

- Have small plots of squash, 60 or fewer plants or hills.
- Prepare the soil with a tiller rather than a plow,
- Use compost or other organic supplements
- use minimal pesticides
- Harvest two to five times a week.

In summary, the vendors who sell squash at Farmers' Market have small plots of squash, generally only a row or two, 60 or fewer plants or hills. Most prepare the soil with a tiller rather than a plow, most plant by hand, use compost or other organic supplements as fertilizer, and use minimal pesticides. Most harvest two to five times a week. Daily harvests are rare, though harvesting takes only 15 to 20 minutes for most vendors. Only two vendors reported selling baby squash, including me. The other vendor who sold baby squash did not sell much at farmers' market, but sold it to restaurants. The most that vendors reported bringing to market was 75 lbs of squash. Most vendors sell out of squash at the market or sell most of what they bring, with vendors doing better at the Capitol City Public Market than at the Nampa Farmers' Market.

Enterprise Budget

The information from the vendor survey helped me formulate an enterprise budget for market squash production that should be useful to other market gardeners. The budget is discussed in a separate essay, appended to this report.

Observations and Recommendations

1. The extra effort to grow baby squash was justified. The time for harvest was not that great, although it required diligence to harvest daily. (Weighing squash daily was time consuming, but would not be part of normal harvest procedures). If baby squash is sold for 5 – 8 for \$1, the price per pound (\$2 and \$3) was considerably better than could be achieved with the sale of larger squash. This study suggests that squash growers on small acreage should consider increased production of baby summer squash.
2. My Enterprise Budget indicates that my income from squash covered variable costs of production and marketing in 2007, but not fixed costs or unpaid labor. I used the excel spreadsheet for the budget to determine what changes would result in a profit for my mini squash sales. Planting earlier in the season so that I can sell at more markets and increase total squash yield would increase my profits.
3. In 2006 I found that mini squash would sell at close to \$3.00 a pound, especially late in the season. If I can build a clientele to purchase squash at this price throughout the season, and double my production of squash, I should be able to not only pay my expenses, but also make a profit with mini squash.
4. One trade off is that problems from squash bug pests were avoided by planting late. I saw only one adult squash bug during the entire season. Pest management can be achieved by late planting.
5. Selling by numbers rather than weight was preferable for baby squash, and preferred by customers for all summer squash. Large patty pan squash sold poorly; growers who plant these varieties are especially encouraged to harvest small fruits. Monitoring size at which squash are harvested is encouraged as the basis for determining how many squash to sell for \$1.00 when selling by numbers instead of pounds.
6. Grilling squash was not only productive in that our squash sold out completely the day we tried it, but we also had great fun and customers loved it. We are considering getting a temporary food establishment license and selling grilled squash and other vegetables routinely at the market as well as fresh produce. Growers should consider offering samples and/or selling grilled squash at farmers' markets to increase profits.

Outreach

September, 2006. One customer who visited the Nampa Farmers' Market on the day that we did our customer survey was interested in the project. She brought the Homedale Garden Club to visit our market garden and see the squash patch.

September, 2006. Extension Educator Kevin Laughlin from Ada Co., ID visits the experimental squash patch, along with Extension Educator Tony McCammon from Payette, Co., ID.

January, 2007. Discussed the squash research at the University of Idaho's Living on the Land Course in Parma, ID.

April – May, 2007. Copies of my Jan. 2007 preliminary report were shared with the market growers at the beginning of the Nampa Farmers' Market. During the 2007 season I noticed that more growers at the Nampa market brought small squash for sale.

July, 2007. Started a Blog to keep track of my time and costs, as well as observations of my 2007 squash patch. The Blog is ongoing, and will be continued in 2008.
<http://squashblossomdiary.blogspot.com/>

November 29, 2007. Discussed the squash project with "Cultivating Success" class taught by grower Mary Rohlfing at the Ada Co. Library. (One young couple participating in the course have volunteered to be interns with us during the 2008 market season).

December 2007– February 2008. Added my report and my enterprise budget to my website:
http://www.pollinatorparadise.com/Squash_Project/SquashResearch.htm

January, 2008. Contacted researchers at University of Florida and Pennsylvania State University who have studied squash production and the ecology of squash respectively to discuss my squash research.

February 8, 2008. Discussed the squash project at a workshop run by Rural Roots, referred growers to the web site for further information.

February 18, 2008. Sent an e-mail inviting members of the Rural Roots Listserve and Living on the Land alumni and participants to visit my website and read about my squash research.

February, 2008. I am working with our new Canyon County Extension Educator, Ariel Agenbroad to find additional ways to share the results of this project, including possible extension bulletins and the enterprise budget.

March, 25 2008. Invited to present a poster on the project at the National SARE Conference in Kansas City, MO.

April, 2008. Will discuss the squash project with the 2008 Living on the Land course in Caldwell, Fruitland, and Emmett.

Future: I would like to publish a book about growing squash based on this research and the essays in my blog. I would also like to develop a model with the user-friendly systems modeling program Stella that will show dynamically how squash yields vary with harvest frequency, and how profits increase with increasing price and yield.

Acknowledgements

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Thanks also to Beth Rasgorshek for grilling vegetables for us at the market, and to Janie Burns for loaning us the grilling equipment. C.J. Soltis from Southwest District Health advised us on health issues for grilling, and approved our temporary food establishment license for the Nampa Farmers' Market. Our neighbors, the Blancet kids, helped out with a couple of hours of a weeding marathon. Dr. Brad Brown from the UI Parma Research and Extension Center advised on experimental design.

We also appreciate support from the Market Managers of the Nampa and Caldwell Farmers' Markets, and all the vendors and customers who participated in our surveys, tasted and purchased our produce.

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Contact information



Pollinator Paradise

Karen Strickler

31140 Circle Drive

Parma, ID 83660

(208) 722-7808

karens@w-idaho.net

www.pollinatorparadise.com

Ariel Agenbroad, UI Extension Educator
University of Idaho Canyon County Extension
501 Main Street

Caldwell, ID 83605

Telephone: (208) 459-6003 Fax: (208) 454-6349

Email: ariel@uidaho.edu

Kevin M. Laughlin, UI Extension Educator,
University of Idaho Ada County Extension

5880 Glenwood Ave. Boise, ID 83714

Phone (208)377-2107 Fax (208) 375-8715

E-Mail: laughlin@uidaho.edu



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