



NON-GRAFTED AND GRAFTED SEEDLESS WATERMELON TRANSPLANTS: COMPARATIVE ECONOMIC FEASIBILITY ANALYSIS

By
Suzette P. Galinato, Research Associate, IMPACT Center, School of Economic Sciences, Washington State University, Pullman, WA. **Carol A. Miles**, Professor, Department of Horticulture, Northwest Washington Research and Extension Center, Washington State University, Mount Vernon, WA. **Jesse A. Wimer**, Graduate Student, Department of Horticulture, Northwest Washington Research and Extension Center, Washington State University, Mount Vernon, WA.

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Preface

The results presented in this WSU publication serve as a general guide for evaluating the feasibility of growing greenhouse seedless watermelon transplants, both non-grafted and grafted, as well as using grafted transplants to produce seedless watermelon in Washington as of 2014.

This publication is not intended to be a definitive guide to production practices, but is helpful in estimating the physical and financial requirements of comparable plantings. Transplants are grown by commercial nurseries, as well as some watermelon producers. Hence, the information and discussion presented are targeted to both commercial greenhouse transplant producers and watermelon producers who are considering grafting their own plants.

Specific budget assumptions were adopted for this study, but these may not fit every situation since production costs and returns vary across farm operations depending on the following factors:

- Capital, labor, and natural resources
- Crop yield
- Cultural practices
- Input prices
- Prices of transplants
- Management skills
- Size of the operation
- Type and size of greenhouse

Costs can also be calculated differently depending on the budget's intended use. To avoid unwarranted conclusions for any particular operation, readers must closely examine the assumptions made in this study, and then adjust the costs and/or returns as appropriate for their operation.

Objectives of the Study

This study provides information on:

1. The variable and fixed costs required to produce non-grafted seedless watermelon transplants in a greenhouse;
2. The costs of producing grafted watermelon transplants in a greenhouse;
3. The costs and returns of producing seedless watermelon in the field by using grafted transplants.

Excel workbooks are also provided, which allow the user to estimate production costs and examine the impact of different input assumptions, yields, and price scenarios.

Data Sources

The data used in this publication are a composite of information gathered from experienced growers in Washington and Oregon who produce non-grafted watermelon transplants in a greenhouse. Their production practices and requirements for labor and capital are the basis for the budget assumptions used in this study and represent current production methods.

Information about supplies and labor associated with grafting watermelon plants are obtained from Lewis et al. (2014) and greenhouse studies at the WSU Mount Vernon Northwest Research and Extension Center. Data on crop yield resulting from field utilization of grafted transplants are obtained from field experiments in eastern Washington.

Greenhouse Production of Watermelon Transplants

Overview

In Washington, transplants are used for all commercial production of watermelon. Watermelon transplants are grown in a greenhouse, either by the grower (on-farm) or by a commercial propagator (off-farm). In some cases, the commercial propagation facilities are located near the farm; however, it is common for transplants to be shipped hundreds of miles across state boundaries.

Transplant production facilities vary greatly, but a typical design is a hoop-shaped greenhouse covered with polyethylene plastic and equipped with heaters and fans. Seeds are sown into 200-cell plastic trays by hand or machine, and then placed in the greenhouse, either on the ground or on benches. After emergence, the seedlings are regularly watered and fertilized for optimal growth.

The use of grafted watermelon plants is gaining popularity in the U.S. Although there are several grafting techniques available to propagators, only two—one cotyledon splice and hole insertion—are widely used on a commercial scale (Miles et al. 2013). The major challenge with these techniques is rootstock regrowth—the removal of which requires extra labor both in the greenhouse during transplant production and in the field during crop production.

Regardless of the technique employed, additional greenhouse space is needed to grow the rootstock and to graft the plants. Furthermore, extra labor is needed to perform the grafting, and special facilities are required for the proper healing and acclimation of the grafted seedlings.

These facilities range from relatively inexpensive modified greenhouses to state-of-the-art, climate-controlled growth chambers. Despite the inherent challenges and costs of producing grafted watermelon transplants, this practice is becoming increasingly popular as an alternative strategy to manage soil-borne disease in the U.S.

Budget Assumptions for Greenhouse Production of Non-grafted Watermelon Transplants

Below is a list of the budget assumptions used in estimating the production costs and returns of non-grafted watermelon transplants. These assumptions serve as the baseline in which grafted transplants will be compared.

- The baseline enterprise budget is for the production of non-grafted seedless watermelon transplants in a greenhouse. The greenhouse is 20 feet by 100 feet with polycarbonate end walls and is a Quonset-style structure. It is assumed that only seedless watermelon transplants are being produced in the greenhouse.
- Table 1 shows the assumed specifications for greenhouse production of non-grafted seedless watermelon transplants. There are a total of 1,400 trays in the greenhouse, where each tray has 128 cells. Only 80% of the cells have plants (accounting for germination loss), therefore, the net yield is 143,360 plants.
- Estimated return is \$0.10 per plant excluding the seed cost. The price of the seed varies depending on the cultivar. Also, the seeds are often purchased by the watermelon growers who then give the seeds to the nursery; hence, the seed cost is excluded in this analysis.
- The growing season is 35 days before planting in the field. This means that if, for example, the transplants will be planted in the field on May 1, then the transplants will be grown in the greenhouse between March 26 and April 30.
- Interest on investment is 5%.

Study Results

The detailed enterprise budget for greenhouse production of non-grafted seedless watermelon transplants is shown in Table 2. The components of the major costs shown in this table are provided in more detail in the Excel Workbook described below. Production costs are classified as variable and fixed costs. Variable costs include potting medium, fertilizer, chemicals, propane, electricity, water, trays, labor, maintenance and repairs, overhead, and interest on operating capital. Fixed costs are incurred whether the plants are grown or not, and these costs include depreciation on capital, interest, land rent, property insurance, and management.

Given the above assumptions, the total cost of production is about \$5,798 per greenhouse. The estimated net return is about \$8,538 per greenhouse. The breakeven price is approximately \$0.04 per plant given 143,360 plants are grown in a greenhouse.

Note that yield and prices can vary from year to year. Therefore, to be of use to potential investors, the assumptions underlying the cost estimates should be carefully examined. Table 3 shows the net returns that would be expected from different scenarios of yields and prices received for seedless watermelon transplants. These estimates show the sensitivity of profits to yield and price, while holding all else constant.

The fixed costs in Table 2 are based on underlying cost data shown in Tables 4 through 6. Table 4 presents the physical capital requirements. Interest costs and depreciation costs applied to the greenhouse production of watermelon transplants are listed in Tables 5 and 6. Interest costs represent the required return on investments. These costs can be actual interest payments on loans used to finance farm operations and physical capital investment, or they can be opportunity costs, or a combination of the two.

Washington State University Enterprise Budgets are economic budgets (not financial or cash budgets), which means they take into account not only cash costs, but also opportunity costs.

Opportunity costs are defined as revenue foregone by not investing in the next best alternative that carries a similar financial risk; for example, investing money in the stock market, or paying off an outstanding loan. If these costs are not included in calculating their net return, farmers will overlook the profitability of farming relative to alternative uses of their resources.

Partial Budget Analysis of Greenhouse Production of Grafted Transplants

The costs and benefits of producing grafted seedless watermelon transplants relative to producing non-grafted watermelon are examined through a partial budgeting framework. A partial budget provides a method of calculating the net change in profit that can be expected from a specific change in production.

The change in production can have one or more of the following effects (Kay et al. 2012):

1. Incur new or additional costs
2. Reduce or eliminate current costs
3. Receive new or additional revenue
4. Lose or reduce current revenue

In this study, partial budgets are used to evaluate the profitability of producing grafted seedless watermelon transplants relative to non-grafted transplants.

It is assumed that grafting is an add-on operation to the existing greenhouse enterprise. In contrast to the baseline scenario, a commercial propagator will need two greenhouses for growing grafted transplants—one for producing the rootstock and another for scion. Hence, in the *grafted transplants* scenario, an additional greenhouse is built to grow scion plants.

Additional costs associated with grafting include labor, supplies, and a healing chamber. The design of the healing chamber can vary with each nursery. For this study, the newly grafted plants are assumed to be placed in racks inside a storage shed with a misting system.

Table 7 shows the partial budget where the only effect on an enterprise's net return comes from the additional costs incurred for grafting plants. The net change in profit is approximately \$22,211.

Table 8 shows the side-by-side comparison of the costs and returns for the greenhouse production of non-grafted and grafted transplants. With the additional grafting costs, the total greenhouse production costs increase to about \$27,961. The break-even price required for 143,360 grafted plants is about \$0.20 per plant. The price must be about \$0.25/plant in order to achieve the same net returns as for non-grafted plants.

Field Production of Seedless Watermelon Using Grafted Transplants

Overview

The use of grafted transplants is considered an alternative disease and abiotic stress (i.e., high salinity, drought, flooding, high and low temperature) management strategy in watermelon production. Galinato et al. (2014) estimated watermelon production costs where non-grafted seedless transplants are utilized in the field. The study will serve as the baseline in which the field utilization of grafted transplants will be compared.

Since the production cost and return estimates in Galinato et al. represent 2013 prices, the data are adjusted by using the price received indexes for melons and prices paid indexes for production inputs in 2013 and 2014. Inputs of production include commodities, services, interest, taxes, and wage rates (USDA NASS 2015). The total cost of production and net returns in producing watermelon using non-grafted transplants are estimated at about \$7,887 per acre and \$1,473 per acre, respectively.

Partial Budget Analysis of Watermelon Production Using Grafted Transplants

The partial budget (Table 9) shows where the effects on the grower's net return will come from:

- Additional costs of grafted transplants, scion seeds, marketing and advertising, and additional contributions of the aforementioned costs to the overhead and interest on operating capital. The grafted transplants are purchased for \$0.50/plant (assuming a markup of 2.5 times the break-even price of grafted transplants), and the seeds are given to the nursery for seedling production and grafting. Marketing and advertising cost is 8% of the gross revenue.
- Reduced costs due to the elimination of fumigation, disease control, and non-grafted transplants.
- Additional revenue due to increased crop yield by 31% relative to the baseline (i.e., 32.75 tons/acre from 25 tons/acre). Field experiments in eastern Washington have shown a range of 31% to 64% increase in average yield of grafted watermelon relative to non-grafted, depending on the cultivars that are grafted together and the level of disease in the field (Wimer et al. 2015). The minimum increase (i.e., 31%) is used as a conservative reference point for the partial budget analysis.

The above effects lead to a net change in profit of approximately \$1,357 per acre. Holding all else constant in the watermelon production enterprise budget (Galinato et al. 2014), this result means that the additional costs and revenue obtained from the field utilization of grafted transplants will increase profit to \$2,830 per acre (i.e., \$1,473/acre plus \$1,357/acre).

Sensitivity Analysis

To examine the sensitivity of profit, certain parameters can be changed, particularly crop yield and the price of grafted transplants.

Figure 1 shows that expected profit increases as crop yield increases, when other factors remain constant. The grower breaks even when yield is about 24.5 tons/acre.

If a grower’s goal is to earn a minimum of \$1,000 per acre in order to continue producing watermelon, the yield of grafted seedless watermelons must be about 27.4 tons/acre. On the other hand, a grower’s profit will be equal to that of the non-grafted crop (\$1,473/acre), if the yield of grafted seedless watermelon is about 28.8 tons/acre.

The differences in potential profit given varying prices of grafted transplants are illustrated in Figure 2. As expected, profit declines as the price of grafted transplants increases when other factors remain constant. The grower breaks even when grafted transplants cost about \$1.38 per plant. The grower’s estimated profit with the field utilization of grafted transplants will be equal to the profit with non-grafted transplants, if the price of grafted transplants is about \$0.92 per plant.

Discussion

Given the study’s assumptions, results of the partial budget analysis suggest that the production of grafted watermelon transplants can be economically feasible for commercial greenhouse producers if the transplants can be sold at more than \$0.20/plant. The breakeven price of grafted transplants is about \$0.20 per plant, which is five times greater than the breakeven price of non-grafted transplants.

The price is higher with grafted transplants due to the additional capital investments and labor-intensive grafting process. However, the higher cost of grafted transplants can be acceptable to watermelon producers if using these transplants would improve crop yield and provide a viable alternative to field fumigation.

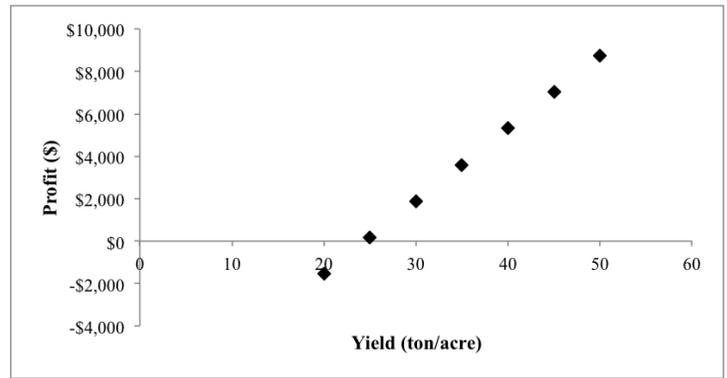


Figure 1. Estimated profit given different yields of grafted seedless watermelon.

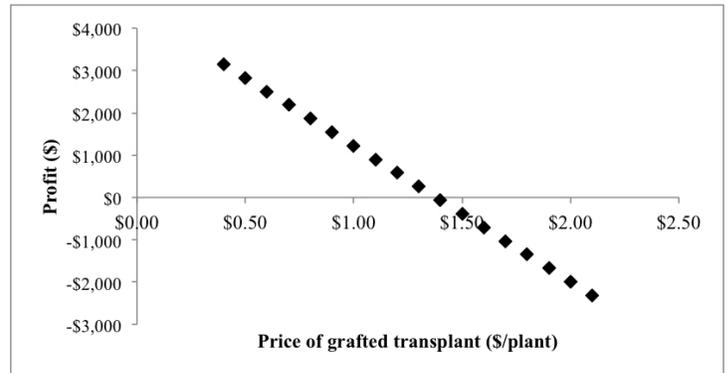


Figure 2. Estimated profit given different prices of grafted watermelon transplants.

Similarly, the field utilization of grafted watermelon transplants can be economically feasible for watermelon producers. If the price of grafted transplants is \$0.92 per plant, they will then earn about \$1,473/acre, which is the same return as when non-grafted watermelons are produced.

As previously mentioned, the grower’s choice of using grafted over non-grafted transplants will primarily depend on the benefits gained from the effectiveness of grafted transplants as alternative to chemical use in managing soil-borne disease (i.e., reduced costs), and from improved yield, which should outweigh the cost of grafted transplants. Another key consideration for the grower in choosing grafted transplants is a maintained or augmented profit relative to using non-grafted transplants.

It must also be noted that the key results of the enterprise budgets are formed by production-related assumptions established for the study. Production costs and returns for individual transplant producers and watermelon producers may vary, thus the results cannot be generalized to represent the population of producers.

Excel Workbook

An Excel spreadsheet version of the enterprise budget (Table 2), as well as associated data underlying the per-acre cost calculations in Tables 3 through 6 are available at the WSU School of Economic Sciences Extension webpage for [crop enterprise budgets](#).

Users can view the page to find “watermelon transplants” in the list of commodities or type those key words in the “Search” field. This technical bulletin and the Excel Workbook files can be accessed from the website.

Additional supplementary tables are also provided for users interested in the underlying data related to grafting. Under “watermelon transplants” in the website, the supplemental tables available for access are: Appendix A: Cost of Producing Grafted Seedless Watermelon Transplants in a Greenhouse; and Appendix B: Cost of Producing Seedless Watermelon in Eastern Washington using Grafted Watermelon Transplants.

These two references are the basis for calculating the partial budgets. Growers can modify select values in the Excel Workbooks provided to evaluate their own production costs and returns.

References

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Table 1. Production Specifications of Seedless Watermelon Transplants Grown in a Greenhouse

Size of greenhouse	20 ft x 100 ft
Per house	
No. of trays	1,400
No. of cells per tray	128
No. of cells per house	179,200
Percentage of cells with plants	80%
Total transplants per house per year	143,360

Table 2. Estimated Annual Costs and Returns of Producing Seedless Watermelon Transplants in a Greenhouse (\$/house/year)

	Unit	Price/unit	Quantity	Total
Total Returns				
Seedless watermelon transplants ^A	transplant	\$0.10	143,360	\$14,336.00
Variable Costs				
Potting medium	cu. ft.	\$5.00	150	\$750.00
Fertilizer	gallon	\$30.00	4	\$120.00
Chemicals	house	\$100.00	1	\$100.00
Propane	gal	\$0.98	360	\$352.80
Utilities ^B	house	\$130.00	1	\$130.00
Disposable trays	each	\$1.70	1,400	\$2,380.00
Labor ^C	house			\$468.00
Other Variable Costs ^D	house			\$339.29
Total Variable Costs				\$4,640.09
Total Fixed Costs^E				\$1,108.91
Total Cost				\$5,749.00
Estimated Net Returns				\$8,587.00

A. Does not include cost of seed as farmers usually pay for this separately.

B. Includes electricity and water.

C. Includes seeding and end of season clean-up.

D. Includes maintenance and repairs, overhead and interest on operating capital.

E. Includes depreciation and interest on fixed capital, and other fixed costs (land rent, property insurance and management overhead).

Table 3. Estimated Net Returns Per Greenhouse at Various Prices and Yields of Watermelon Transplants

Yield (no. of transplants per greenhouse)	Price (\$ per transplant)								
	\$0.04	\$0.05	\$0.06	\$0.07	\$0.08	\$0.09	\$0.10	\$0.11	\$0.12
89,600	-\$2,165	-\$1,269	-\$373	\$523	\$1,419	\$2,315	\$3,211	\$4,107	\$5,003
107,520	-\$1,448	-\$373	\$702	\$1,777	\$2,853	\$3,928	\$5,003	\$6,078	\$7,153
125,440	-\$731	\$523	\$1,777	\$3,032	\$4,286	\$5,541	\$6,795	\$8,049	\$9,304
143,360	-\$15	\$1,419	\$2,853	\$4,286	\$5,720	\$7,153	\$8,587	\$10,021	\$11,454
161,280	\$702	\$2,315	\$3,928	\$5,541	\$7,153	\$8,766	\$10,379	\$11,992	\$13,605
179,200	\$1,419	\$3,211	\$5,003	\$6,795	\$8,587	\$10,379	\$12,171	\$13,963	\$15,755

Notes:

Price does not include cost of seed as farmers usually pay for this separately.

Based on the assumed greenhouse production specifications (Table 1), there are 179,200 transplants per greenhouse if all cells have plants.

Shaded area denotes a positive profit based on the combination of yield and price.

Table 4. Capital Requirement of Growing Watermelon Transplants in a Greenhouse

	Unit	Current Market Value		
		Number of Units	Purchase Price (\$/Unit)	Total Cost (\$)
Construction - durable items and services:				
Site preparation	Each	1	500	500
Greenhouse kit (20 ft x 100 ft)	Kit	1	3,800	3,800
End wall kit (20 ft)	Kit	1	145	145
Plastic	Each	1	225	225
T-rail and frames	Each	1	1,200	1,200
Lumber (2 ft x 6 ft)	Each	8	6	48
Concrete	Yard	3	65	195
Greenhouse heater	Each	1	1,000	1,000
Irrigation system	Each	1	400	400
Electrical service (professionally wired)	Each	1	3,400	3,400
Gas hook-up	Each	1	500	500
Building of greenhouse (labor)	Hour	100	12	1,200
Other:				
Seeder	Each	1	750	750
Other durable items (small tools, gloves, etc.)	Each	1	400	400
Total Cost				13,763

Note: Purchase price is approximate and corresponds to new greenhouse, equipment, tools and other durable items.

Table 5. Interest Costs (\$/house/year) of Greenhouse Production of Watermelon Transplants

	Total Purchase Price	Salvage Value	Total Interest Cost
Greenhouse and other durable items	\$13,138	\$0	\$328
Plastic	\$225	\$0	\$6
Irrigation system	\$400	\$0	\$10
<i>Interest Rate</i>	5.0%		
<i>Salvage Value</i>	10.0%		

Note: Interest Cost is calculated as: (Total Purchase Price + Salvage Value)/2 x Interest Rate.

Table 6. Depreciation Costs (\$/house/year) of Greenhouse Production of Watermelon Transplants

	Total Purchase Price	Useful Life (years)	Depreciation Cost
Greenhouse and other durable items	\$13,138	20	\$656.90
Plastic	\$225	4	\$56.25
Irrigation system	\$400	20	\$20.00

Note: The depreciation cost is calculated as straight line depreciation: (Total Purchase Price – Salvage Value)/Years of Use.

Table 7. Partial Budget (\$/year) for Greenhouse Production of Grafted Seedless Watermelon Transplants

<u>Additional Returns</u>	\$0.00	<u>Additional Costs</u>	\$22,210.64
		Additional inputs, labor and maintenance and repair ^A	\$4,400.80
		Grafting labor	\$12,494.00
		Supplies	\$1,648.64
		Other (overhead, interest)	\$1,008.30
		Additional greenhouse (depreciation, interest)	\$1,077.23
		Healing chamber (depreciation, interest)	\$1,550.00
		Additional other fixed costs ^B	\$31.68
<u>Reduced Costs</u>	\$0.00	<u>Reduced Returns</u>	\$0.00
A. Total additional revenue and reduced costs =	\$0.00	B. Total additional costs and reduced revenue =	\$22,210.64
Net Change in Profit (A minus B) =			-\$22,210.64

Notes:

A. Includes potting medium, fertilizer, chemicals, propane, utilities, disposable trays; and labor for seeding and removal of trays for end-of-season clean-up for the additional greenhouse.

B. Includes land rent, property tax and management overhead for the additional greenhouse.

Grafting labor includes manual grafting, monitoring of grafted plants, and healing chamber clean-up.

Supplies include razor blades and grafting clips.

Overhead and interest costs are included because they are calculated as percentage of the variable costs. Thus, the additional costs of labor and supplies will have a contribution to the calculation of overhead and interest costs.

A healing chamber is an outdoor storage shed with racks and a misting system.

Table 8. Comparison of Costs and Returns (\$/year) of Producing Non-grafted and Grafted Seedless Watermelon Transplants in a Greenhouse in Washington, 2014

	Non-grafted plants	Grafted plants
Yield (no. of plants)	143,360	143,360
Price (\$/plant)	\$0.10	\$0.25 ^F
Total Returns	\$14,336	\$36,547
Variable cost		
Potting medium	\$750	\$1,500
Fertilizer and chemicals	\$220	\$440
Propane and utilities	\$483	\$966
Disposable trays	\$2,380	\$4,760
Labor ^A	\$468	\$936
Grafting labor ^B	-	\$12,494
Grafting supplies ^C	-	\$1,649
Other variable costs ^D	\$339	\$1,447
Total Variable Cost	\$4,640	\$24,192
Fixed cost		
Greenhouse, equipment, durable supplies, plastic, irrigation system (D&I)	\$1,077	\$2,155
Healing chamber (D&I)	-	\$1,550
Other fixed costs ^E	\$32	\$64
Total Fixed Cost	\$1,109	\$3,769
Total Cost	\$5,749	\$27,961
Estimated Net Returns	\$8,587	\$8,587
Break-even Return (\$/plant)	\$0.04	\$0.20

Notes:

Total returns for grafted plants do not add up due to the rounding of price.

D&I refers to depreciation cost and interest cost on fixed capital.

A. Filling trays, dibbling and seeding labor; and removing trays and end-season clean-up.

B. Includes manual grafting, monitoring of grafted plants, and healing chamber clean-up.

C. Includes razor blades and grafting clips.

D. Includes maintenance and repairs, overhead and interest on operating capital.

E. Includes land rent, insurance cost (all farm), and management cost.

F. Selling price required so that the net returns will be equal to that of non-grafted seedless watermelon plants.

Table 9. Partial Budget (\$/acre) for Field Utilization of Grafted Seedless Watermelon Transplants

<u>Additional Returns</u>	\$2,901.60	<u>Additional Costs</u>	\$2,305
Improved yield by 31%	\$2,901.60	Grafted watermelon transplants	\$1,500
		Seeds for rootstock	\$156
		Additional harvest and packing labor	\$263
		Marketing and advertising	\$232
		Other (overhead, interest)	\$155
<u>Reduced Costs</u>	\$760.50	<u>Reduced Returns</u>	\$0.00
Fumigation	\$288.75		
Disease control	\$120.75		
Non-grafted watermelon transplants	\$300.00		
Other (overhead, interest)	\$51.00		
A. Total additional revenue and reduced costs =	\$3,662.10	B. Total additional costs and reduced revenue =	\$2,305.20
Net Change in Profit (A minus B) =	\$1,356.89		

Notes:

Additional yield is 7.75 tons (i.e., baseline of 25 tons/acre increased by 31%) multiplied by the price of watermelon (\$374.40/ton).

Non-grafted and grafted watermelon transplants are assumed to cost \$0.10/plant and \$0.50/plant respectively, excluding the seed cost.

The median price of scion seeds is \$52 per thousand seeds.

Marketing and advertising is estimated at 8% of gross returns regardless of whether the crop is grafted or non-grafted.

Overhead and interest costs are included because they are calculated as percentage of the variable costs.



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