

Final Project

Van Drunen Farms – Diversification of Frozen Pepper and Basil Supply Chains

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Executive Summary

Supply chain design for Van Drunen Farms is one of the most critical aspects of the business. It revolves around fast cycle times and transportation due to the nature of perishable goods and high transportation costs. Processing facilities are intentionally located near the raw materials to support rapid receipt of goods for this reason. From Van Drunen Farms perspective, the finished good logistical expense exceeds the raw material expense as raw materials are procured in full containers while finished goods are shipped in small quantities to customers. While customers are considered first under this model and the goods can be sent locally, the current model does not account for situations where significant yield loss occurs geographically or locally. The proposed model within this report capitalizes on cost reduction from outsourcing goods through a mix of homegrown and sourced product from foreign and domestic growing regions. It additionally addresses the risk of crop loss due to climate anomalies or disaster and improves capacity constraints within Van Drunen Farms. Region diversification is crucial to overcoming these risks, as many of the current regions can only grow commodities during one period of the year. Through modifying the levers of inventory levels, direct costs, and overall sourcing strategy for two large cost drivers: frozen peppers and basil, the proposed improvements can yield substantial savings.

Introduction

Van Drunen Farms (VDF) is an ingredient manufacturer and supplier with five high capacity facilities in the Midwest and one in Serbia. The largest: Momence, IL, contains a 1600-acre farmland, three freeze-dried ingredients production facilities, two drum-dried ingredient production facilities, one individual quick-freezing production facility, a finished product storage center and a shipping warehouse. Crown Point, IN contains one freeze-dried ingredient production facility. VDF Europe in Serbia is an additional freeze-dried ingredient production facility. Frozen peppers are used to illustrate the benefits of expansion through diversification by expanding to China. As for the other sector of the business focusing on frozen herbs, an emphasis on expanding operations to Southern CA or Arizona to reduce company risk and cost is highlighted through frozen basil. The team collected current market demand and pricing information and analyzed proposed pricing alternatives with Van Drunen Farms employee Justin Vander Ploeg, and developed an optimized solution which is presented in the report.

Van Drunen Farms – Operations Overview

Within the current and proposed facilities, the typical production cycle is comprised of the following processes:

- Freeze-drying: frozen raw materials are placed in a refrigerated vacuum system, and without thawing, are dehydrated. Ice in the product is sublimated into water vapor.
- Drum-drying: Pureed raw ingredients are dried at relatively low temperatures over 2 rotating, high-capacity drums that produce sheets of product.
- Freezing / Individual Quick Freezing (IQF): freshly harvested herbs and vegetables are spread in a single layer onto a conveyor moving slowly through sub-zero air.

On the farming side, the success of an herb crop cycle can essentially be measured by the number of cuts per field at the end of the season compared to the projected number of cuts. With majority of the

farming and processing coming from the Midwest, there is an extreme risk of crop loss from significant rainfall which expands to the facilities as well in the case of natural disasters [1]. In addition to loss of crop due to climate related causes, VDF is also vulnerable to natural fallout of crops during processing. For example, Van Drunen Farms procures full container loads of frozen strawberries and then dries the strawberries where there is a possibility of experiencing a yield loss of up to 80% [2].

Research Design

The following steps summarize the team's research methodology

- Step 1:** Obtained one year's representative data on inventory of Van Drunen Farms and different regions' harvest costs from VDF employee Justin Vander Ploeg.
- Step 2:** Evaluated inventory data to understand inventory turnover and associated holding costs, order quantities and implied demand for frozen peppers and basil.
- Step 3:** Set up and analyzed different sourcing scenarios with demand assumptions derived from Step 2.
- Step 4:** Arrived at recommendations for frozen peppers and basil and calculated resulting savings.

Case Study: Frozen Peppers

Problem

Currently, VDF sources all peppers from California and Mexico where the peppers are grown and frozen. The frozen peppers are then shipped to Momence, IL for storage. From there peppers are distributed to customers throughout the United States. Like all fresh produce, production is seasonal, requiring VDF to purchase peppers in high quantities during the growing season of June through November. From December through May, low or even zero quantity is purchased; thus, VDF heavily relies on healthy crops in the middle of the year from their current farms and suppliers (Figure 1). Demand for peppers is historically consistent with sales of 604,167 lbs. per month, which is good for forecasting, but sourcing peppers from one geographical area exposes the company to risk of poor harvests (Table 1). From a supplier perspective, the response time, lot sizes, variety, price, and demand are stable, thus the implied demand uncertainty is rather low. This puts VDF in a unique position to capitalize on their solid understanding of the customer by focusing on their distribution network and ordering policies.

In order to alleviate the risk of poor harvest VDF has begun exploring alternative options of sourcing and recently received the opportunity to source peppers from China. The Chinese peppers growing season compliments the American Southwest, thus reducing risk of shortages should this distribution option be exercised. Adding Chinese peppers to the supply chain would also smooth out monthly shipments to VDFs facilities thus decreasing the burden on the facilities upon receipt.

Chinese peppers are cheaper than the current supply at \$0.8/lb. compared to the current \$1.25/lb. (Table 3) from California and Mexico, but their lead time to the states is ten months versus the current five months. There is also an associated transportation cost of \$0.3/lb. from China compared to \$0.15/lb. from the southwest and a tariff cost of \$0.24/lb. It ends up being \$0.06/lb. cheaper to go with Chinese peppers and would be even cheaper if President Trump eases tariffs on China in the future. However, factoring lead time and the risk associated with international transit and political implications does highlight questions about the right distribution between the two supply channels. The holding costs remain stagnant given the

growing seasons are complementary and the customer ordering quantities are known to be very stable compared to most industries. With a total average demand and current yearly order quantity of ~7,250,004 lbs./year, the total cost of production and transit reaches \$10,150,006 under the current implementation.

Data Analysis

From a general cost-saving standpoint, the following problem was considered:

$$\begin{aligned} \text{Min. Cost} &= (\text{Purchasing}_C^{\#} + \text{Transportation}_C^{\#} + \text{Tariff}_C^{\#}) * \text{Volume}_C \\ &+ (\text{Purchasing}_S^{\#} + \text{Transportation}_S^{\#} + \text{Tariff}_S^{\#}) * \text{Volume}_S \\ \text{Volume}_C + \text{Volume}_S &= 7,250,004 \text{ lbs.} \\ \text{per pound cost}^{\#}, \text{Southwest}^S, \text{China}^C \end{aligned}$$

Given the stable shipping costs due to the bulk purchase and shortened opportunity to purchase the peppers due to climate constraints, we focused mainly on decreasing the overall purchase price. While the safety stock vs. setup cost was not available, the safety stock is built into the current model thus it is still possible to improve the ordering technique to the economic order quantity since the exact demand with stock is known along with the full cost breakdown. From a sourcing perspective, the lowest cost option is to only source from China which would yield a total cost of \$9,715,005, creating annual savings of \$435,000; however, this defeats the purpose of diversifying sources to mitigate risks.

Recommendation

Since the goal for the frozen peppers is to diversify the supply chain, the team decided to propose a 60%/40% sourcing option with China and the southwest respectively. This conclusion was made due to the longer lead time in China where the response time is effectively half in the Southwest. Thus, China received a larger proportion of the supply chain since it is the more difficult lever to adjust. Implementing

the new supply chain results in a total annual cost of \$9,889,005 and a savings of \$261,001 or 2.57% per year (Table 3). Currently, Van Drunen Farms is only able to source low quantities from December to May (250,000 lbs. max/month excluding March due to climate). However, by sourcing from China as well, the ordering quantities can be readjusted to average 650,000 lbs./month (Figure 2) which reduces total average inventory thereby decreasing the annual carrying cost from \$100,260.42 per year to \$67,639.00 per year. Implementing these changes results in a savings of \$293,622.42 per year on the frozen peppers (Table 2).

Case Study: Frozen Basil

Problem

VDF produces and processes 16 different types of herbs ranging from Basil to Nettles to Cilantro. Current production is concentrated in the Midwest on Van Drunen Farms and processed on site or close by. Like peppers, limiting herb production to one geographic location caps the growing season to four to six months. However, unlike peppers, herbs can be harvested multiple times throughout the season. Therefore, the longer the growing season, the greater the economies of scale as fixed harvesting costs can be spread across all production. In the Midwest, the farm can't begin producing Basil until July and there is a hard cutoff for harvesting in early-mid October due to the drastic shift in climate (Figure 3).

Since the profit margins on herbs is already slim, sourcing from abroad was not considered due to the additional tariff charges and expenses associated with shipping longer distances. As such, the possibility to capitalize on utilizing the American Southwest region to extend the growing season thus obtaining additional cuts is a good option. Because of the desert-like conditions during the extreme summer heat, the growing season is actually prior to the Midwest where crops run roughly from October to March; however, different herbs will shift within this timeframe and slightly beyond. Take Maricopa County, Arizona for example, where Basil grows from February to May [3] and San Diego which can grow year-round in frost free areas [4].

Data Analysis

Analyzing the representative inventory data, average sales per month are very stable at ~500,000 lbs. (Figure 3). Due to the sourcing cycle, corresponding inventory levels show cyclicity, peaking in October and steadily declining through May, and only being stocked from July through October. The team inferred that annual demand is expected, and can be reliably predicted to be 6,000,000 lbs. The annual inventory turnover was calculated to be 2.4x (Table 4).

Analyzing the representative harvesting costs data for a 100-acre plot for the Midwest and the Southwest, it is important to note that cost per pound decreases with quantity ordered. As the number of

cuts ordered increases, the cumulative cost per pound decreases. The reason for this is due to high establishment costs, which are fixed at ~ \$60,000 per plot and distributed across each additional pound that is harvested from these fields (Table 5, Figure 4). Due to the shorter summers in the Midwest region, fewer cuts can be made. Thus, from a purely cost minimization standpoint, the following would be minimized:

$$\begin{aligned} \text{Min. Cost} &= (Purchasing_M^{\#} + Transportation_M^{\#}) * Volume_M \\ &+ (Purchasing_S^{\#} + Transportation_S^{\#}) * Volume_S + (Fields_M + Fields_S) \\ &* \text{Fixed Cost s.t.} \end{aligned}$$

$$Volume_M + Volume_S = 6,000,00 \text{ lbs.}$$

$$\text{per pound cost}^{\#}, Southwest^S, Midwest^M$$

The current holding cost is \$206,250 with 2.4 turns expected per year as previously mentioned; however, should the southwest be used entirely opposed to the Midwest, the total harvest cost reduces from \$872,727 to \$814,286.

Two risk evaluation scenarios were analyzed considering the current hurdles the industry is facing - firstly, higher chance of crop failure due to more volatile weather in temperate climates; secondly, shortening of Midwestern summers. Considering a crop failure of 10%, the status quo would cause ~100,000 lbs. of basil demand to go unfilled in June of the following year, whilst a proposed just-in-time dual sourcing model would be able to fulfill all demand (Table 7). Considering a seasonal shortening of 1 month, the status quo would cause 2 entire months (~1,000,000 lbs.) of demand to go unfilled, while the dual sourcing model would come 200,000 lbs. short (Table 8). In both cases, a diversification mechanism would limit the amount of demand that would go unfilled.

Recommendation

Rather than holding large amounts of inventory over time (Figure 3), we recommend shifting the supply chain to support just in time delivery with a slight buffer of inventory (Figure 5). Like the peppers, we even out inventory and processing flow by sourcing from the Southwest in the months where the

Midwest is unable to produce crops. The inventory turns increases from 2.4 to 7.7 and the holding costs are reduced to \$63,937.50. This reflects savings of \$142,312.50 (Table 6).

We recommend that Van Drunen Farms sources more basil from the Southwest, however we are limited by current acreage owned. Therefore, we maximize what we can at 500,000 lbs./month. This strategy also allows VDF to plant less basil in the Midwest and use that land for other herbs or more hearty produce varieties in high demand.

Limitations and Further Research

Since most ingredient manufacturers are privately held companies, there is very low visibility into the supply chains of ingredients manufacturers, let alone for very specific ingredients. As a result, the team was unable to do comparative analyses between the costs of regions being considered by VDF with its competitors. Thus, choices for optimization are limited. If alternatives were available, the optimal sourcing mix could have looked very different. Further research on a longer time-frame and with more primary research opportunities could delve into the possibilities of sourcing 1) other regions and 2) from other farms. The proper S value was unavailable to calculate the official EOQ, thus a rational representation was made through distributing the inventory receipt over the year to minimize the holding costs and decrease the overall procurement costs.

The team's lack of access to sales and pricing data, as well as the location of consumers also limited optimization analysis, as transportation costs from plant to client were not able to be admitted into the analysis. Target service level analyses were not run also for this reason - although further conversation and research revealed that due to the slim margins on frozen produce, the target service level is typically not utilized in industry practice, as suppliers tend to assign substantial value to retaining clients year over year, possibly to keep demand stable and simplify forecasting. Greater transparency in clients' purchasing behavior and the industry landscape would perhaps shed light on an optimal solution to peppers and basil that varies from what is proposed in this paper.

Appendix

Figure 1 - VDF Peppers Inventory Turns (Current Sourcing Method)

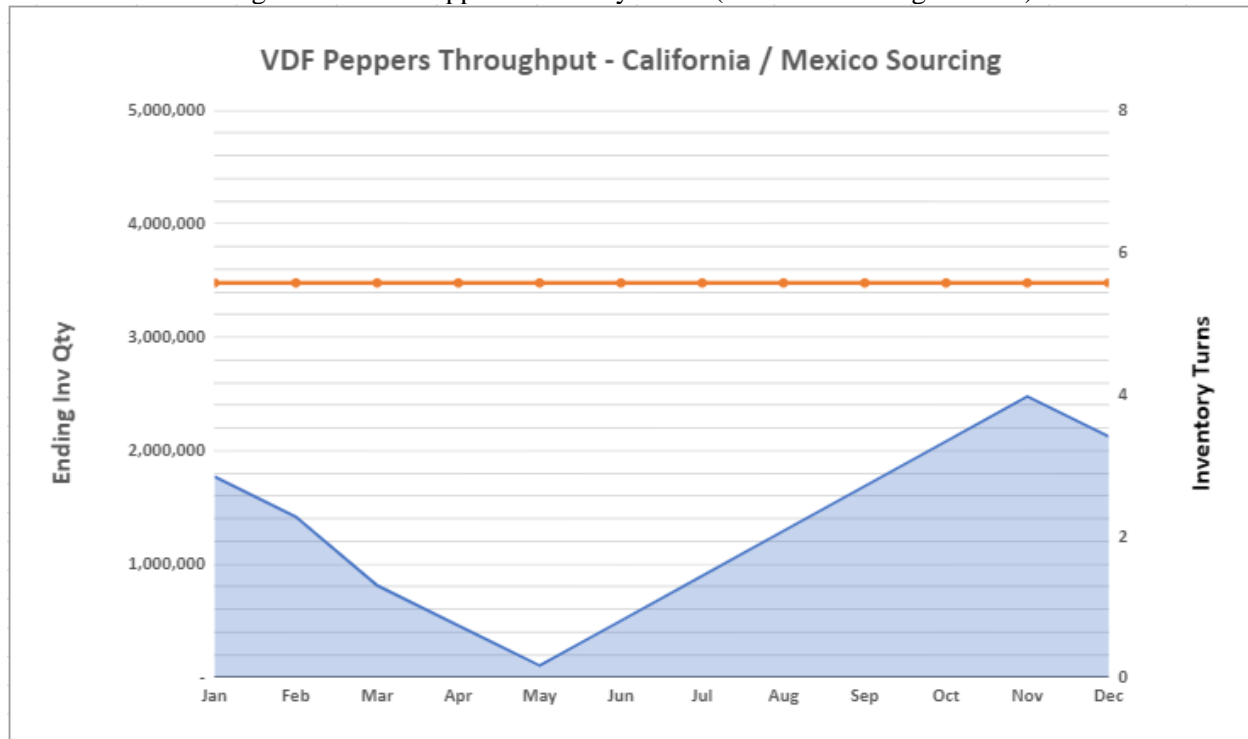


Table 1 - VDF Peppers Yearly Inventory Cost Analysis (Current Sourcing Method)

	Peppers Inventory Analysis											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Starting Qty	2,125,000	1,770,833	1,416,667	812,500	458,333	104,167	500,000	895,833	1,291,667	1,687,500	2,083,333	2,479,167
Jobs	250,000	250,000	-	250,000	250,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	250,000
Sales	604,167	604,167	604,167	604,167	604,167	604,167	604,167	604,167	604,167	604,167	604,167	604,167
Ending Qty	1,770,833	1,416,667	812,500	458,333	104,167	500,000	895,833	1,291,667	1,687,500	2,083,333	2,479,167	2,125,000
Turns	5.568	5.568	5.568	5.568	5.568	5.568	5.568	5.568	5.568	5.568	5.568	5.568
Avg Inv	1,302,083											
Avg Direct Cost/LB	\$1.40											
Annual Carrying Cost of Inv/LB	\$0.08											
Annual Carrying Cost	\$100,260.42											

Figure 2 - VDF Peppers Inventory Turns (Proposed Sourcing Method)

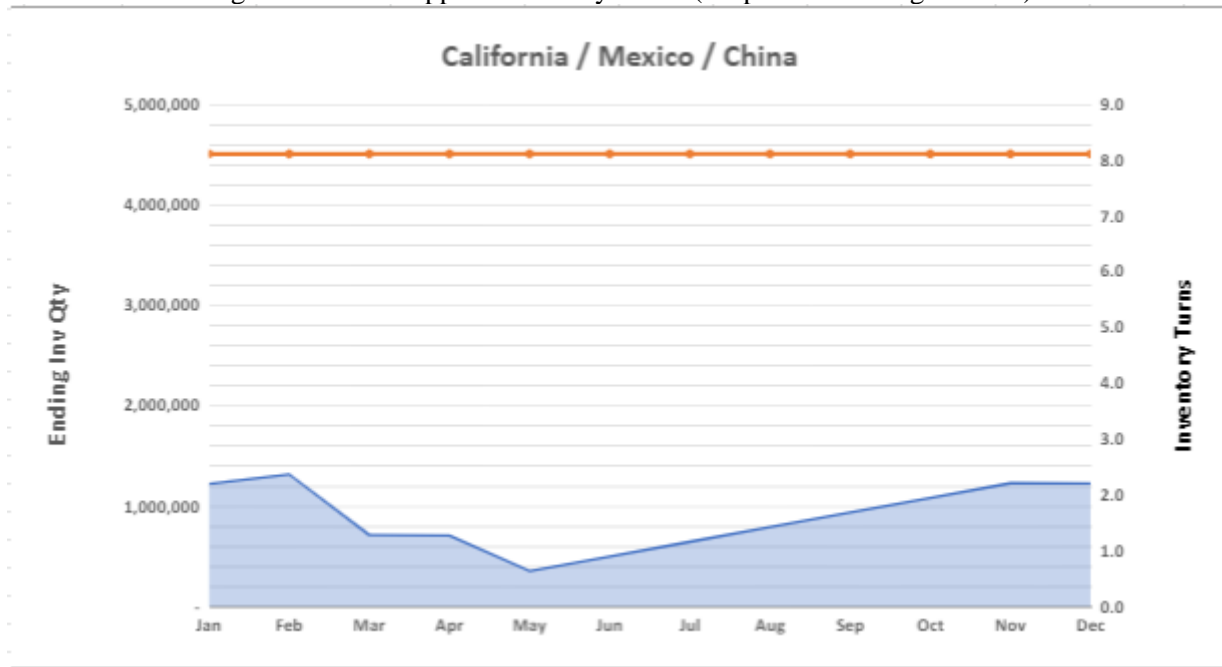


Table 2 - VDF Peppers Yearly Inventory Cost Analysis (Proposed Sourcing Method)

	Proposed Peppers Inventory Analysis											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Starting Qty	1,225,000	1,220,833	1,316,667	712,500	708,333	354,167	500,000	645,833	791,667	937,500	1,083,333	1,229,167
Jobs	600,000	700,000	-	600,000	250,000	750,000	750,000	750,000	750,000	750,000	750,000	600,000
Sales	604,167	604,167	604,167	604,167	604,167	604,167	604,167	604,167	604,167	604,167	604,167	604,167
Ending Qty	1,220,833	1,316,667	712,500	708,333	354,167	500,000	645,833	791,667	937,500	1,083,333	1,229,167	1,225,000
Turns	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Avg Inv	893,750											
Avg Direct Cost/LB	\$1.38											
Annual Carrying Cost of Inv/LB	\$0.08											
Annual Carrying Cost	\$67,639.00											
China Percentage	0.6											
USA Percentage	0.4											

Table 3 - VDF Peppers Yearly Total Cost Analysis (Current vs. Proposed Sourcing Method)

Costs are Per Pound	CA & Mexico	China	Current Strategy		Proposed Strategy		
Purchasing Cost	\$1.25	\$0.80		CA & Mexico		CA & Mexico	China
Transportation Cost	\$0.15	\$0.30	Cost / LB	\$1.40	Cost / LB	\$1.40	\$1.34
Tariff Cost	\$0.00	\$0.24	Volume	7,250,004	Volume	2,900,002	4,350,002.40
Total Cost	\$1.40	\$1.34	Total Cost	\$10,150,008	Total Cost	\$4,080,002	\$5,829,003
Lead Time (Months)	5	10					
							\$9,889,005

Figure 3 - VDF Herbs Inventory Turns (Current Sourcing Method)

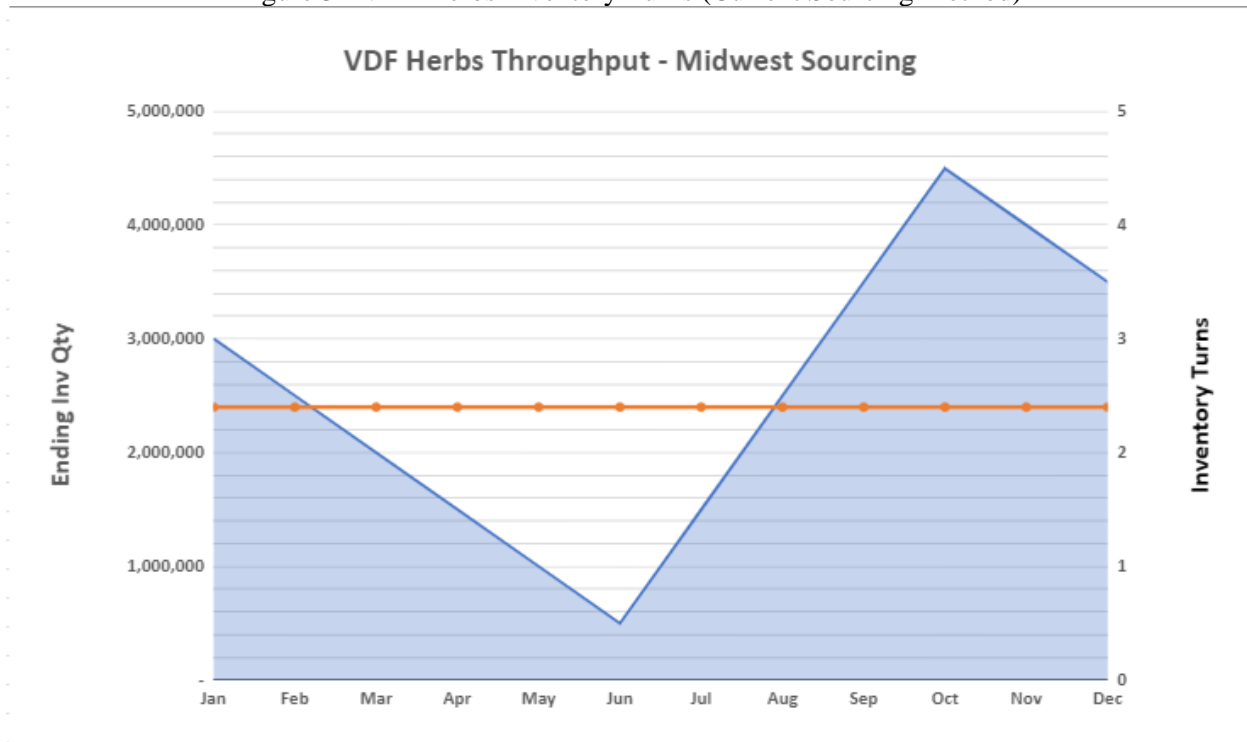


Table 4 - VDF Peppers Yearly Inventory Cost Analysis (Current Sourcing Method)

	Herbs Inventory Analysis											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Starting Qty	3,500,000	3,000,000	2,500,000	2,000,000	1,500,000	1,000,000	500,000	1,500,000	2,500,000	3,500,000	4,500,000	4,000,000
Jobs	-	-	-	-	-	-	1,500,000	1,500,000	1,500,000	1,500,000	-	-
Sales	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Ending Qty	3,000,000	2,500,000	2,000,000	1,500,000	1,000,000	500,000	1,500,000	2,500,000	3,500,000	4,500,000	4,000,000	3,500,000
Turns	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Avg Inv	2,500,000											
Avg Direct Cost/LB	\$1.50											
Annual Carrying Cost of Inv/LB	\$0.08											
Annual Carrying Cost	\$206,250.00											

Table 5 - VDF Herbs Yearly Total Cost Analysis (Current vs. Proposed Sourcing Method)

100 Acre Field	Basil Cost/lb					Cut Possible?	
	Cost	Qty Harvested	Cumulative Cost	Cumulative Lbs	Cost/LB	Midwest	Southwest
Establishment Costs	\$ 60,000	-	\$ 60,000	-	-	-	-
1st Cut	\$ 25,000	250,000	\$ 85,000	250,000	\$ 0.34	Yes	Yes
2nd Cut	\$ 25,000	300,000	\$ 110,000	550,000	\$ 0.20	Yes	Yes
3rd Cut	\$ 25,000	300,000	\$ 135,000	850,000	\$ 0.16	Yes	Yes
4th Cut	\$ 25,000	250,000	\$ 160,000	1,100,000	\$ 0.15	Yes	Yes
5th Cut	\$ 25,000	200,000	\$ 185,000	1,300,000	\$ 0.14	No	Yes
6th Cut	\$ 25,000	200,000	\$ 210,000	1,500,000	\$ 0.14	No	Yes
7th Cut	\$ 25,000	200,000	\$ 235,000	1,700,000	\$ 0.14	No	Yes
8th Cut	\$ 25,000	200,000	\$ 260,000	1,900,000	\$ 0.14	No	Yes
9th Cut	\$ 25,000	200,000	\$ 285,000	2,100,000	\$ 0.14	No	Yes
	Midwest	Southwest					
Total Lbs/Acre	11,000	21,000					
Total Cost/LB	\$0.145	\$0.136	Southwest Savings				
Total Cost	\$872,727	\$814,286	\$58,442	6.70%			

Figure 4 - VDF Herbs Harvest Cost per Cut

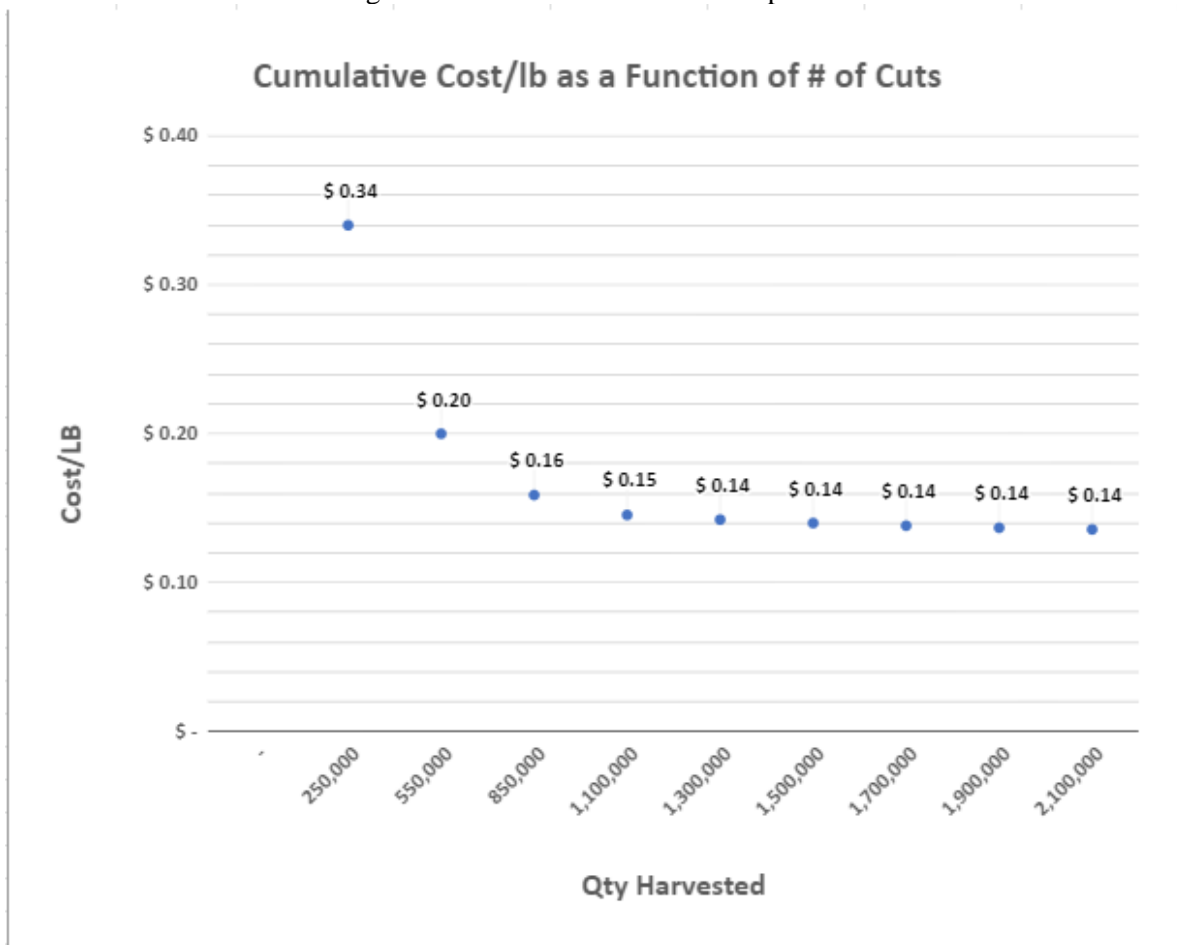


Figure 5 - VDF Basil Inventory Turns (Proposed Sourcing Method)

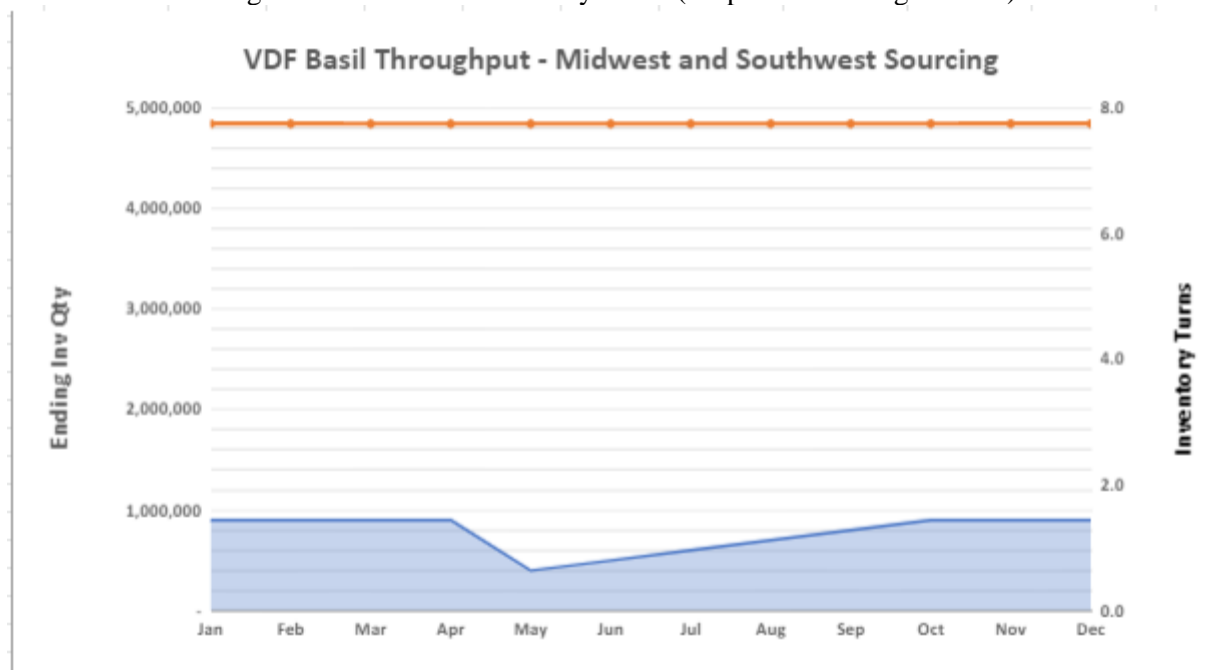


Table 6 - VDF Basil Yearly Inventory Cost Analysis (Proposed Sourcing Method)

Basil Inventory Analysis - Midwest and Southwest												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Starting Qty	900,000	900,000	900,000	900,000	900,000	400,000	500,000	600,000	700,000	800,000	900,000	900,000
Jobs	500,000	500,000	500,000	500,000	-	600,000	600,000	600,000	600,000	600,000	500,000	500,000
Sales	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Ending Qty	900,000	900,000	900,000	900,000	400,000	500,000	600,000	700,000	800,000	900,000	900,000	900,000
Turns	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
Avg Inv	775,000											
Avg Direct Cost/LB	\$1.50											
Annual Carrying Cost of Inv/LB	\$0.08											
Annual Carrying Cost	\$63,937.50											

Table 7 - Basil Crop Failure Fill Analysis

Crop Failure (10%)												
10%												
Midwest												
Starting Qty	3,500,000	3,000,000	2,500,000	2,000,000	1,500,000	1,000,000	500,000	1,350,000	2,200,000	3,050,000	3,900,000	3,400,000
Jobs	-	-	-	-	-	-	1,350,000	1,350,000	1,350,000	1,350,000	-	-
Sales	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Ending Qty	3,000,000	2,500,000	2,000,000	1,500,000	1,000,000	500,000	1,350,000	2,200,000	3,050,000	3,900,000	3,400,000	2,900,000
Midwest + Southwest												
Starting Qty	900,000	900,000	900,000	900,000	900,000	400,000	500,000	540,000	580,000	620,000	660,000	660,000
Jobs	500,000	500,000	500,000	500,000	-	600,000	540,000	540,000	540,000	540,000	500,000	500,000
Sales	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Ending Qty	900,000	900,000	900,000	900,000	400,000	500,000	540,000	580,000	620,000	660,000	660,000	660,000

Table 8 - Basil Season Shortening Fill Analysis

Season Shortens												
Midwest												
Starting Qty	3,500,000	3,000,000	2,500,000	2,000,000	1,500,000	1,000,000	500,000	1,500,000	2,500,000	3,500,000	3,000,000	2,500,000
Jobs	-	-	-	-	-	-	1,500,000	1,500,000	1,500,000	0	-	-
Sales	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Ending Qty	3,000,000	2,500,000	2,000,000	1,500,000	1,000,000	500,000	1,500,000	2,500,000	3,500,000	3,000,000	2,500,000	2,000,000
Midwest + Southwest												
Starting Qty	900,000	900,000	900,000	900,000	900,000	400,000	500,000	600,000	700,000	800,000	300,000	300,000
Jobs	500,000	500,000	500,000	500,000	-	600,000	600,000	600,000	600,000	0	500,000	500,000
Sales	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Ending Qty	900,000	900,000	900,000	900,000	400,000	500,000	600,000	700,000	800,000	300,000	300,000	300,000

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