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UNDERSTANDING THE ECONOMIC SUSTAINABILITY OF STRAWBERRY FARMING IN NORTH CAROLINA

Saman Janaranjana Herath Bandara
University of Mount Olive, Tillman School of Business, USA
Email: sbandara @umo.edu, ORCID ID: orcid.org/0000-0001-9763-922X

Abstract:

In the field of vegetable and fruit production, Strawberry is a high value product, that shows potential economic benefits for growers. In North Carolina, strawberry farming shows a strong growth potential, where most producers sell directly to consumers through pick-your-own, roadside stands, and some commercial and industrial levels. This study attempts to understand and evaluate the economic potentials of strawberry production in North Carolina, using data for the period of 1980 – 2018. Data was collected from the United States Department of Agriculture (USDA), North Carolina Department of Agriculture and Consumer Sciences (NCDA&CS), U.S. Bureau of Labor Statistics, U.S. Bureau of Census & U.S. Bureau of Economic Analysis. Ordinary least squares method was used to estimate the parameters of the Cobb-Douglas production function to analyze data. The results indicate significant and positive relationships of strawberry farming with changes in labor and household income. Furthermore, the results indicate that production is decreasing as the number of strawberry farms decreases, while production per acre is increasing. The results imply that strawberry farming is supported by the increase in price per CWT (Price per 1000 pounds) of strawberries. Policies to enhance strawberry production with other supportive services can provide more economic benefits to North Carolina strawberry farmers.
Keywords: *Economic sustainability, Strawberry farming, North Carolina.*
JEL Codes: *Q10, Q12, Q13, Q18*

1. Introduction

Strawberries are widely cultivated, in high demand and consumed all over the world. The United States is the second largest producer of strawberries by 2020, while China takes the lead. Mexico, Turkey, Egypt, Spain, Russia, South Korea, and Poland are the other main producers (Strawberry, n.d.). Among the favorite fruits of Americans, strawberries are leading with high in vitamin C, fiber, folate, and potassium. It says that an individual should eat a serving of eight strawberries a day (USDA, 2012). Clinical research highlights the health benefits of improved heart and brain health, reduced risk of certain cancers, and better management of type 2 diabetes with strawberries (Basu et al., 2014; Seth et al., 2014; American Diabetes Association, 2015; Devore et al., 2012). In the United States, fresh strawberries are primarily grown in the states of California and Florida, followed by New York, North Carolina, Oregon, and Washington states (NASS, 2019). In 2011, the United States produced more than 3,015 million pounds of strawberries (FAO, 2015). In the United States, commercial strawberry production is primarily based on annual hill production (AHP) systems (Poling, 2015), which is a system relies on the combination of plastic mulches and pre-plant fumigants that helps mitigate soil-borne diseases and weeds, conserving soil moisture, and reaching profitable yields (Wu et al., n.d.). The farm gate economic value of the strawberry production was between $2.3 billion and $2.8 billion during the past 2-3 years

(USDA, 2017). The strawberry income is mainly generated from fresh fruit sales through direct marketing from growers to consumers or direct sales to grocery stores, wholesale providers, restaurants, etc. (Samtani, et al., 2019). In 2017, nearly 91 percent of strawberry was produced in California, 8% was produced in Florida, and all other states combined (North Carolina, Oregon, and Washington) produced the other 1 percent (USDA, 2018). According to USDA (2019), the average grower price for fresh strawberries was $125/hundredweight for the year 2017.

The United States fresh - market-strawberry production shows an upward trending with the increasing demand for more fruits and vegetables, with changing eating habits, increasing awareness of the health benefits associated with berry consumption and year -round availability of strawberries with different varieties with increased production and increased imports (Wu, et al., n.d.; AGMRC, 2019). For instance, the average strawberry consumption has increased significantly during the past two decades, from 2 pounds per person in 1980 to 8 pounds in 2013 (USDA, 2014). The United States imports berries, especially during the off-season mainly from Mexico (Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food, 2014), and it was the fourth largest importer of fresh strawberries, reaching a record 351 million pounds in 2012 (Wu, et al., n.d.). The United States is one of the major exporters of strawberries as well. In 2013, US fresh strawberry exports totaled 339 million pounds, with a value of US$467.8 million, which was second to the Spain (Wu, et al., n.d.)). Canada is the number one importer of US fresh strawberries.

1.1 Strawberry Farming in North Carolina

In North Carolina, strawberry production is highly decentralized, and relies mainly on small- to medium-size family farms, selling on direct markets (NCSU-Extension (n.d.). Most of the strawberries produced is for direct marketing and the most popular ways are U-pick, ready-pick (pre picked) berries at the farm, roadside stands, satellite markets and farmers markets. Nearly half of the strawberry production is coming from a few large farms that produce a minimum of 10 acres of fruit. The remaining is from small farms with 1 to 3 acres (Wu et al., n.d.). North Carolina reports nearly 2,000 acres of plasticulture production of strawberry in the state. Some mountain areas and the parts of Piedmont report limited amounts of commercial matted row (MR) production as well (Fernandez, 2001). The plasticulture system has largely replaced MR system in most parts of the state. There are several strawberry varieties that are popular in North Carolina and each of these varieties have their own uniqueness to be popular ("Production Methods", n.d.). The popular plasticulture strawberry cultivars are Chandler, Camarosa and Sweet Charlie (Fernandez, 2001). The plasticulture production is more popular among U-pick customers while prepicked production is popular among the rural growers as it can be successfully sold at satellite stands, farmers markets, high-end supermarkets, and restaurants (NCSU- Extension, (n.d.)). For decades, the predominant system was the matted row system (MR) and is widely known for the growth and development of strawberries (Fernandez, 2019). However, the introduction of plasticulture systems, increased production, quality, and better disease and weed control (Fernandez, 2001; Durner et al., 2002; Johnson & Fennimore, 2005; Greene et al., 2010), though the put down of new plastic every strawberry system can become expensive in this production (Nyoike, 2014). There are several other cost factors involved in the production of strawberries for land preparation, pre-planting, transplanting, dormancy, pre-harvesting and harvesting. The total annual production, harvest, and marketing costs for a plasticulture production system in North Carolina is estimated to be $13,540 per acre (Safley, 2004). Nearly half of the cost is for material inputs, while labor costs made up around one-third of the total cost (Safley, 2004). An issue that impacts the strawberry industry is Methyl Bromide regulations (MeBr). MeBr is a highly effective broad-spectrum fumigant use to control insects, nematodes, weeds, and pathogens but not good for the environment in the long run (Awja et al., 2003; Sydorovych, 2006). However, strawberry production has significant growth potential, particularly in the southeastern United States and in North Carolina (Garland, 2011).

1.2 Objectives and Research Questions

In North Carolina, strawberry farming is getting popular with the increasing demand by consumers. However, to meet the demand, growers need to know the efficient production practices, marketing mechanisms, and others specific factors related to the region. Therefore, it is important to measure differences with the challenges, potentials, and opportunities in North Carolina to guide producers, marketers, researchers, and policy makers to improve the strawberry production. It is important to be familiar with the current production systems, varieties/cultivars as well as future economic trends for strawberry farming specific to North Carolina. The regional challenges like pest control, pesticides and chemical usage, labor requirements, labor availability, climate and weather impacts, technologies and applications, network communication, and other relevant agricultural activities are essential to understand (Poling, 2015; Santos et al., 2012; Samtani et al., 2016; Karst, 2018; Jyoti and Singh, 2020).

Even though the research studies are abundant for strawberry farming in the United States as a whole, and for the leading states like California and Florida, studies are limited to North Carolina. These limited studies are mainly concerned with basic production practices, varieties, and other horticultural aspects. Therefore, other studies, such as economic estimates, are key to discussing strawberry farming in North Carolina. Due to the lack of research mentioned above, the current study attempts to find answers to the following research questions:

- What is the potential of strawberry farming in North Carolina?
- Is strawberry cultivation economically feasible in North Carolina?

With significance of the above research questions, the study has the following objectives:

- To understand the factors affecting strawberry farming in North Carolina
- To estimate the strawberry production function using data for the period of 1998-2018
- To propose effective and practical policy suggestions to enhance strawberry farming in North Carolina.

2. Materials and methods

2.1 Background of the Study Area

North Carolina is the 28th largest state with a relatively high population density, with 10.5 million people at present (Census Bureau, n.d.). It shows a steady increment of population every year with healthy natural growth and net immigration. North Carolina agriculture is diverse, and the state's 46,000 farms produce top commodities and crops, with the typical farm averaging about 182 acres in size. Farmland makes up 8.4 million acres of the state's land. The state is one of the leading producers of sweet potatoes, tobacco, Christmas trees, hogs, turkeys, trout, strawberries, and pickling cucumbers in the United States (USDA, 2016). The state reports the commodities of broilers, eggs, blueberries, peaches, peanuts, apples, catfish, watermelons, tomatoes, corn, soybeans, cotton, cattle, grapes, and squash as well. The state's agriculture sector contributes around $78 billion to its economy, and it provides 17% of all jobs in North Carolina (USDA, 2016). The median household income is around 54,600 US dollars in 2020 (Census of Bureau, n.d.) which increases annually.

Small scale strawberry farming can be seen in many counties of the state, and the prominent season is from mid-April until the end of May. However, it depends on whether and how quickly the strawberries are picked as well. North Carolina Strawberry Association (NCSA) is the key organization working to promote strawberry production and marketing (NCSA, n.d.). The organization funds strawberry research projects for producers, operates monthly newsletters, training programs, harvest-time media campaigns, recipe brochures as well as promotions in cooperation with the NC Dept. of Agriculture.

2.2 Description and Data Sources

To estimate strawberry production in North Carolina, annual data on strawberry production, prices, harvesting acreages, number of farms and other demographic data at the state level were collected for the period from 1980 to 2018. The data for strawberry production, prices, harvesting acreages and values were collected from the United States Department of Agriculture (USDA), the North Carolina Department of Agriculture and Consumer Sciences (NCDA&CS) and the U.S. Bureau of Labor Statistics. Income, education, crime rate and other data were gathered from the U.S. Bureau of Census and U.S. Bureau of Economic Analysis. Number of labor hours of strawberry production was calculated using a proxy, multiplying the estimated average number of labor hours for one acre of strawberry cultivation assessed by the Strawberry Growers information of NC State Extension (Budget /Cost Estimates, NC Extension) by number of cultivated acres collected from the Bureau of labor statistics (see Table 1).

Table 1. Labor Estimates for Strawberry Production in Hours

Activity	**Labor**	**Percent Total**
Land Preparation	27.6	1.26%
Pre-Plant	24.10	1.10%
Transplant	47.26	2.15%
Dormant	83.78	3.81%
Pre-harvest	97.46	4.44%
Harvest	1917.24	87.25
Total (annual)	2197.44	100.00%

Source: Budget and Cost Estimates (n.d.). NC Extension, Strawberry Growers Information. Retrieved from https://strawberries.ces.ncsu.edu/strawberries-budgets/

2.3 Formulation of Empirical Model

Agricultural productivity can be examined from different perspectives, such as the productivity of land, labor and capital. Different types of economic models can be used to measure this, and Cobb-Douglas production function approach is one of them. The Cobb-Douglas production function models the relationship between production output and production inputs (Cobb & Douglas, 1928). The estimation of the parameters of the function can be used to calculate ratios of inputs to one another for efficient production and to estimate technological change in production methods. The model has the benefit of permitting hypothesis as well as testing the reliability of estimations (Dharmasiri & Datye, 2011). The model is more flexible, and it measures the marginal contributions of each input variable to aggregate output. The Cobb Douglas function is still the most abundant form in theoretical and empirical analyses of productivity and growth. The researchers in the agricultural sector have been endeavoring to measure agricultural productivity by using different input parameters of labor, technology, and other physical capital (Han et al. 2013; Liang & Xiu-Juan, 2010;

Vanloon, Patil & Hugar 2005; Bravo-Ortega & Lederman, 2004; Weijun, 2007; Shafi, 1984; Dunajewski H., 1981; Bardhan,1973; Fruit., 1962).

The general form of the Cobb-Douglas function is:

$Y = a.\prod_i x_i^{\beta_i}$ Avec a>0, $\beta_i \geq 0$, $i = 1 \ldots . n$ (1)

where, x_i represents the factors of production, βi the elasticity of production with respect to factor $_i$

Taking logarithm of the equation (1), linear model of can be taken as

$\ln(Y) = \ln(a) + \sum_i \beta_i . \ln(x_i)$ (2)

When considered the general form of the application of the Cobb Douglas function for two factor productions:

$Y = c\, K^{\alpha}\, L^{\beta}$ (3)

where Y is the level of output, c is a constant, K is capital and L is labor, and α, β are coefficients. With the condition of linearity, the sum of the exponents is equal to 1. The expression of the function is then of the type:

$Y = c\, K^{\alpha}\, L^{1-\alpha}$ (4)

When the sum of the coefficients is equal to 1, the returns to scale are constant, means that if inputs are increased by a certain percentage, output is increased by the same percentage.

Therefore, from equation (1), the functional form can be written as:

$Y = Ax_1^{\beta 1} x_2^{\beta 2} x_3^{\beta 3} \ldots \ldots \ldots \ldots \ldots . x_n^{\beta n}$ (5)

$\log Y = a + \beta_1 \log x_1 + \beta_2 \log x_2 + \beta_3 \log x_3 \ldots\ldots\ldots + \beta_n \log x_n$ (6)

Where Y = output; x_i = inputs; a = constant; β_i = production elasticities with respect to input i

2.4 Empirical Model

Beginning from the functional form of Cobb Douglas function at equation 6, the estimated econometric model for Strawberry productivity can be written as:

$LYPA = \beta_0 + \beta_1 \text{LTTL} + \beta_2 \text{ LINC} + \beta_3 \text{LFAM} + \varepsilon_t$ (7)

Where, LYPA is the logarithm of Strawberry productivity, LTTL is the logarithm of total labor hours per year, LINC is the logarithm of average household income, LFAM is the logarithm of number of farms. β_0 is the constant term. β_i are elasticity of productivity with respect to the corresponding input parameters; ε_t is the error term.

The considered variables and the expected theoretical signs of the associated parameters are presented in Table 2.

Table 2. Definition of Variables Considered for the Analysis at State Level

Variables	Description and Unit	Expected Effect
YPA (D.V.)	Strawberry yield per acre per year (in1000 lbs).	N/A
TTL	Total labor hours per acre per year	+
FAM	Number of Strawberry Farms per year	+
P/CWT	Price per CWT of strawberry in dollars	undetermined
PAC	Planted Acreage of strawberry per year in acres	+
HAC	Harvested Acreage strawberry per year in acres	+
INC	Average household income per year in dollars	+
CRM	Crime rate per 100000 people per year	undetermined
EDU	Number having bachelor’s degree or more per year	undetermined

Source: Author's construction from the literature review.

3. Results and Discussion

3.1 Descriptive Analysis

The summary statistics of the variables for the period of 1980 to 2018 at the state level are presented in Table 3. The table shows the average strawberry yield per acre per year (YPA) is 9.18 and it ranges from 2.6 to 13.5. This higher deviation could be associated with the different geographical and farming factors. The average Total labor hours per acre per year (TTL) 3,689 and its standard deviation is 598, which indicates a high value, may be due to differences in cultivation practices. The average number of Strawberry Farms per year (FAM) is 373 and it indicates the number ranges from 60 to 500, increased and decreased in time to time for the period of 1980-2018. This could be affected by many factors of farm consolidation, diseases, price impacts, etc. The average price per CWT (1000 lbs) of strawberry is 89.84 dollars and its standard deviation is 41.51 dollars. Thus, it indicates a high price fluctuation throughout the study period. Average planted acreage of strawberry per year in acres (PAC) and the average harvested Acreage strawberry per year in acres (HAC) are 1,679 and 1,566. The difference shows that in average 113 planted acreage is not harvested. The average annual household income (INC) of the state is 35,060 dollars, and the minimum reported 20,569 dollars and the maximum was 54,603 dollars. The average crime rate per 100,000 people per year (CRM) is 4,578 and the average number having bachelor's degree or more per year (EDU) is 951,732. In both cases, high standard deviations indicate that average numbers found hiding disparities of the variables.

Table 3. Descriptive Statistics of Variables at State Level

Variable	Mean	Std. Dev.	Min	Max
YPA (D.V.)	9.182051	4.146011	2.6	13.5
TTL	3689.833	598.879	2416.7	4613.7
FAM	372.5897	60.60863	279	500
P/CWT	89.84615	41.51825	50	187
PAC	1679.487	272.5894	1100	2100
HAC	1566.667	266.6393	1000	2000
INC	35059.72	10158.66	20569	54603
CRM	4578.884	928.7357	2361.2	5999.6
EDU	951732.3	255650.2	450423	1307251

Source: Author's calculation based on data.

Figure 1 shows the change of YPA over the period of 1980-2018. The YPA has been increased from 1980 till 2000 and then after remained at a level of 12- 14 thousand pounds per year. Simply, the graph suggests that strawberry farming is getting popular in North Carolina though the number of farms has been decreased with the time being (see figure 2). Figure 3 shows the price paid for CWT which has been increased time being. Both figures 1 and 3 indicate that high price per CWT has increased the strawberry production in North Carolina.

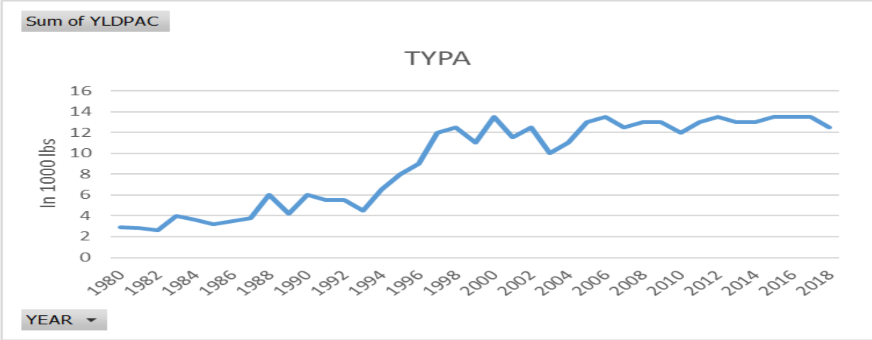

Figure 1. Total Strawberry Production per acre per year in 1000 lbs

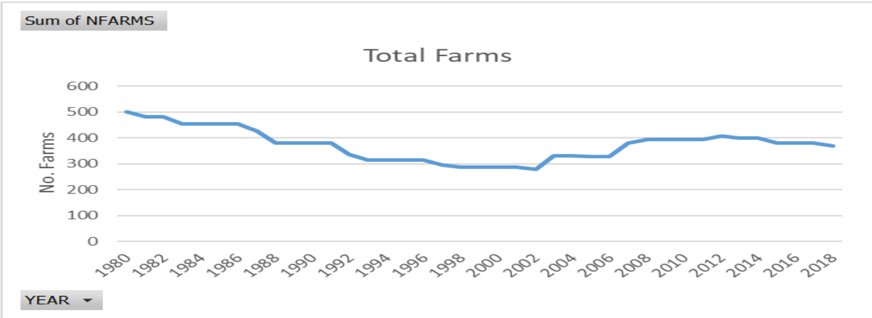

Figure 2. Total Number of Strawberry Farms (1980 -2018)

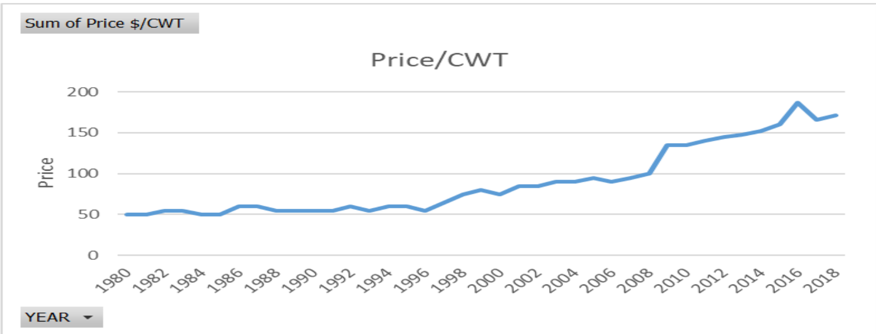

Figure 3. Price per 1000 Pounds (CWT) of Strawberry (1980 – 2018)

3.2 Econometric Analysis

Table 4 presents the estimation of strawberry productivity (Cobb Douglas) function using the ordinary least squares method. To verify the model specification and clarity of the method, multicollinearity and heteroscedasticity were tested. Multicollinearity is the occurrence of high intercorrelations among independent variables in a multiple regression model. One way of measuring this is the variance inflation factor (VIF) that assesses how much the variance of an estimated regression coefficient increases if predictors are correlated. Generally, the VIF value between 5 to 10 indicates high correlation. As none of the VIF values were more than 5 in this estimation and the selected independent variables were not inter-correlated (Appendix - see table 1).

Heteroskedasticity is a condition in which the variance of the residual form varies widely in a regression model leading the analysis results may be invalid. Heteroskedasticity can be identified using several tests and one is the Breusch-Pagan / Cook-Weisberg test that used in this study. Breusch-Pagan / Cook-Weisberg tests the null hypothesis that the error variances are all equal versus the alternative that the error variances are a multiplicative function of one or more variables. The chi-square value indicates the heteroskedasticity and smaller the value lowers the probability of heteroskedasticity (Appendix – see table 2).

Table 4. Regress results for strawberry production (log-log): Dependent variable = LYPA

Variable	Coefficient	Std. Err.	T Value	P Value
LTTL	0.50457*	0.30376	1.66	0.104
LINC	1.89291***	0.19747	9.59	0.000
LFAM	-0.43810**	0.21903	-2.00	0.053
Cons.	-19.1927	5.39817	-3.56	0.001
N = 39: F =166.74; R^2 = 0.9346: Adj R^2 =0.9290				

Note: (*), (**), (***) Significant at 10%, 5% and 1%, respectively.

Regression results for the log- log estimation of strawberry yield per acre per year (YPA) with respect to the total labor hours (TLL), average household income per year (INC) and number of strawberry farms per year (FAM) are in Table 4. The F value and R^2 values show that the proposed model was statistically significant and was correctly defined overall. R^2 value was found 0.9346, thus it shows that around 93 percent variation in strawberry production can be explained by undertaken variables. The coefficients associated with the variables are elasticities of productivity with respect to the same variables. The coefficient of each independent variable is interpreted as the percentage of productivity for a one-unit change in the independent variable, when all other variables having remained constant.

There is a positive and significant relationship between total labor hours per acre per year (LTTL) and yield of strawberry per acre (LYPA). An increase of one percent of labor hour per acre translates into an increase in productivity of 0.50% per acre. That means more labor hours spent on strawberry production process, helping to increase the yield. This labor usage could be any stage of the production from growing to the final harvesting. Thus, it indicates the need of proper and efficient use of labor, might be skilled labor, to enhance the farming and production capabilities. Moreover, the result suggests the importance of labor management, with a higher percentage of labor hours is needed for harvesting strawberry (Budget and Cost Estimates, n.d.; Guan, Wu & Whidden, 2017). For instance, more facilities towards "U-pick" would cut down the labor shortages, especially with the limited skilled farm labor availability in North Carolina (Samtani et al., 2019).

The results show that strawberry productivity, yield per acre per year (LYPA) is positively and significantly related with an average household income per year (LINC). When the average household income of North Carolinas is increased by one percent the yield per acre is increased by 1.8 percent. This implies that increasing household income effect in more human & capital allocation, production efficiency, and technological process on strawberry production in one way (Mishra et al., 2002) and another increases the demand for more healthy fruits like strawberries (Lallukka et al.,2007; Roos et al., 2008). Results validates the NCSA key role in funding, training, and promoting programs in cooperation with the NC Dept. of Agriculture (NCSA, n.d.). According to American Farm Trust, planning for economically and environmentally sustainable agriculture with reduced regulatory barriers, encouraged policies that support infrastructure development, new farming opportunities, and farm tenure and transfer could increase the income of farming communities. (American Farm Trust, n.d.)

The results reveal a negative and significant relationship between strawberry productivity (LYPA) and the number of strawberry farms (LFAM). According to results, when the percentage farms increased by one percent, the productivity decreased by 0.4 percent. According to various research findings, this could be due to many reasons like management & production inefficiencies with some factors like lack of skilled labor, inputs, financial related issues, harvesting and marketing issues, or any other effects (Rudra, 1968; Mitchell et al., 1996; Salami et al., 2010; Rahman et al., 2013). Further, the number of farms could be increased without increasing the acreage as well. However, it needs more information related to each strawberry farm to identify the exact reasons.

4. Conclusions and Policy Recommendations

North Carolina ranks the fourth leading strawberry producer in the United States. Strawberry growing is a high-value product that has potential economic benefits for North Carolina producers due to increased consumer demand and favorable farming conditions. The primary objective of this study was to understand and evaluate the factors affecting strawberry production in order to discuss possible policy suggestions for improving strawberry production in North Carolina. The results reveal the potential for economic gains with increased labor, increased income change, and higher market prices for strawberries.

Therefore, the state government and agricultural authorities need policies to allocate more funds to expand education and training programs on strawberry cultivation, particularly in farming communities. This can be done through the various agricultural programs in secondary schools, community colleges and universities, as well as non-profit agricultural associations.

Further, the private and public sectors can implement collaborative policies to strengthen strawberry marketing channels to maximize product value. Both direct and indirect marketing systems should improve while improving consumer knowledge, preference, understanding, and demand for strawberries.

Finally, strawberry farmers should seek high-yield strawberry varieties, quality products, efficient farming techniques, handling and practices that improve the demand for their production.

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Appendix

Table 1. Test for Multicollinearity: vif

Variable	VIF	1/VIF
LINC	6.06	0.165075
LTTL	4.81	0.207728
LFAM	2.09	0.478372
Mean VIF	4.32	

Table 2. Test for Heteroscedasticity: hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity Ho: Constant variance Variables: fitted values of LYPA chi2(1) = 0.85 Prob > chi2 = 0.3552