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Predicting Size and Length of Apple at Harvest

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Abstract

This study aims to know the time between apple production and marketing to help decision makers for apple products at Washington, in the USA. In order to do so, it needs an application of OLS for a linear and non- linear model for diameter apples and length apple over the years 2010-2013. The diameter or size apple linear model includes DAFB, FB, latitude, mean80, years, and FB. The results indicated that all independent variables are significant and Adj R-squared explains about 75 percent of diameter apple. While the length apple linear model includes DAFB, years, FB, longitude, elevation, latitude, mean120, and mean70.The resulted sate that all independent variables are significant and Adj-R-squares illuminates about 84percent of size apple. Moreover, Actual value and predicted values for linear and nonlinear models are very close. Thus, those models can help farmers make a good decision for apple industry, and achieve to get best size and length for their apple crop.

Keywords: apple production, apple marketing, Washington

1. Introduction

The United States is one of the main countries in the world that leading, importers, producers and supplier for fresh apples and commercial apple production is very common in the United States. Washington State is a leader state for producing apple fruit in the United States. Washington State has produced more than half of US production of the fresh market crop, including apples, and is the about 65% producer of apples in the Nation's annual output. It is clear that there is a gap between domestic fresh market, and production from processing to market since the 1980s, which leads to getting more profit. U.S. apple production has increased compared to the past, especially in Washington State (USDA, 2016).

Accordingly, apple fruits play the main source for Washington economy, and it gets more care because of exporting to local, and international market. Washington State is the famous producer of the crop, and apples are the major product in Washington. Similarly, Washington State is the first state for producing apples in the United States. The total production of apples in Washington is 180,000 acres (WSDA, 2015). It seems that agricultural and crop is most important income for Washington economy, and farmers need more help from policy decisions in order to make a good decision for them between demand and supply of apples and other agricultural product. Agriculture plays a major role in Washington State economic. It is one of the main sources to the state's GDP, which it adds about $55 billion yearly. In addition, more than 39,000 farms are located in Washington. Washington State has ranked 14th in the nation in production, commodity and it is the 1st one in apple production. Note, if the apple production produces placed side by side in 2015, they will be an earth circle about 29. Washington apple growers and farmers' apples are hurt because their products for shipment and marketing problems. Washington state apple growers have estimated the lost about $100 because of the same reasons (Chris, 2016).

2. Objective

The objective of this paper is to make a prediction model to help for decision makers on apple harvest. This paper aims to get a model to predict both mean apple size, and mean length apple at harvest season based on the data providing. We will select the best models can be useful for the marketing and harvest seasons.

3. Data and Methodology

The model focuses on data that get from apples to grow in different locations (Note 1) in Washington State. The limited time period of data (Note 2) used in this paper from 2010 to 2013. The major methodological uses in this paper are that running different linear and non-linear regressions to estimate length and size of apples for different stages of their growing. Then, we use the stepwise method to select the best models for developing mean length and mean diameter, and comparing for predicting diameter and length means of apples at harvest seasons. Stepwise method have used for selecting best independent variables for running the regression. We used an OLS method for time series, which is a good choice for running the regression for our models.

3.1 Summary Statistics

Table 1. Summary statistics for test sample with mean D

Variable	N	Mean	Std Dev	Minimum	Maximum
mean_D	557	2.2655893	0.6735124	0.2087397	6.1486000
Year	557	2011.61	1.1586860	2010.00	2013.00
FB	557	117.5116697	7.2500526	107.0000000	136.0000000
DAFB	557	100.6247756	36.5118138	7.0000000	182.0000000
lat	468	47.1726496	0.6102443	46.2000000	47.8000000
lng	468	120.1042735	0.1957331	119.9000000	120.5000000
ele	468	1150.91	507.3951555	690.0000000	2321.00
mean20	99	0.5453143	0.0627547	0.4759439	0.6496444
mean30	209	1.7360493	1.8915910	0.7202468	6.1486000
mean40	368	1.2075531	0.2525747	0.7654500	1.6102000
mean50	434	1.5771977	0.1760739	1.1878171	1.8994000
mean60	466	1.8294882	0.1721415	1.4601643	2.1442000
mean70	546	1.9647143	0.1903987	1.4884153	2.3022944
mean80	557	2.1675566	0.2018835	1.3873988	2.5856169
mean90	557	2.3124522	0.2153104	1.5388158	2.6266558
mean100	503	2.4668150	0.2125336	1.6522014	2.7580194
mean110	557	2.5981742	0.2113651	1.7155084	2.8792000
mean120	557	2.6832172	0.2125597	1.7470831	2.9798417
mean130	557	2.8038681	0.2197064	1.7833035	3.0724556
mean140	543	2.8234213	0.2342932	1.8839726	3.1393319
mean150	481	2.7957311	0.3068670	1.9333032	3.1744961
mean160	290	2.8728300	0.2687797	2.1702516	3.2925641

Note. mean D= mean diameter of apple, FB = Full Bloom, DAFB = Days after full bloom, Mean = Average size of apple (averaged across 50 apples in the same lot) measured at various growth stages (DAFB). lat=latitude, lng=longitude, and ele=elevation.

Mean diameter (mean D) being 2.3 with minimum .2 and maximum 6.1

Mean Full Bloom (FB) being 117.5 with minumum107.0 and maximum136.0.

Mean DAFB being 100.5 with minumum7.0 and maximum182.0.

Mean lat being 47.2 with minumum46.2 and maximum47.8

Mean lng being 120.1 with minumum119.9 and maximum 120.5

Mean ele being 1150.9 with minimum 690.0 and maximum 2321.0

The number of observations varied from 99 to 557 for the four study years (2010 – 2013) and the measurements taken every 9 days.

3.2 Summary Statistics

Table 2. Summary statistics for sample test with mean L

Variable	N	Mean	Std Dev	Minimum	Maximum
mean_L	557	2.3928515	0.6786701	0	3.5695238
Year	557	2011.61	1.1586860	2010.00	2013.00
FB	557	117.5116697	7.2500526	107.0000000	136.0000000
DAFB	557	100.6247756	36.5118138	7.0000000	182.0000000
lat	468	47.1726496	0.6102443	46.2000000	47.8000000
lng	468	120.1042735	0.1957331	119.9000000	120.5000000
ele	468	1150.91	507.3951555	690.0000000	2321.00
mean20	99	0.7296363	0.0674229	0.6288570	0.8018094
mean30	209	1.1486818	0.2056364	0.9620453	1.6084000
mean40	368	1.3516442	0.2682465	0.9098000	1.7088000
mean50	434	1.7203922	0.1923010	1.3319301	2.0102000
mean60	466	1.9669482	0.1963359	1.5795994	2.2578000
mean70	546	2.1273754	0.1770871	1.7616959	2.4092532
mean80	557	2.2914895	0.2374226	1.4202334	2.6605833
mean90	557	2.4221126	0.2605193	1.5251151	2.8217125
mean100	503	2.5818633	0.2692239	1.6109810	2.9881528
mean110	557	2.7379561	0.2645529	1.6638549	3.0893194
mean120	557	2.8295836	0.2671439	1.7249178	3.2419944
mean130	557	2.9604084	0.2626778	1.8066106	3.3096194
mean140	543	2.9758069	0.3141429	1.8762561	3.4352571
mean150	481	2.9623315	0.4057990	1.8579490	3.5014437
mean160	290	3.0212426	0.3824148	2.0542850	3.5573333

Note. mean L= mean length of apple, FB = Full Bloom, DAFB = Days after full bloom, Mean = Average size of apple (averaged across 50 apples in the same lot) measured at various growth stages (DAFB). lat=latitude, lng=longitude, and ele=elevation.

Mean diameter (mean_L) being 2.4 with minimum 0 and maximum 3.6.

Mean Full Bloom (FB) being 117.5 with minimum107.0 and maximum136.0.

Mean DAFB being 100.6 with minumum7.0 and maximum182.0.

Mean lat being 47.2 with minumum46.2 and maximum47.8

Mean lng being 120.1 with minumum119.9 and maximum 120.5

Mean ele being 1150.9 with minimum 690.0 and maximum 2321.0

The number of observations varied from 99 to 557 for the four study years (2010 – 2013) and the measurements taken every 9 days.

3.3 Correlations among the Mean Variables

Before we do regression, we calculate apple diameter average and the apple length average of every 10 days. It seems that 10 days are good enough to look for a correlation between apples means diameter, as well as apples, mean length. For more details, we do create different variables mean such as mean 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, and mean 160, by using average size base on DAFB range for each FB. For example, for the FB of 107 days, in order to get mean 70, we average means apple diameter between 70 and 79 using average length base on DAFB range for each FB. For example, for the FB of 107 days, in order to get mean 70, we average means the apple length between 70 and 79, and so on for the rest of other means.

There are several notes here:1) mean 20 is defined for all mean sizes at DAFB less than or equal 29 and similarly mean 20 for all mean length; 2) Mean 160 is defined for all mean sizes at DAFB greater than or equal to mean 160, as well as defined mean 160 for mean length; 3) Mean 40 is defined for mean sizes at DAFB between 40 and 49. In a similar vein, mean 40 for mean length, Mean 50 is defined for mean sizes at DAFB between 50 and 59. Similarly, mean 50 for mean length, Mean 60 is defined for mean sizes at DAFB between 60 and 69 and similarly mean 60 for mean length, and so on. Tables 3 and 4 show the correlation between new variables for means apple size and for means apple length.

We may note the correlation between mean size groups that close have high correlation; for example, the correlation between mean size 30 and mean size40 is .92 (see Table 3), but the correlation between mean 30 and mean 70 is .58 and it has negative correlation when we go more different in some cases. Also, it applies for generally in mean diameter in Table 4. For example, the correlation between mean size 50 and mean size60 is 0.98, but the correlation between mean50 and mean 70 is .93 and it may have negative correlation when we go more different in some cases.

Table 3. Correlations among the mean variables for Mean Length L

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	mean20	mean30	mean40	mean50	mean60	mean70	mean80	mean90	mean100
mean20	1.00000	0.51598	0.95878	.	-1.00000	0.82328	0.91381	0.80387	1.00000
		<.0001	<.0001	.	<.0001	<.0001	<.0001	<.0001	<.0001
	99	99	83	0	32	99	99	99	45
mean30	0.51598	1.00000	0.92288	0.94113	0.66423	0.58954	0.59346	0.48065	0.59195
	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	99	209	193	110	142	209	209	209	155
mean40	0.95878	0.92288	1.00000	0.96667	0.77621	0.58947	0.63020	0.52477	0.71028
	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	83	193	368	285	301	368	368	368	330
mean50	.	0.94113	0.96667	1.00000	0.98445	0.93756	0.90494	0.86086	0.90176
	.	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001
	0	110	285	434	434	434	434	434	434
mean60	-1.00000	0.66423	0.77621	0.98445	1.00000	0.96659	0.93796	0.85386	0.90102
	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001
	32	142	301	434	466	466	466	466	450
mean70	0.82328	0.58954	0.58947	0.93756	0.96659	1.00000	0.87920	0.82346	0.77748
	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001
	99	209	368	434	466	546	546	546	492
mean80	0.91381	0.59346	0.63020	0.90494	0.93796	0.87920	1.00000	0.92810	0.94219
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001
	99	209	368	434	466	546	557	557	503
mean90	0.80387	0.48065	0.52477	0.86086	0.85386	0.82346	0.92810	1.00000	0.97771
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001
	99	209	368	434	466	546	557	557	503
mean100	1.00000	0.59195	0.71028	0.90176	0.90102	0.77748	0.94219	0.97771	1.00000
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	
	45	155	330	434	450	492	503	503	503
mean110	0.03883	0.34243	0.52457	0.91123	0.91991	0.75099	0.93537	0.94246	0.98094
	0.7027	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	99	209	368	434	466	546	557	557	503
mean120	-0.17831	0.48417	0.51577	0.82241	0.81624	0.66051	0.87565	0.94496	0.98491
	0.0774	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	99	209	368	434	466	546	557	557	503
mean130	0.02119	0.12599	0.37273	0.80347	0.83075	0.62470	0.88143	0.90027	0.95395
	0.8351	0.0691	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	99	209	368	434	466	546	557	557	503
mean140	-0.26592	0.32400	0.26589	0.59738	0.56939	0.49873	0.72055	0.87718	0.88406
	0.0078	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	99	195	354	420	452	532	543	543	489
mean150	1.00000	0.98330	0.41377	0.45199	0.38104	0.31715	0.52227	0.71632	0.74782
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	54	133	292	403	419	470	481	481	427
mean160	.	-1.00000	-0.05732	0.34658	0.16016	0.07177	0.14239	0.56824	0.48176
	.	<.0001	0.4408	<.0001	0.0115	0.2230	0.0152	<.0001	<.0001
	29	76	183	248	248	290	290	290	290

Table 4. Correlations among the mean variables for Mean Diameter D

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	mean20	mean30	mean40	mean50	mean60	mean70	mean80	mean90	mean100
mean20	1.00000	0.87015	0.46718	.	-1.00000	0.84886	0.54211	0.17198	1.00000
		<.0001	<.0001	.	<.0001	<.0001	<.0001	0.0887	<.0001
	99	99	83	0	32	99	99	99	45
mean30	0.87015	1.00000	0.58991	0.57793	0.45203	0.47360	0.52631	0.60848	0.76608
	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	99	209	193	110	142	209	209	209	155
mean40	0.46718	0.58991	1.00000	0.96627	0.80674	0.70784	0.57266	0.46721	0.75934
	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	83	193	368	285	301	368	368	368	330
mean50	.	0.57793	0.96627	1.00000	0.98835	0.93745	0.87961	0.87346	0.86699
	.	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001
	0	110	285	434	434	434	434	434	434
mean60	-1.00000	0.45203	0.80674	0.98835	1.00000	0.95965	0.92638	0.91147	0.90975
	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001
	32	142	301	434	466	466	466	466	450
mean70	0.84886	0.47360	0.70784	0.93745	0.95965	1.00000	0.69397	0.61660	0.63084
	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001
	99	209	368	434	466	546	546	546	492
mean80	0.54211	0.52631	0.57266	0.87961	0.92638	0.69397	1.00000	0.94268	0.95055
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001
	99	209	368	434	466	546	557	557	503
mean90	0.17198	0.60848	0.46721	0.87346	0.91147	0.61660	0.94268	1.00000	0.98481
	0.0887	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001
	99	209	368	434	466	546	557	557	503
mean100	1.00000	0.76608	0.75934	0.86699	0.90975	0.63084	0.95055	0.98481	1.00000
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	
	45	155	330	434	450	492	503	503	503
mean110	-0.30442	0.71839	0.54387	0.83707	0.89279	0.50369	0.92215	0.96462	0.98572
	0.0022	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	99	209	368	434	466	546	557	557	503
mean120	-0.22195	0.74353	0.55073	0.78083	0.84168	0.45241	0.91138	0.93790	0.97582
	0.0272	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	99	209	368	434	466	546	557	557	503
mean130	-0.36937	0.56143	0.36502	0.74780	0.81540	0.39182	0.88789	0.92084	0.95667
	0.0002	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	99	209	368	434	466	546	557	557	503
mean140	-0.22994	0.63810	0.35698	0.70484	0.71266	0.37146	0.81266	0.86769	0.87876
	0.0220	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	99	195	354	420	452	532	543	543	489
mean150	-1.00000	0.92363	0.35396	0.38514	0.33976	0.28432	0.53334	0.58031	0.62441
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	54	133	292	403	419	470	481	481	427
mean160	.	1.00000	0.05780	0.55400	0.30337	-0.10216	-0.01297	0.12768	0.11070
	.	<.0001	0.4370	<.0001	<.0001	0.0824	0.8259	0.0297	0.0597
	29	76	183	248	248	290	290	290	290

4. Results

In this section, we present estimated regression models for linear and nonlinear models for both means mean D and mean L.

4.1 Model Estimation and Selection

We use linear models as follows

The model for the mean diameter apples is:

$$mean\_D = \beta_0 + \beta_1 year + \beta_2 FB + \beta_3 DAFB + \beta_4 lat + mean80 + \varepsilon_i$$

where one assumes that $\varepsilon \sim N[0, \sigma^2]$

where:

MeanD = mean diameter of apple

FB= Full Bloom

DAFB= Days after full bloom

lat= latitude

The model for mean length apples is:-

$$mean\_L = \beta_0 + \beta_1 year + \beta_2 FB + \beta_3 DAFB + \beta_4 lat + \beta_5 lang + \beta_6 ele + mean70 + mean80 + \varepsilon_i$$

Mean L = mean length of apple

FB= Full Bloom

DAFB= Days after full bloom

Lat = latitude longitude, and ele = elevation.

Lang = longitude

Ele = ele

Table 5. Ordinary Least Squares regression results for model dependent variable mean D Diameter of Apple

Variable	Parameter	t Value	Pr > |t|
Intercept	-155.14192***	-5.13	<.0001
Year	0.07396***	4.93	<.0001
FB	-0.01310***	-4.86	<.0001
DAFB	0.01525***	33.97	<.0001
lat	0.14772***	4.43	<.0001
mean80	0.77237***	8.67	<.0001
R-squared	0.7504		
Adj. R-squared	0.7477		
No. of Obs.	557		

Note. Significance: *P < 0.10, **P<0.05, ***P<0.01.

We estimate an OLS regression, linear model and nonlinear model for the mean diameter of apple using years, DAFB, FB, lat, and mean size of apple 80 (Table 5). We see the coefficient for all independent variables is highly statistically significant at 01%. We note that positive coefficient for DAFB, and when it increases 1%, mean diameter of apple increases at the rate of 0.02 inch per day after full bloom. The R-square was 0.75 and the adjusted R- square of the model was 0.75 indicating that approximately 75 percent of the variation in mean length (D) was explained by the independent variables. Note that the other tests are meeting the requirement like normality.

Table 6. Ordinary Least Squares regression results for a model dependent variable mean L length of Apple

Variable	Parameter	t Value	Pr > |t|
Intercept	-110.49014***	-4.34	<.0001
Year	0.05174***	4.1	<.0001
FB	-0.01226***	-4.85	<.0001
DAFB	0.01631***	44.16	<.0001
lat	0.12671***	4.01	0.0003
lng	0.00006915***	2.42	0.1478
ele	0.43416***	3.7	0.9899
Mean70	0.56742***	7.43	0.7518
Mean120	-110.49014***	-4.34	0.0004
R-squared	0.8434		
Adj. R-squared	0.841		
No. of Obs.	558		

Note. Significance: *P < 0.10, **P<0.05, ***P<0.01.

We estimate an OLS regression, linear model and nonlinear model for the mean length of apple using years, DAFB, FB, ele, lng and mean size of apple 70,and120 (Table 6). We see the coefficient for all independent variables is highly statistically significant at 01%. We note that positive coefficient for DAFB, and when it increases 1%, mean length of apple increases at the rate of 0.02 inch per day after full bloom. The R-square was 0.84 and the adjusted R-square of the model was 0.84 indicating that approximately 84 percent of variations in mean length (L) was explained by the independent variables. Note that the other tests are meeting the requirement like normality.

Table 7. Predicted Mean Diameter of Apple for a linear model and non-linear

Pred_Li	Pred_nonli
1.795918	1.921370653
1.887418	2.013170653
2.009418	2.135570653
2.131418	2.257970653
2.222918	2.349770653
2.329668	2.456870653
2.436418	2.563970653
2.543168	2.671070653
2.665168	2.793470653
2.771918	2.900570653
2.863418	2.992370653
2.970168	3.099470653
1.324602	1.448660653
1.431352	1.555760653
1.538102	1.662860653
1.660102	1.785260653
1.751602	1.877060653
1.873602	1.999460653
1.965102	2.091260653
2.056602	2.183060653
2.178602	2.305460653
2.285352	2.412560653
2.285352	2.412560653
2.498852	2.626760653
2.605602	2.733860653
2.727602	2.856260653

Table 7 (Note 3) and figure 1 show the values for predicted mean diameter of apple for a linear model and nonlinear model. It indicates that the prediction values of the mean diameter in the linear model close to the prediction values of the mean diameter in the nonlinear model which mean our estimation is useful.

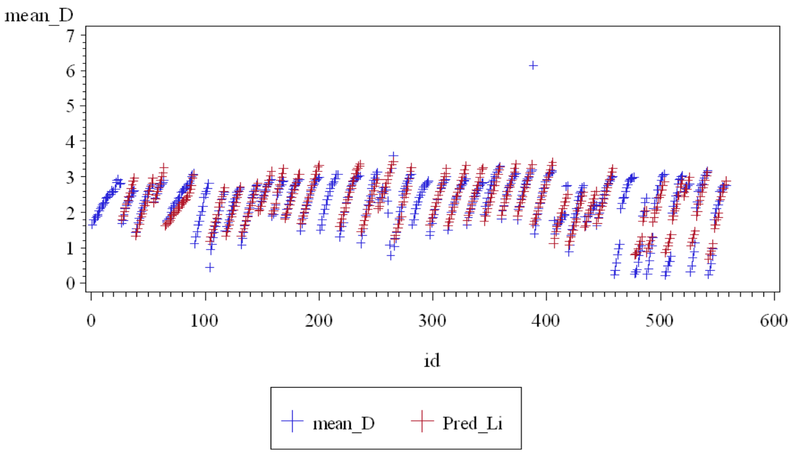

Figure 1. Plots of Predicted Versus Actual Values for Mena Diameter D

Table 8. Predicted Mean Length of Apple for a linear model and non-linear

Pred_Li	Pred_nonli
1.830063	1.734074174
1.927923	1.831874174
2.058403	1.962274174
2.188883	2.092674174
2.286743	2.190474174
2.400913	2.304574174
2.515083	2.418674174
2.629253	2.532774174
2.759733	2.663174174
2.873903	2.777274174
2.971763	2.875074174
3.085933	2.989174174
1.323062	1.227382174
1.437232	1.341482174
1.551402	1.455582174
1.681882	1.585982174
1.779742	1.683782174
1.910222	1.814182174
2.008082	1.911982174
2.105942	2.009782174
2.236422	2.140182174
2.350592	2.254282174
2.350592	2.254282174
2.578932	2.482482174
2.693102	2.596582174
2.823582	2.726982174

Table 8 (Note 4) and figure 2 show the values for predicted mean length of apple for a linear model and nonlinear model. It indicates that the prediction values of the mean length in the linear model close to the prediction values of the mean length in the nonlinear model which mean our estimation is useful.

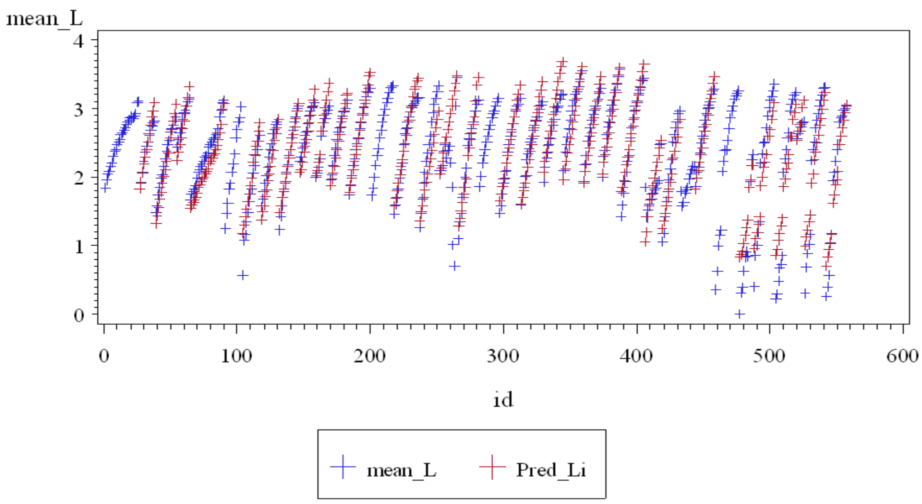

Figure 2. Plots of Predicted Versus Actual Values for Mena Length L

5. Conclusion

Washington's apple industry is the major element of agriculture, and its economy. Apple industry has continued to grow even in difficult times like a recession, and the domestic market is limited growing for exports. Apple industry has useful for getting jobs in the state (The Washington Apple Industry, 2014). Farmer and growers in

Washington State have faced difficult factors for their apple production and some of the other products, the factors such as bad weather, prices and high costs like fuels. Also, they face issues for wholesale and distribution, storages, sold domestic or export (WSAFP, 2015). It is important to consider the size and the length of apples and making good organizing between apple production and apple marketing. Thus, knowing the time between marketing and production can help the farmer to make good decisions for their apple product. We do develop a linear model for both size or diameter apples and length apple. The size apple linear model includes years, DAFB, FB, mean 80, and latitude. All independent variables are significant and Adj. R-squared explains about 75percent of size apple. Length apple model linear model includes years, DAFB, FB, latitude, longitude, elevation, mean 70, and mean120.All independent variables are significant and Adj. R-squared explains about 84percent of size apple. Moreover, Actual value and predicted values for linear and nonlinear models are close. Therefore, those models can help farmers make a good decision for apple industry, and manage to get good size and length for their apple crop.

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Notes

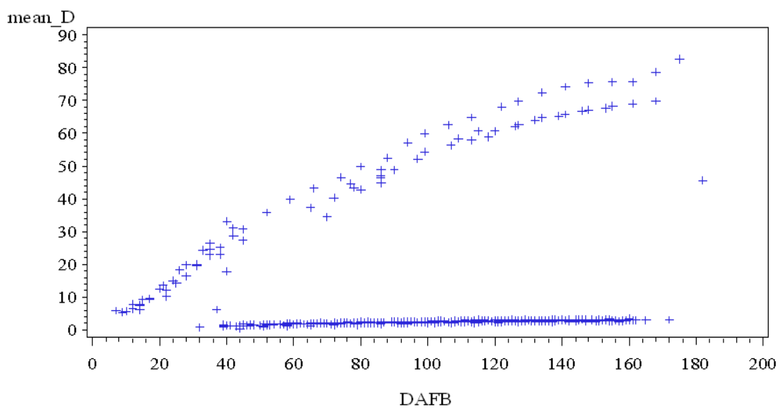
Note 1. Data are referred to Red Delicious apple variety.

Note 2. Data are got from 11 locations that include Lewis Delay, Sun Orondo CO, East Wenatchee, Auvil Chelan, Auvil Brays, Sun Orondo CO, Sunrise, Olmstead Wapato, Gwen Ballard, Prossor, and Finley, Ines Kon Pass.

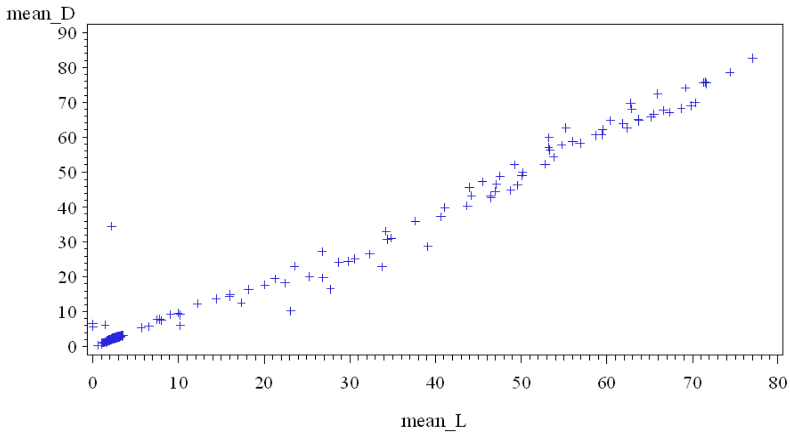
Note 3. This is just some of values of predication, and note that figure1 shows all the values.

Note 4. This is just some of values of predication, and note that figure2 shows all the values.

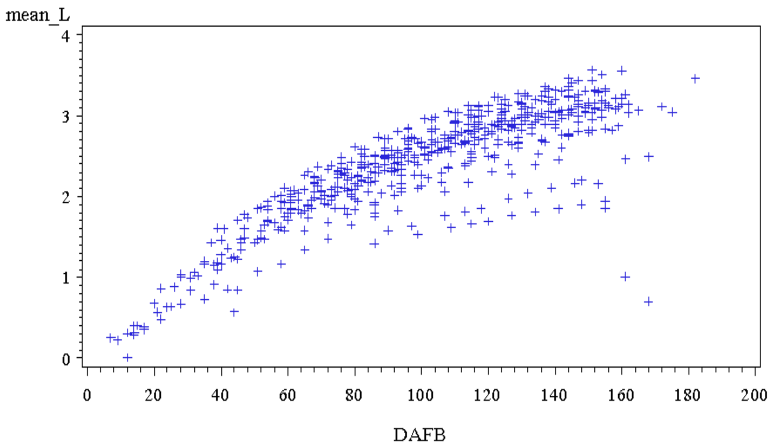
Appendix



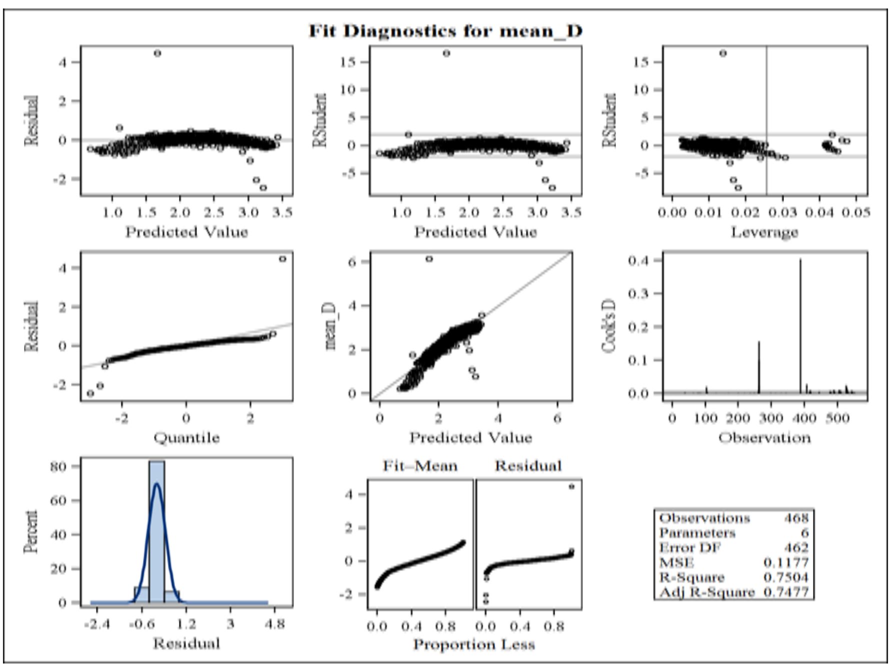
Appendix A. Plots of Mean Size Apples Versus DAFB



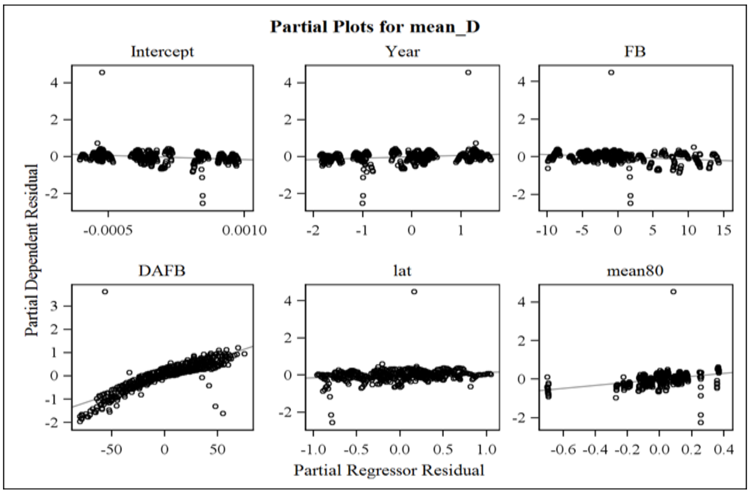
Appendix B. Plots of Mean Size Apples Versus Mean Length Apples



Appendix C. Plots of Mean Length Apples Versus DAFB



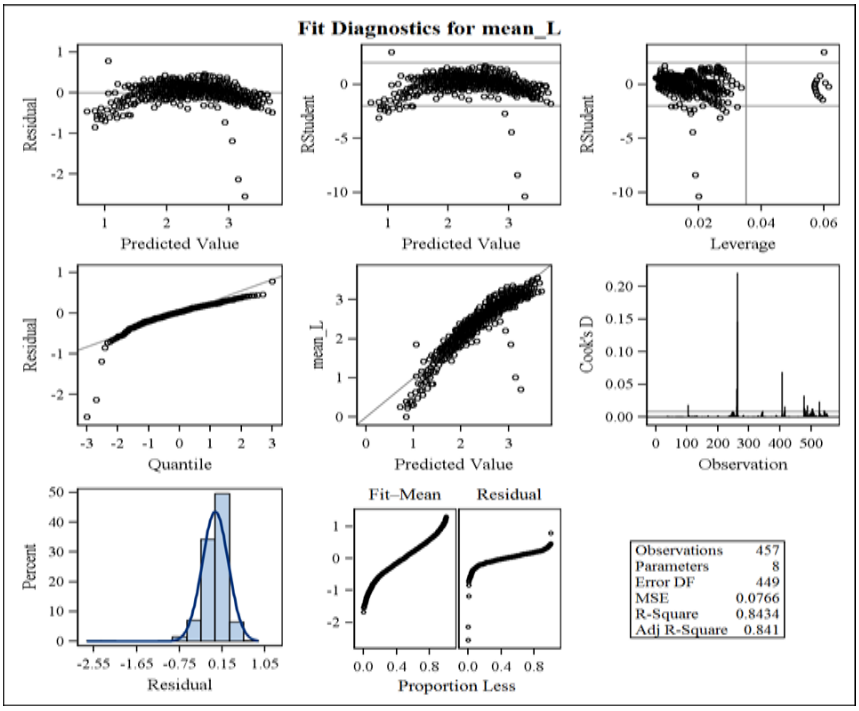
Appendix D. Fit Diagnostics for Mean Diameter of Apples



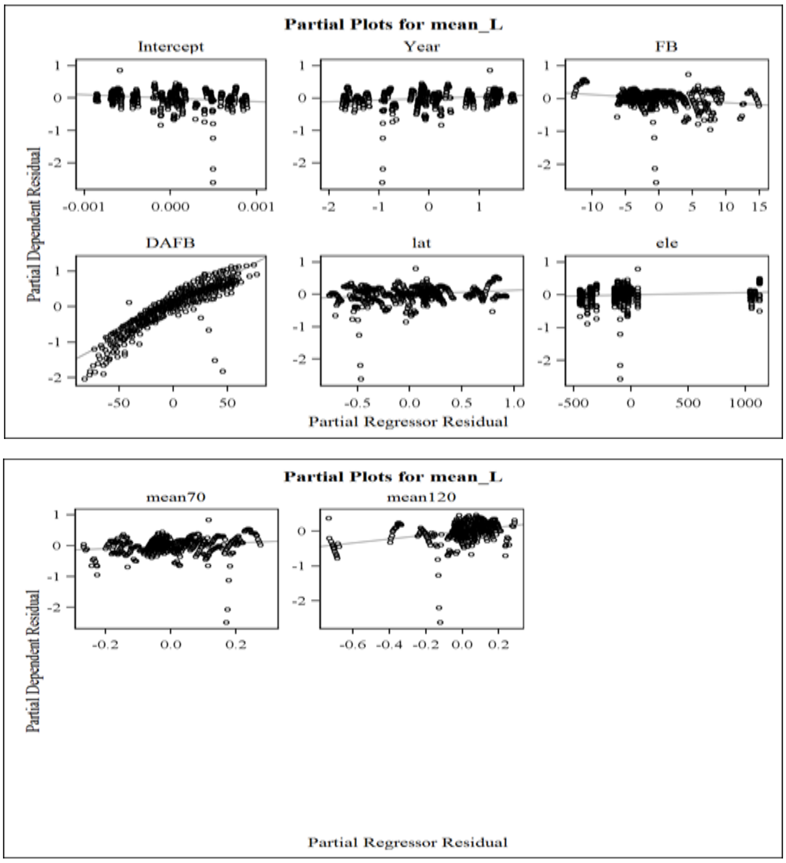
Appendix E. Partial Plots for Mean Diameter of Apples

Appendix F. Tests for Normality for Mean Diameter of Apples

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.653998	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.129312	Pr > D	<0.0100
Cramer-von Mises	W-Sq	2.797796	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	18.70323	Pr > A-Sq	<0.0050



Appendix G. Fit Diagnostics For Mean Length of Apples



Appendix H. Partial Plots for Mean Length of Apples

Appendix I. Tests for Normality For Mean Length of Apples

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.803764	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.103135	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.614076	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	10.35237	Pr > A-Sq	<0.0050