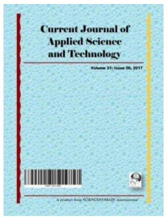

Current Journal of Applied Science and Technology

30(1): 1-8, 2018; Article no.CJAST.43430
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Statistical Model for Yield Estimation of 'Gala Red Lum' Apples after Bloom in Northern India

Tabasum Mushtaq[1*], S. A. Mir[1], Nageena Nazir[1], T. A. Raja[1], A. H. Pandith[2], Khalid Rasool[2] and Mushtaq A. Lone[1]

[1]Division of Agricultural Statistics, Sher-e-Kashmir University of Agricultural Sciences and Technology, Shalimar Campus, Srinagar, Jammu & Kashmir, 190025, India.
[2]Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology, Shalimar Campus, Srinagar, Jammu & Kashmir, 190025, India.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2018/43430
Editor(s):
(1) Dr. Sait Engindeniz, Professor, Department of Agricultural Economics, Faculty of Agriculture, Ege University, Turkey.
Reviewers:
(1) Nondan Pal, Sylhet Agricultural University, Bangladesh.
(2) Subrata Kumar Mandal, CSIR-Central Mechanical Engineering Research Institute, India.
(3) Olutosin A. Otekunrin, Federal University of Agriculture, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/26874

Original Research Article

Received 20 July 2018
Accepted 08 September 2018
Published 27 October 2018

ABSTRACT

The objective of this paper is to develop the best fitted model for estimating yield in Gala Red *Lum after bloom*. The data used for this research were primary data collected from high density apple block of SKUAST-Kashmir (HDP, Plate-1). The study was undertaken at experimental field of Division of Fruit Science, SKUAST-Kashmir, Srinagar, J&K, Northern India, during the years 2015 and 2016. The measurements of various tree/fruit characteristics in *Gala Red Lum* were recorded. The data recorded was pooled to average out the on /off bearing effect. Regression technique was used to find the relationship between the yield and various biometrical characters of apple trees. Models were first developed on the whole population and then on sample. The best fitted model was Y= -FCT+FCA-FCT*FCA and was validated by using k-fold cross validation and bootstrap validation techniques. Thus, the developed model can be used for estimating the yield in *Gala Red Lum after bloom*.

Keywords: Yield estimation; regression models; k-fold cross validation; bootstrap technique.

**Corresponding author: E-mail: tabumushtaq2010@gmail.com;*

1. INTRODUCTION

Jammu and Kashmir State is endowed with natural advantages of topography and climate with enormous diversity of agro-climatic condition has immense scope for horticultural development. Apple ranks first covering 43.30 percent area and 80.18 percent production. During the last 30 years, yield of apple has shown an increase from 4.12 to 10.00 MT/ha. Though it appears to be highest among the apple producing states like Himachal Pradesh, Uttarakhand and Arunachal Pradesh in the country, yet it is far below the level achieved by advanced countries where productivity is of 50-60 MT/ha [1]. Jammu and Kashmir government is now emphasizing on the of use high density plantation (HDP) system, which gives the fruit production within 2-3 years after plantation. From last few years progressive farmers are switching over to high density apple plantation and the university SKUAST-K is following the pursuit as well to develop the new technologies so that farmers adapting HDP system are benefited. Natural disasters like spring frosts, hail storms etc. can cause damage to the crop, so it is common to insure crops against the damage. These natural calamities usually affect flowers or young developing fruits. It is necessary to evaluate the loss so that any damage must be estimated comparing the amount of fruit left on the tree to the number that would have been produced under normal conditions. Insurance companies face two main difficulties in their work: the study must be performed after the damage has occurred (i.e., must be performed using variables which can be measured after the damage) and it must be performed in the field, quickly and without complex equipment.

Tree yield is a function of the number of both fruit on the tree and their weight. The number of fruit depends on the flower density (number of flower clusters per TCA, [2]), the tree's size and percentage of set. The percent of fruit set decreases as the flower density increases, but this relationship is heavily influenced by climate [3,4]. When fruit set is too large for the tree's size, it becomes necessary to thin to ensure both return bloom and a good fruit development [5].

Typical fruit size is different for each cultivar [6], although it is also highly dependent on the number of fruit left on the tree [7,8,9], climate ([10,11]) and cultural techniques [12,13]. Fruit growth rate is faster for early cultivars but growth time is shorter, final size tends to be smaller [6].

Only tree size, plantation density and number of flower buds after pruning are available at the beginning of the active period to estimate yield in simple and rapid way. Potential yield increase with tree size, although not linearly since bigger trees are less efficient [14,6,15]. Many studies have shown that tree size and trunk cross-sectional area (TCA) are closely related, so that TCA is used regularly to compare different plots vigor (TCA/ha), efficiency (kg/TCA), flower load (number of flowers/TCA), etc. [14,16,17,2,18,19]. Plant density also influences yield, since it affects the amount of light intercepted by the trees. Barritt et al. [14] found that the amount of light intercepted by a tree was correlated with TCA per available area (TCA/ha).TCA/ha has been shown to be a good parameter to estimate potential yields in peach, nectarine and pear orchards [9,20].

The productivity of an apple tree also depends on the bud load after pruning, i.e., the magnitude of flowering [3,21,2]. Some pomologists have proposed flower bud density (number of flower buds per TCA) as an index to express the magnitude of flowering [2]. Flower density per land area (number of flower buds/m^2) in pear cultivars 'Blanquilla' and 'Conference' [9] was found to be the most influential parameter in multiple regression models that allowed cluster set and cluster yield estimation. Miranda and Royo [22] developed the models between various tree parameters of 'Golden Delicious' and 'Royal Gala' Apples before bloom and showed that the models are good predictors of fruit clusters per TCA and yield per fruit cluster, so the potential yield of an apple orchard for 'Golden Delicious' and 'Royal Gala' can be determined reasonably well from the knowledge of TCA/ha, FD, FCT, FCA. Kiprijanovski et al. [23] reported yield efficiency expressed by means of trunk development and crown volume is an important indicator of tree prediction.

Emdad et al. [24] observed correlation in six strawberry genotypes. The trial was laid out in a randomised complete block design with three replications. Data on crown height, number of flower buds per plant, number of flowers per plant, number of fruits per plant, length and breadth of fruit and fruit yield per plant were collected. Significant correlation was shown by all the characters with fruit yield.

The focus of the study was confined to the statistical evaluation of the biometrical characters in high density apple orchards and to develop model for 'Gala Red Lum' after bloom that can be employed by the users to predict yield, using parameters which can be easily measured at the beginning of the active period.

2. MATERIALS AND METHODS

2.1 Data Collection

Data were collected in 2015 and 2016 on the yield and biometrical characters of apple trees of the block namely (HDP, Plate-1) located at Shalimar campus of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Science & Technology of Kashmir, Shalimar, Srinagar, Jammu & Kashmir in Northern India. The exotic variety ‘Gala Red Lum’ of apple grafted on M-9 T337 rootstock was introduced by SKUAST-Kashmir in spring 2013 from an Italian nursery, GRIBA, Italy. The plant material was one year old with 3 plus feathers. These two year old trees with uniform size, vigor and bearing capacity were used for study. All these trees received uniform cultural practices during the years under study as per the package of practices of SKUAST-Kashmir. The required data for the present study included only primary data. The orchard consisted three blocks of ‘Gala Red Lum’ having 49 trees in each block, with block spacing of 3 meters and tree spacing 1.5 meters. For development of yield estimation/prediction model (before bloom) on the population of Gala Red Lum independent variables (parameters) used were crop density (CD, no. of fruits/ cm^2 TCA), flower density per trunk cross sectional area (FD, no. of flower buds/ cm^2 TCA), flower density per land area (FA, no. of flower buds/ m^2), fruit clusters per trunk cross sectional area (FCT, no. of fruit clusters/ cm^2 TCA), fruit clusters per land area (FCA, no. of fruit clusters/ m^2), average fruit number per cluster (FNC) and average yield per fruit cluster (CY, g). Primary data collected individually for two years (2015 and 2016) was pooled to average out the on/off bearing effect and a population of 270 plants was used for the development of models in Gala Red Lum. Models were first developed for population and then were tried on sample of 41 trees.

2.2 Model Building

Relationship between yield & biometrical characters of tree and fitting the regression models in biological studies is gaining a lot of importance in horticulture. Multiple regression equations play a vital role in prediction of yield of fruit crops, thus an effort is made to fit a multiple linear regression equation considering apple yield as a dependent variable and biometrical characters as explanatory variables. To estimate the yield for an apple plot before bloom on the basis of various parameters of apple trees, multiple linear regression models linking parameters that could be measured at the beginning of the activity cycle were examined. The models used for the present study were linear, log-linear, single variable, two variable and multiple variable models.

Linear models selected for study were:

Set A

- $Y = \beta_0 + \beta_1 X_1$
- $Y = \beta_0 + \beta_1 X_1^{\,2}$

Set B

- $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2$
- $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2^{\,2}$
- $Y = \beta_0 + \beta_1 X_1^{\,2} + \beta_2 X_2^{\,2}$

Set C

- $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2$
- $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1^{\,2} X_2$
- $Y = \beta_0 + \beta_1 X_1 X_2 + \beta_2 X_2^{\,2}$

Set D

- $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_5 X_5$

Log-linear models selected for the study were

Set E

- $LnY = \beta_0 + \beta_1 LnX_1$
- $LnY = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2$
- $LnY = \beta_0 + \beta_1 LnX_1 X_2 + \beta_2 LnX_2^{\,2}$

Many models were developed on the population of ‘Gala Red Lum’ having single variables, two variables and more than two variables. In all the models yield (Y) was the dependent variable and the independent variables were crop density (CD), flower density per trunk cross-sectional area (FD), flower density per land area (FA), fruit clusters per trunk cross-sectional area (FCT), fruit clusters per land area (FCA), average fruit number per cluster (FNC) and average yield per fruit cluster (CY). The relationships were evaluated by fitting the linear, log-linear and polynomial regression models with the linear regression procedure of R- software and a backward stepwise elimination option. The models were given the ranks on the basis of coefficient of determination (R^2), adjusted R^2 and AIC. The models with highest value of adjusted R^2 and least AIC value were selected for sample study. Residuals were analyzed to determine the presence of outliers and non-constant error variance. The best fitted model in Gala Red Lum after bloom was, Y=-FCT+FCA-FCT*FCA and showed the significance at 5% with highest value of adjusted R^2 (0.9597).

2.3 Model Validation

The models that were tested on sample population were cross validated. Various characteristics like root mean square error (RMSE), mean absolute error (MAE) and cross validated R^2 were obtained during the process. Adjusted R^2 obtained during the normal fitting was compared with the cross validated R^2. The root mean square error (RMSE) has been used as a standard metric to measure model performance. Mean absolute error (MAE) was also considered a better metric to choose a model. The process was done on the yield predicting models. R software was used for validation. The Bootstrap method has been used to quantify the uncertainty associated with a predictive model. It consisted of randomly selecting a sample of *n* observations from the original data set. This subset, called bootstrap data set has been used to evaluate the model. This procedure was repeated a large number of times and the standard error of the bootstrap estimate were calculated. The results provide an indication of the variance of the model performance. The sampling in this case was performed with replacement, which means that the same observation can occur more than once in the bootstrap set. Bootstrap with 100 resample was used to test the selected model.

3. RESULTS AND DISCUSSION

The results obtained are presented in (Table 1). R^2 and adjusted R^2 in the model at S. No. 3 is more as compared to other models. This model has the least value of RMSE (0.373) and MAE (0.279) and the highest value of cross validated R^2 (0.9830). Thus we select the model $YIELD = 4.26 - 0.27FCT + 0.66FCA - 0.01FCT * FCA$ for predicting yield (after bloom) in Gala Red Lum. *k* -fold cross validation of the selected model is shown in (Table 2).

Fig. 1 displays Cross-validation of selected yield predicting model (after bloom) in Gala Red Lum. Here we can see that each fold is near the best fit which reveals the closeness of the actual fit and predicted fit. Thus from the plot also we conclude that among the other models the model $YIELD = 4.26 - 0.27FCT + 0.66FCA - 0.01FCT * FCA$ is the best fit model for predicting the yield (after bloom) in Gala Red Lum.

The output showed the average performance of the selected models across the 100 resample. RMSE (root mean squared error) and MAE (mean absolute error), represent two different measures of the model prediction error. Lower the RMSE and the MAE, the better the model. The R^2 represents the proportion of variation in the outcome explained by the predictor variables included in the model. Higher the R^2 better is the model. (Table 3) provides the output of the model accuracy by bootstrap statistics of selected yield predicting model. The ‘original’ column corresponds to the regression coefficients. The associated standard errors are given in the column ‘S.E’, u_1 corresponds to the intercept and u_2, u_3, u_4 correspond to the independent variables of the selected yield predicting model (after bloom) in Gala Red Lum. It also depicts the corresponding values of RMSE (0.462), MAE (0.317) and R^2 (0.9980) during bootstrap validation. The model showed good performance with less bias and hence can be used for predicting yield in ‘Gala Red Lum’ after bloom.

Table 1. Cross validation of selected yield predicting models (after bloom) in Gala Red Lum

S. No.	Normal fitting			Cross validated		
	Model	**R^2**	**Adj.R^2**	**RMSE**	**MAE**	**CV R^2**
1	$Y= \beta_0+\beta_1FCA$	0.8584	0.8548	0.860	0.776	0.8620
2	$Y= \beta_0+\beta_1FCT +\beta_2FCA$	0.9100	0.9053	0.684	0.596	0.9520
3	$Y=\beta_0+\beta_1FCT+\beta_2FCA+\beta_3FCT*FCA$	0.9627	0.9597	0.373	0.279	0.9830

Source: R- software analysis output

Table 2. *k*-Fold cross validation of selected yield predicting model Y= -FCT+FCA-FCT*FCA

Folds	Obs.	Predicted	CV predicted	Actual	CV residual	SS	MS	Test set obs.
1	2	9.77	9.76	9.940	0.185	0.25	0.06	4
	8	8.41	8.39	8.530	0.142			
	19	7.59	7.56	7.990	0.427			
	38	13.29	13.27	13.370	0.105			
2	3	8.711	8.72	8.690	-0.025	0.26	0.05	5
	11	7.63	7.61	7.710	0.101			
	25	12.98	13.06	12.790	-0.268			
	33	12.84	12.92	12.610	-0.306			
	36	7.78	7.76	8.040	0.282			
3	5	6.00	6.08	5.600	-0.481	0.46	0.11	4
	12	6.88	6.93	6.490	-0.441			
	20	10.94	10.92	11.040	0.125			
	30	9.42	9.42	9.290	-0.134			
4	4	7.618	7.62	7.680	0.063	0.6	0.15	4
	28	7.26	7.19	7.940	0.747			
	35	10.62	10.62	10.630	0.008			
	40	9.62	9.61	9.420	-0.194			
5	6	5.69	7.62	5.460	0.063	1.24	0.31	4
	21	12.70	7.19	12.430	0.747			
	29	12.53	10.62	12.200	0.008			
	32	6.89	9.61	7.770	-0.194			
6	1	7.69	7.69	7.730	0.037	0.02	0	4
	18	8.66	8.66	8.680	0.019			
	37	9.06	9.06	8.990	-0.073			
	39	5.94	5.93	6.020	0.094			
7	9	6.05	6.09	5.610	-0.482	0.42	0.11	4
	26	9.24	9.27	9.180	-0.088			
	27	9.70	9.73	9.420	-0.309			
	34	12.64	12.67	12.370	-0.295			
8	16	10.88	10.75	13.060	2.310	5.37	1.34	4
	17	8.93	8.82	8.950	0.130			
	31	11.40	11.33	11.230	-0.096			
	41	13.11	12.99	12.860	-0.137			
9	10	6.96	6.97	6.580	-0.393	0.25	0.06	4
	14	8.13	8.12	8.300	0.178			
	22	11.52	11.53	11.320	-0.214			
	24	8.20	8.23	8.110	-0.119			
10	7	6.94	6.99	6.540	-0.457	0.48	0.12	4
	13	7.03	7.08	6.600	-0.484			
	15	7.27	7.33	7.200	-0.128			
	23	10.85	10.84	10.990	0.152			

Overall MS =0.228

Source: R- software analysis output

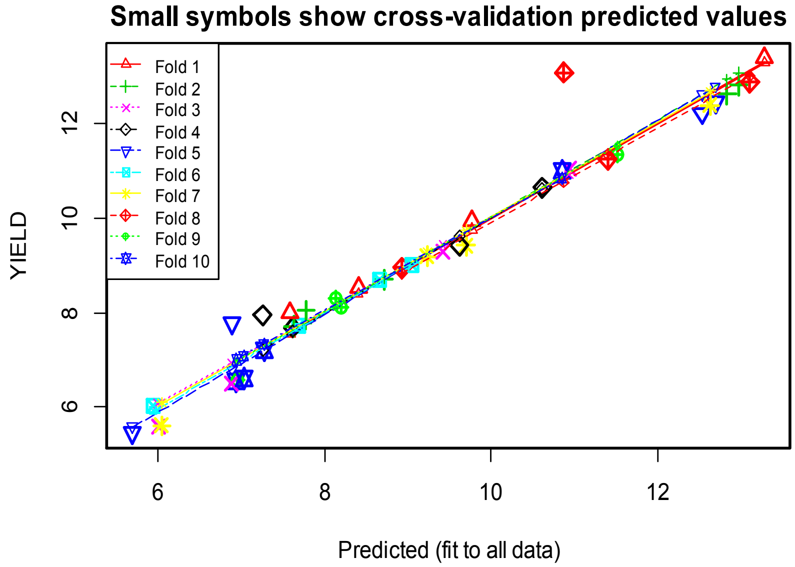

Fig. 1. k-fold cross-validation of the model YIELD=4.26-0.27FCT+ 0.66FCA-0.01FCT*FCA

Source: R- software analysis output

Table 3. Bootstrap validation of yield predicting model (after bloom) in Gala Red Lum

ORDINARY NONPARAMETRIC BOOTSTRAP						
	Original	**Bias**	**S.E**	**RMSE**	**MAE**	R^2
u_1*	4.2579	-2.87e-02	0.334	0.462	0.317	0.9980
u_2*	-0.2717	1.35e-03	0.031			
u_3*	0.6641	7.31e-04	0.028			
u_4*	-0.0113	-1.16e-05	0.001			

Source: R- software analysis output

4. CONCLUSION AND RECOMMENDATION

Flower density (FD) had the greatest influence and a positive effect in explaining fruit clusters per TCA, which is supported by previous research [25,26,27]. Similar results were obtained by Miranda et al. [20] in peach, where bud load per TCA due to the growing patterns of peach trees, also was the most influential parameter and had a positive effect to explain crop density. TCA/ha had a minor, though significant, effect in explaining FCT. The negative influence of fruit load on fruit weight has been shown in previous studies [8,21,9,15]. FCA and FCT are indices to express fruit load, both had the greatest influence in explaining yield. Similar results were obtained in peach by [20], where crop density was the most influential parameter in explaining fruit weight. Miranda and Royo [9] found in pear that FCT had a significant effect in explaining yield per cluster, though flower density per land area (FA) had a higher influence. FA is a factor for explaining yield per cluster in pear, but not in apple probably because, in our region , apple trees are customary chemically thinned at early stages of fruit development, where as pear trees are usually only thinned at 50 to 80 DAFB [9]. This late thinning in pear allows more developing fruitlets in the first 7 to 9 weeks, when fruit growth is due to cell division [6], and consequently, stronger competition between developing fruitlets before the June drop [3]. In this study fruit clusters per trunk cross-sectional area (FCT), fruit clusters per land area (FCA) and their interaction term (FCT*FCA) had the greatest influence and a positive effect in explaining Yield. These parameters had the significant effect on the yield of ‘Gala Red Lum’. The predictive model generated with linear regression analysis indicated that yield could be estimated fairly accurately. Since the purpose of the research was to estimate the yield of ‘Gala Red Lum’ apple variety through the use of parameters which can be measured at the beginning of the cycle, it can be considered valid within reasonable error limits. Thus, the model is acceptable to forecast crop efficiency, and so provide a useful tool for early forecast of yield and evaluation of crop losses due to natural calamities like hail etc. The results of this study show that the model developed is good predictor of yield in Kashmir, so the potential yield of an apple orchard for 'Gala Red Lum' can be determined reasonably well from the knowledge of FCT and FCA.

5. RECOMMENDATION

To find the crop loss due to natural calamities the developed model can be used as a tool to estimate the yield of 'Gala Red Lum' apples after bloom in Northern India.

Insurance companies can easily use the model for prediction of losses.

The model can work accurately up to the tree age of ten years.

With increase in age the efficiency of fruit bearing of an apple decreases so the work must be continued for years to get the different models for different age groups.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous. Statement showing area, production and productivity of fruits in J&K State. Department of Horticulture, Government of Jammu and Kashmir, Srinagar, Kashmir; 2013.
2. Lombard PB, Callan FG Dennis, Looney NE, Martin NE, Renquist GC, Mielke EA. Towards a standardized nomenclature, procedures, values and units in determining fruit and nut tree yield performance. Hort Science. 1988;23:813-817.
3. Dennis FG. Apple. 1st ed. CRC Press, Boca Raton, Fla.p1-41. In: S.P. Monselise (ed.). CRC handbook of fruit set and development; 1986.
4. Tromp J, Borsboom O. The effect of autumn and spring temperature on fruit set and on the effective pollination period in apple and pear. Scientia Hort. Sci. 1994,124:468-477.
5. Wertheim SJ. Developments in chemical thinning of apple and pear. Plant Growth Regulat. 2000;31:85-100.
6. Faust M. Physiology of temperate zone fruit trees. Wiley. N.Y.; 1989.
7. Chang LS, Iezzoni AF, Flore JA. Yield components in 'Montmorency' and 'Meteor, sour cherry. J. Amer. Soc. Hort. Sci. 1987;112:247-251.
8. Gu S, Lombard PB. Effect of crop density on vegetative growth, flowering, fruit size, and yield in 'Nijisseiki' pear trees. Acta Hort. 1994;367:271-277.
9. Miranda C, Royo JB. A statistical model to estimate potential yields in pear cultivars 'Blanquilla' and 'Conference' before bloom. Journal of American Society for Horticulture Science. 2003a;128:452-457.
10. Lakso AN, Corelli Grappadelli L, Barnard J, Goffinet MC. An expolinear model of the growth pattern of the apple fruit. J. Hort. Sci. 1995;70:389-394.
11. Warrington IJ, Fulton TA, Halligan EA, de Silva HN. Apple fruit growth and maturity are affected by early season temperatures. J. Amer. Soc. Hort. Sci. 1999;124:468-477.
12. Berman ME, Dejong TM. Water stress and crop load effects on fruit fresh and dry weights in peach (*Prunus persica*). Tree Physiol. 1996;16:859-864.
13. Naor A, Klein I, Doron I, Gal Y, Ben-David Z, Bravdo B. The effect of irrigation and crop load on stem water potential and apple fruit size. J. Hort. Sci. 1997;72:765-771.
14. Barritt BH, Konishi BS, Diley MA. Tree size, yield and biennial bearing relationships with 40 rootstocks and three scion cultivars. Acta Hort. 1997;451:105-112.
15. Robinson TL, Lakso AN, Carpenter SG. Canopy development yield and fruit quality of Empire and Delicious apple trees grown in four orchard production systems for ten years. Journal of American Society for Horticulture Science. 1991;116:179-187.
16. Carusso T, Inglese P, Sotile F, Marra FP. Effect of planting system on productivity, dry- matter partitioning and carbohydrate content in above-ground components of 'Flordaprince' peach trees. J. Amer. Soc. Hort. Sci. 1999;124:39-45.
17. Dennis FG, Masabni JG, Ketchie DO. Evaluating twenty eight strains of ' Delicious' apple in Michigan. J. Amer. Soc. Hort. Sci. 1996;121:988-995.
18. Strong D, Azarenko AN. Relationship between trunk cross-sectional area, harvest index, total tree dry weight and yield components of 'Starkspur Supreme

Delicious' apple trees. J. Amer. Pom. Soc. 2000;54:22-27.

19. Westwood MN, Robersts AN. The relationship between trunk cross-sectional area and weight of apple trees. J. Amer. Soc. Hort. Sci. 1970;95:28-30.
20. Miranda C, Royo JB. A statistical model to estimate potential yields in peach before bloom. Journal of American Society for Horticulture Science. 2003b;128:297-301.
21. Kappel F. Yied component analysis of 'horrow Delight', 'Kieffer', and 'harvest Queen' pear. J. Amer. Soc. Hort. Sci. 1990;115:25-29.
22. Miranda C, Royo JB. Statistical model estimates potential yields in 'Golden Delicious' and 'Royal Gala' apples before bloom. Journal of American Society for Horticulture Science. 2004;129(1):20-25.
23. Kiprijanovski M, Ristevski B, Arsov T, Gjanovski V. Influence of planting distance to the vegetative growth bearing of apple cultivar Jonagold on rootstock MM106. Acta Horticulturae. 2009;825:453-458.
24. Emdad A, Hossain MI, Kabir K, Jahan MS. Correlation and path analysis in six Strawberry (*Fragaria ananassa*) genotypes. Scientific Journal of Krishi Foundation. 2013;11(2):74-78.
25. Dennis FG, Masabni JG, Ketchie DO. Evaluating twenty eight strains of 'Delicious' apple in Michigan. Journal of American Society for Horticulture Science. 1996;121:988-995.
26. Knight JN. Fruit thinning of the apple cultivar Cox's Orange Pippin. Journal of American Society for Horticulture Science. 1980;114:852-855.
27. Stover E. Relationship pf flower intensity and cropping in fruit species. 2000;10:729-732.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/26874