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Regression analysis of apple yield on the basis of some morphological and nutritional parameters

S.D. Sharma*, Sunil Dutt Sharma, S.K. Bhardwaj, P.S. Chauhan***and Ashu Chandel******

Department of Fruit Science, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan 173 230

ABSTRACT

The studies were conducted on the age groups (15-20, 21-25 and > 25 years) of Royal Delicious apple orchards at Jubbal, Mashobra, Seobagh and Bajaura locations. Yield was influenced significantly by growth, volume, secondary spurs, flowering and fruit set at Mashobra location i.e. the increase in these plant parameter proportionally increased the yield but primary spur has no effect on yield. 73 per cent of the total variation in yield was explained by variables included in the function. At Jubbal yield was influenced significantly by all the parameters except primary spur and flowering. 64 per cent of the total variation in yield was explained by variable included in the function. 62 and 55 per cent of the total variation in yield was explained by variables included in the function at Seobagh and Bajaura, respectively. The yield was affected by proportion of reproductive buds in spur categories S_2 and S_4 under Mashobra and Jubbal locations. Explanatory variable (the variable which influences the value of dependent variable, used for prediction and also known as regression or independent variable) included in the function have explained about 65% and 71 % of total variation in the yield at Mashobra and Jubbal; respectively. At Seobagh, variables included in the function have explained about 76% of total variation in yield. At Bajaura, variables have explained 62% of total variation in the yield. Yield was affected significantly by leaf N, P, K, Ca and Mg at Jubbal and Seobagh and the explanatory variable included in the function have explained about 81 % (Jubbal) and 89% (Seobagh) of total variation in the yield. Under Mashobra and Bajaura conditions, explanatory variables have explained 78% and 74% of the total variation in the yield.

Key words: Apple, regression coefficient, nutrients, yield, morphological parameters, spur.

INTRODUCTION

Apple (*Malus* x *domestica* Borkh) production is a function of the bearing area of the crop and yield per unit area. But yield is a function of complex interacting factors, which are governed by environmental conditions and intrinsic potential of the plant. Yield (quantity and quality) of horticultural plants is based on their growth, development, and canopy architecture. Temperate fruit production in India revolves around apple production. Apple has become the leading commercial crop in North-western Himalayas of India. In spite of regular horticultural practices, apple production continuous to vary from year to year. In perennial fruit crops, especially apple, tree biometrical parameters along with the flowers and fruit yielding buds occupy the prime position in defining the yield (Espinasse and Delort, 4; Robbie and Atkinson, 10). Cluster leaves are the major site of photosynthetic production, particularly early in the fruit development as well as important centre of hormonal balance. The photosynthetic potential of these leave is dependent on their supply of minerals, primarily nitrogen Competition for carbohydrate supply as well as mineral resources may occur between vegetative shoot extension growth and reproductive development. Cropping is enhanced when vegetative vigour is restricted.

For a long time growers have known to adopt the management of their orchards to the fruiting behaviour of the chosen varieties. Some have elaborated the cultural strategies based on fruiting type such as the spur type. Much work has been carried out to gain a better understanding of fruiting and in particular, the relationship between vegetative growth and fruiting (Forshey and

*Correspondence author's present address: Department of Fruit Science, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan 173 230; E-mail: somdevsharma2004@yahoo.co.in
** Department of Soil Science, YSPUHF-Nauni, Solan; *** Regional Horticultural Research Station, Mashobra, Shimla 171007; ***Department of Basic Sciences, YSPUHF-Nauni, Solan

Elving, 5). However little has been done to investigate the initiation and development of fruiting organs as a function of time. In order to understand the development of fruiting types, a precise description of their characteristics has been undertaken (Lauri and Laspinasse, 7). The findings emerged from the present investigation to be undertaken to study the links between certain morphological characters of the tree and regularity of fruit production year after year. The present investigation aims at advance estimation of fruit apple yield on the basis of flowering, fruit set and nutrient contents as a yield forecasting strategy.

MATERIALS AND METHODS

The present study was conducted in Shimla and Kullu districts of Himachal Pradesh at different altitudes. Multistage random sampling technique was used to select the samples. Orchards were divided into three age groups i.e. A_1 (15-20 years), A_2 (21-25 years) and A_3 (> 25 years). The four locations viz. Jubbal and Mashobra of Shimla district and Seobagh and Bajaura of Kullu district were selected. Trees of three age groups were randomly selected from each location. Ten trees of each age group were selected and thus a population of 30 trees was selected in each location for conducting investigation.

Observations on trunk girth, tree volume, spur of 5 different categories and total spur count, flowering, fruit set and yield were recorded. The data on these parameters were taken on per cubic meter volume basis, which was taken in four compass directions in cubic meters of each experimental tree and averaged for the particular tree. Total canopy volume of the experimental trees was calculated from the height and spread measurements, using formula suggested by Westwood (11). The tree volume was expressed in cubic meters. The data on flowering (number of flowers per cubic meter of the volume) was taken at the time of full bloom. Fruit set was recorded 20 days after full bloom and percent fruit set was calculated as following formula.

$$\text{Fruit set (\%)} = \frac{\text{No. of fruit set/m}^3 \text{ tree volume}}{\text{No. of flower/m}^3 \text{ tree volume}} \times 100$$

Spur were categorized into 5 categories for spur count: S_1 (Buds on shoot terminals); S_2 (Buds on branched spurs); S_3 (Buds on spurs that were bearing fruit last season); S_4 (Swollen buds on spur without branching and without fruit); S_5 (Pointed buds on spurs).

Uniform and healthy leaves from middle portion of the current seasons shoot were collected for leaf nutrient analysis, and placed in properly labeled butter paper bags, which were washed and dried for further analysis. Nitrogen in the leaf samples was determined by digesting plant material in concentrated sulphuric acid in the Auto Digestion System-Foss Tecator. The total nitrogen was estimated by Nitrogen Auto Analyzer-Foss Tecater model-2300. Other elements viz. P, K, Ca and Mg were estimated by digesting plant material in a diacid mixture of nitric acid and perchloric acid in the ratio of 4: 1. Phosphorus in the aliquot was estimated by vanado-molybdophosphoric yellow colour method using Spectronic-2l and potassium was estimated by flame photometric method. Ca and Mg were determined using Atomic Absorption Spectrophotometer. Multiple linear regression equations were fitted to estimate the yield on the basis of morphological characters, spur categories and leaf nutrient content at different locations.

RESULTS AND DISCUSSION

It is evident from the Table 1 that yield was influenced significantly by growth, volume, secondary spurs, flowering and fruit set at Mashobra location i.e. increase in growth, volume, secondary spurs, flowering and fruit set correspondingly increased the yield, whereas, primary spur had no effect on yield. Seventy- three percent of the total variation in yield was explained by these variables included in the function. At Jubbal also, yield was influenced by growth, volume, secondary spurs and fruit set significantly and the primary spur and flowering exerted no effect on yield. These variables included in the function accounted for 64 percent of total variation in yield.

At Seobagh, yield was significantly influenced by volume, primary spurs, flowering and fruit set, but growth and secondary spur count had no impact on fruit yield. 62 percent of the total variation in yield was explained by those variables included in the function. Growth, volume, flowering and fruit set have influenced the yield significantly at Bajaura location, whereas, primary and secondary spur count has no effect on yield although negative but non-significant effect on yield was observed for primary spur count. 55 percent of the total variation in yield was explained by variable included in the function. Similar results were observed by Awasthi and Sharma (2) in apple while comparing different age groups and found the significant relationship between yield and other parameters except trunk girth. These results are also in accordance with the findings of Espinasse and Delort (4), and Lezzoni and Pritts (8).

The observations recorded in Table 2 depicted that under Mashobra and Jubbal locations, yield was affected by proportion of reproductive buds in spur categories S2 and S4 but S1, S3 and S5 spur proportion had no impact on fruit yield. Explanatory variables included in the function have explained about 65% and 71% of total

variation in the yield, respectively. Yield was affected significantly by proportion of buds in spur- categories S2, S3 and S4 at Seobagh and the variable included in the function have explained about 76% of total variation in yield. At Bajaura, yield was affected by the proportion of buds in spur category S4 only, whereas other categories of spur had no impact on fruit yield. The variable included in the function has explained 62 percent of total variation in the yield at this location. It is also observed that category S1 and S5 had no influence on the fruit yield at any location. Awasthi and Sharma. (2) found that the regression equations selected through various procedures explained 70 to 74 percent of the total variation in yield in different age groups. Robbie and Atkinson (8) also observed the significant variation in fruit set with tree age.

Yield was affected significantly by leaf N, P, K, Ca and Mg content at Jubbal and Seobagh locations and the explanatory variable included in the function have explained about 81 % at Jubbal and 90% at Seobagh of total variation in the yield (Table 3). Bhandari and Randhawa (3), and Mamgain *et al.* (9) also observed that leaf N, P and K have significant and positive correlation with fruit yield in apple. The coefficient of determination indicated that variability in yield is attributed to the factors mentioned in the regression equation. The regression coefficient is significant and positive with leaf K indicating that a unit change in independent variable (K status) will bring a change equal to the magnitude of regression coefficient in dependent variable (fruit yield). Under Mashobra condition, yield was significantly affected by leaf N, P, K and Ca. whereas, yield was not affected by leaf Mg content. Explanatory variable have explained 78% of the total variation in the yield. Yield was affected significantly by leaf N, K, Ca and Mg at Bajaura but P has to have no effect on fruit yield and the

Table 1. Growth, flowering and fruit set based regression coefficient with yield under different locations

Location	Constant	Growth	Volume	Primary spur	Secondary spur	Flowering	Fruit set	R^2	AdjR^2	F_{cal}
Mashobra	-185.8*	0.67*	1.07*	0.13	4.83*	0.33*	5.35*	0.727	0.730	*
Jubbal	-101.5*	0.86*	2.10*	-13.56	1.55*	0.19	4.66*	0.628	0.641	*
Seobagh	-301.8*	0.19	1.11*	10.0*	2.12	0.39*	7.59*	0.608	0.621	*
Bajaura	-22.14*	0.29*	0.86*	-3.11	0.32	0.21*	2.88*	0.542	0.552	NS

*Significant at 5% level of significance

Table 2. Regression coefficient for proportion of reproductive buds with yield in different spur categories under different locations.

Location	Constant	S_1	S_2	S_3	S_4	S_5	R^2	Adj R^2	F_{cal}
Mashobra	-186.2	-1.70	7.10*	3.49	10.90*	2.30	0.718	0.649	*
Jubbal	-160.4	0.19	6.56*	4.80	9.10*	-1.02	0.756	0.708	*
Seobagh	-380.2	-2.10	19.6*	24.3*	20.6*	8.2	0.783	0.756	*
Bajaura	-152.3	0.70	2.49	4.91	8.15*	3.15	0.624	0.619	*

*Significant at 5% level of significant

Table 3. Regression coefficient for nutrients with yield under different locations.

Location	Constant	N	P	K	Ca	Mg	R^2	Adj R^2	F_{cal}
Mashobra	-81.14*	25.15*	170.8*	12.13*	29.11*	80.11	0.801	0.781	*
Jubbal	-149.4*	45.37*	117.5*	18.12*	23.12*	31.04*	0.844	0.813	*
Seobagh	-155.4	19.10*	418.3*	3.99*	23.80*	248.6*	0.901	0.895	*
Bajaura	-80.28*	23.66*	6.60	29.11*	41.48*	120.81*	0.756	0.736	*

*Significant at 5% level of significance

explanatory variable have explained 74% of total variation in the yield. Available nutrients reflected significantly positive relationship with their respective contents in leaves (Awasthi *et al*., 1). Multiple regression equation of fruit yield on leaf nutrient status showed the sensitivity of fruit yield to leaf K status.

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