Study on yield and some morphological characters for optimizing kinnow yield through multivariate statistical techniques

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ABSTRACT

The paper deals with the usefulness of discriminant and principal component analysis for determining the relative contribution of morphological and reproductive characters responsible in increasing the yield of kinnow. For this purpose a field experiment was conducted during 2014-15 at kinnow orchards of farmers in Indpur block of Kangra district as this area represents the main kinnow growing belt of the state. An optimum sample size of 96 kinnow trees was selected randomly for the study. The technique discriminant analysis was applied to formulate categorization rule for allocating the kinnow trees to 'high' and 'low' yielder groups. This discriminant equation revealed that the characters plant height (X_1), number of leaves per plant (X_4) and fruit weight (X_8) were the most important characters that discriminated the two groups. Principal component analysis in high yielder group showed that three of the ten principal components had eigen values greater than unity (Gutman's lower bound) which played the main role in the analysis. These components were fruiting and growth and vigour and growth characteristics which explained 40.59, 13.52 and 11.98 per cent respectively and collectively 66.09 per cent of the total variation of the original variables. In case of low yielders four principal components were retained for the analysis. These were fruiting, growth and fruiting and growth characteristics. These principal components explained 24.70, 18.36, 14.91 and 11.95 per cent of the total variation and in aggregate 69.92 per cent of original variables.

Keywords: Discriminant analysis; Gutman's lower bound; kinnow; principal component analysis

INTRODUCTION

The cultivation of citrus fruits is an important horticultural activity in the subtropical region of Himachal Pradesh. Citrus fruits belong to the family Rutaceae which includes mainly lime, lemon, orange and kinnow. Among citrus fruits kinnow mandarin has shown tremendous potential in the foothills of the state. It plays an important role in the socio-economic transformation of rural masses in the low-hill zone of the state.

Kinnow yield is a complex trait which is influenced by several factors namely tree, blooming, fruit set and crop density characteristics identifying a single variable representative of the complex trait ie yield. Therefore an attempt to conduct a series of univariate statistical analysis carried out for each of the variables does not hold promise as it ignores the correlation among the variables and sometimes the conclusions may be misleading. On the contrary multivariate analysis takes into account the interdependence and relative importance of the various influencing characters and yields more meaningful information.

Under the present study discriminant analysis was carried out to formulate the categorization rule for allocating the kinnow tree to high and low yielder groups. An attempt has also been made to bring out the basic components with linear combination of morphological and reproductive characters contributing significantly towards kinnow yield by using principal component analysis. The components having eigen values greater than one were retained in the analysis because of the substantial amount of the variations. The factors corresponding to eigen values less than one were not considered. These factors were ignored due to Gutman's lower bound principal according to which eigen values less than unity (λ <1) should be ignored (Kaiser 1958). Qurrie et al (2000) used principal component analysis in agricultural research. The techniques are described in detail in standard statistical book such as that of Anderson (1958).

METHODOLOGY

Field experiment was conducted during 2014-15 at kinnow orchards of farmers in Indpur block of Kangra district as this area represents the main kinnow growing belt of the state. An optimum sample size of 96 kinnow trees was selected randomly by following a two-step approach as suggested by Stein (1945) and Cox (1958). Four branches from each tree in four directions as per the practice in vogue were selected and the observations recorded were plant height (X_1), plant girth (X_2), plant spread (X_3), number of leaves per branch (X_4), annual shoot extension growth (X_5), number of flowers per branch (X_6), number of fruits per branch (X_7), fruit weight (X_8), fruit set (X_9) and LD ratio (X_{10}).

The data collected were subjected to discriminant analysis to define a systematic and statistically valid procedure for categorizing the trees as high and low yielders. For these two populations principal component analysis was carried out to bring out the basic components associated with the above mentioned morphological characters.

RESULTS and DISCUSSION

Discriminant analysis: The essence of discriminate analysis is to categorise the observations into desired number of groups. In the present study the observations were first divided into two groups namely 'high yielder' and 'low yielder' and then discriminant function was fitted. The discriminant analysis resulted into the following equations

$$D = -13.507 + 0.375 X_1 + 0.008 X_4 + 0.386 X_8$$

The equation reveals that the characters plant height (X_1), number of leaves per plant (X_4) and fruit weight (X_8) were the most important characters that discriminated the two groups in location-2. To test the statistical hypothesis of no difference in mean vectors (μ_1 and μ_2) of ten characters for these two groups the value of Wilk's lambda statistic was used. It was concluded that smaller the lambda for an independent variable the more that variable contributes to the discriminant function. Lambda varies from 0 to 1 with 0 meaning group means differ and 1 meaning all group means are the same. The value of lambda was obtained to be 0.325 which in turn gave the computed value of chi-square (χ^2) as 63.25 was much more than the table value of chi-square at 5 per cent level. The hypothesis of equity of group mean vectors was rejected means principal component analysis would be appropriate for data reduction. Having found that the groups differed significantly the trees were assigned to group I (high yielder) if $D \geq m$ otherwise to group II (low yielder) where m= 0.062 is the average of groups centroids (Lawley and Maxwell 1963). The groups formed on the basis of allocation rule were subjected to principal components analysis and population-wise the results are discussed below:

Population-I (high yielder): The main results of principal component analysis pertaining to this population have been presented in Table 1 which reveal that three of the ten principal components (PCs) had eigen values greater than unity (Gutman's lower bound) which played the main role in the analysis pertaining to 'high yielder'. First, second and third components with 4.06 and 1.35 and 1.20 eigen values justified 40.59, 13.52 and 11.98 per cent of variation respectively. The first component extracted in a principal component analysis accounted for a maximal amount of total variance in the observed variables. Under typical conditions this means that the first component was correlated with at least some of the observed variables.

The variable weighted for first principal component was highest for number of fruits per branch (X_7) followed by number of flowers per branch (X_6), plant girth (X_2), plant height (X_1) and LD ratio (X_{10}) and can be termed as fruiting and growth component. The second principal component (PC_2) was dominated by two groups. In first group number of leaves per branch (X_4) can be termed as plant vigour whereas in second group consisting of annual shoot extension growth (X_5) only can be termed as growth characteristic.

Population–II (low yielder): Table 2 reveals that the first principal component was highest for the character number of fruits per branch (X_7) followed by number of flowers per branch (X_6) and percentage fruit set (X_9) termed as fruiting characteristics. The variables accounting for the second principal component were

Table 1. Eigen vectors PC analysis of high yielder group

Character	PC_1	PC_2	PC_3
Plant height (X_1)	0.38	0.30	0.12
Plant girth (X_2)	0.39	0.02	0.02
Plant spread (X_3)	0.15	0.66	-0.12
Number of leaves/branch (X_4)	0.27	-0.54	-0.09
Annual shoot extension growth (X_5)	0.12	-0.28	0.59
Number of flowers/branch (X_6)	0.40	-0.01	-0.36
Number of fruits/branch (X_7)	0.46	-0.01	0.10
Fruit weight (X_8)	0.16	-0.32	-0.40
Per cent fruit set (X_9)	0.27	0.05	0.53
LD ratio (X_{10})	0.36	0.01	-0.17
Eigen value	4.06	1.35	1.20
Per cent of variance	40.59	13.52	11.98
Cumulative per cent of variance	40.59	54.11	66.09

Table 2. Eigenvectors PC analysis of low yielder group

Character	PC_1	PC_2	PC_3	PC_4
Plant height (X_1)	0.27	-0.02	0.49	-0.49
plant girth (X_2)	0.32	0.28	-0.33	-0.17
Plant spread (X_3)	0.17	0.25	0.64	-0.10
Number of leaves per branch (X_4)	0.16	0.38	0.01	0.39
Annual shoot extension growth(X_5)	0.10	0.54	-0.04	0.23
Number of flowers per branch (X_6)	0.41	-0.21	-0.38	-0.32
Number of fruits per branch(X_7)	0.53	-0.36	-0.04	0.16
fruit weight(X_8)	0.33	0.16	-0.10	0.26
Percentage fruit set (X_9)	0.37	-0.31	0.27	0.47
LD ratio(X_{10})	-0.27	-0.35	0.10	0.32
Eigen value	2.47	1.84	1.49	1.20
Per cent of variance	24.70	18.36	14.91	11.95
Cumulative per cent of variance	24.70	43.06	57.97	69.92

highest for annual shoot extension growth (X_5) followed by number of leaves per branch (X_4) which had positive contribution whereas number of fruits per branch (X_7) and LD ratio (X_{10}) showed negative contribution termed as growth and fruiting characteristics. The third principal explained 14.91 per cent of total variations with eigen value 1.49. In this component variables viz plant spread (X_3) and plant height (X_1) were found to be positive whereas number of flowers per branch (X_6) showed negative weight. The fourth principal component had eigen value of 1.20 and explained 11.95 per cent of the total variations. The contribution of the variables was percentage fruit set (X_9) followed by number of leaves per branch (X_4) whereas negative weights were shown by the plant height (X_1) termed as growth characteristic. The PC_1, PC_2, PC_3 and PC_4 showed relatively large variation with eigen values 2.47, 1.84, 1.49 and 1.20 respectively. The components explained 69.92 per cent of total variation of total original variables. These eigen values were greater than one and represented exact linear dependency.

With the interpretation of vigour by Iezzoni and Pritts (1991) it was now possible to apply different treatments to increase yield and to determine whether the yield increase was the result of an increase in vegetative vigour, a change in the balance of vegetative growth and fruit production, a reduction in fruit set or a combination of these factors. Thus PCA analysis has brought out the basic factor growth and morphological characters of kinnow plant and can be considered as important tools for optimizing yield.

CONCLUSION

The discriminant function revealed that plant height (X_1), number of leaves per plant (X_4) and fruit weight (X_8) were the most important characters that discriminated the groups. The groups were subjected to principal component analysis. In both populations three principal components were extracted which played the main role in the analysis. Thus the principal component analysis has brought out some of the basic components associated with morphological characters of kinnow and could be considered as important tool in explanatory work for optimizing kinnow productivity.

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