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The path coefficient analysis of yield components for leaf nutrient concentrations in Mango (*Mangifera indica* L.) under rainfed agroclimatic conditions of north-west Himalaya

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ABSTRACT

This study aimed to understand the relationship for productivity related traits using correlations and path coefficient analysis of 'Dashehari' mango under rainfed agro-climatic zone conditions of north-west Himalayas of India. The study also identifies the relationship among agronomic and yield-related characteristics to know the direct and indirect effect of independent variables on managerial ability of the crop. Correlation and path coefficient analyses were carried out over two consecutive years (2004, 2005) seasons for plant growth (tree trunk), leaf nutrient concentration, and fruit yield across four districts of Himachal Pradesh. Based on yield performance, an optimum sample size of 20 trees from each orchard comprised of 10 trees each of two categories: high productive (>90 kg $tree^{-1}$) and low productive (<90 kg $tree^{-1}$) were selected using the probability proportional to size multistage sampling scheme. Both high as well as low productive orchards were analyzed for soil and leaf chemical properties. Simple linear correlation and path coefficient analyses were worked out between all possible combinations. The contribution of leaf nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn), copper (Cu), manganese (Mn), and iron (Fe) on growth and fruit yield was studied. In high productive trees, path model showed that leaf N, Mg, Fe, Cu and Mn concentrations recorded the high magnitude of direct effect on fruit yield. However, leaf N concentration had a strong positive indirect effect through leaf Zn. Leaf Cu and Zn concentrations had a positive indirect effect through leaf Mg and leaf Zn on fruit yield. In low productive trees, leaf N concentration had a strong positive direct effect and a strong positive indirect effect via leaf Zn on fruit yield. Similarly, the direct effect of tree volume on fruit yield was positive, while, the maximum positive indirect effect was through leaf K. A residual value of 0.7308 and 0.7292 indicates the collective influence of the variables was to the magnitude of 0.2692 and 0.2708 to the extent of 26.9 and 27.1% toward fruit yield, and contributed 40.7 and 14.7% toward tree volume in high and low productive mango trees, respectively. The collective influence of the variables included on tree volume to the magnitude of 0.8521 and concluded that leaf nutrient content has been contributed to the extent of 14.7% toward tree volume.

1. Introduction

Path coefficient analysis is a standardized partial regression statistical technique of partitioning the correlation coefficients into its direct and indirect effects, so that the contribution of each character to yield could be estimated. It also measures the direct effect of a predictor variable upon its response variable and indirect effects of a predictor variable on the response variable through another predictor variable (Dewey and Lu, 1959), and assisted in identifying the traits that are useful as selection criteria to improve crop yield (Milligan et al., 1990). The correlation coefficient revealed the relationship existing between a pair of characters, where a dependent variable has an interaction with mutually associated components and change in any one component that disturb whole network of cause and effect system. This technique determines yield contributing characters and thus is useful in indirect selection. The correlation along with path analysis provides a better appreciation of cause and the effect relationship between pairs of characters. Knowledge of correlations, if accompanied by the understanding of the magnitude of contribution (direct and indirect) of each component character to the final make up of the fruit yield, the criteria

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formulated would be more effective in selecting the genotypes and using themselves in the successful crop management. The presence of morphogenetic variations in agronomic characteristics of a crop determines more suitable method to improve the yield of a fruit crop. Moreover, it is likely to have a better knowledge of those characteristics that significantly associated with yield components and that can be used as an indirect selection criterion to enhance the cropping performance. The relationship of economic yield components with yield and the partitioning of the correlation coefficient into its components of direct and indirect effects have been extensively studied. Fruit yield is a complex character, besides the climatic factors, also depends on plant vegetative growth attributes, available nutrient content of soil and leaf. Further, this also provides a basis for successful orcharding enterprise and hence the problem of yield increase can be more effectively tackled on the basis of performance of yield components (Choudhry et al., 1986).

Mango (*Mangifera indica* L.) is one of the most choicest and profitable fruit crops of tropical and sub-tropical regions of India and is known as 'King of fruits', belongs to the dicotyledonous family 'Anacardiaceae', originated in the foothills of Himalayas of the Indian-Myanmar region of South-East Asia, and is covering 2.30 million hectare of area with an annual production of 12.7 million tones which is highest in the world (NHB, 2010). India ranks first among mango producers, accounting for more than 40.1% to the global production followed by China bagged with only 11.8% (Sekhar et al., 2013). Global production of mango is concentrated mainly in Asia and more precisely in India. Mango is grown in 87 countries, out of which 63 countries produce more than 1000 MT per annum. In these countries, mango serves as an integral part in human life, is a good source of nutrients, vitamins A and C and dietary fibers. Flavor, volatiles, texture, chemical constituents and appearance of flesh color are the key components that contribute to a high quality fresh mango and in the acceptance of the fruit by the consumer. The analysis of soil and leaf can be a useful tool for monitoring of the nutrient status of mango orchards. Indian mango variety namely, 'Dashehari' is in great demand and subsequently a number of countries are competing to India in the production of high quality mangoes. Nutrition research on mangoes suggests that leaf and soil analyses will be useful when analytical works are carried out over a number of years and the fertilizer program is adjusted according to the results of the monitoring program.

The path coefficient analysis has been used successfully to clarify interrelation between yield and several other characteristics for mango (Majumder et al., 2012) and ber (Islam et al., 2010). This study was thus determined the correlations and path analysis of yield and yield related components to evaluate their suitability in successful and viable mango crop management. This research project therefore, attempted to assess the direct and indirect influences of some important yield components by adopting correlation and path coefficient analysis in mango to determine the contribution of nutrient concentration toward yield. This study also correlated vegetative growth (tree volume), leaf nutrient concentration and fruit yield with each other with a specific objective as a basis for future development of nutrient management programme in mango under rain-fed agro-climatic conditions of the State of Himachal Pradesh.

2. Materials and methods

2.1. Selection of site and sampling scheme

The present investigation was carried out on 15 years old full bearing 'Dashehari' mango trees during 2004–2006, planted at 5×5 m apart. The experimental orchards are situated at an elevation between 600 and 1200 m above mean sea level. Four districts of Himachal Pradesh namely, Bilaspur, Hamirpur, Kangra, Una and were selected purposely according to multistage sampling scheme, being major mango growing districts of the State (Stage-1). Mango orchards grown in 'Bilaspur' district, lies in the coordinates of longitude between 76°23′45″ and 76°55′40″ East and latitude between 31°25′30″ and 31°35′45″ North of the equator; 'Hamirpur' district, lies between the coordinates of longitude 76°18′ and 76°44′ East and latitude 31°25′ and 31°52′ North of the equator, and 'Kangra' district, located between coordinates of 30°22′40″ and 33°12′40″ North latitude and 75°45′55″ to 79°04′20″ East longitude of the equator, and 'Una' district located between coordinates 31°17′52″ and 31°52′00″ North latitude and 75°58′02″ to 76°28′25″ East longitude of the equator in Himachal Pradesh. The experimental area is situated at an elevation between 450 and 1220 m above mean sea level, characterized by sub-tropical climate with an average annual rainfall of 60–100 cm. A representative sample size of 5 orchards from each district was selected using the probability proportional to size sampling scheme, taken number of trees and/or orchard as an auxiliary variable (Stage 2). Based on the apparent yield performance and the past history of the trees, an optimum sample size of 20 trees from each orchard (Stage 2), comprised 10 trees of each category viz., high productive (>90 kg) and low productive (<90 kg) were randomly selected for the observations.

2.2. Sampling and biochemical processing

To measure mineral nutrient concentration in plant tissues, each foliage sample comprised 100 leaves from middle of the shoot (non-fruiting and non-flushing) from December flush were taken during the month of April (Kumar and Nauriyal, 1978). Leaf sampling and their preparation for chemical analysis was carried out according to Chapman (1964). The digestion of leaf sample (1 g) for the estimation of total N was carried out in concentrated H_2SO_4, contained a digestion mixture of potassium sulphate (400 parts), copper sulphate (20 parts), mercuric oxide (3 parts) and selenium powder (1 part). For the estimation of P, K, Ca, Mg, Fe, Cu, Zn and Mn, the samples (0.5 g) were digested in diacid mixture (HNO_4:$HClO_4$) in the ratio of 4:1 (Piper, 1966). Total leaf N was determined using a nitrogen auto-analyzer, Kjeltech Foss Tecator model 2300 (FOSS, Denmark), and P by the phosphovanadomolybdate method (Jackson, 1973). Total K, Ca, Mg, Fe, Cu, Zn and Mn contents were estimated on Perkins Elmen atomic absorption spectrophotometer. The data obtained with respect to the leaf nutrients of the high productive orchards revealed that the concentration was 2.11% N, 0.137% P, 0.692% K, 2.13% Ca, 1.08% Mg, 184.3 mg kg^{-1} Fe, 19.2 mg kg^{-1} Cu, 33.2 mg kg^{-1} Zn and 74.0 mg kg^{-1} Mn, whereas, in the low productive orchards, leaf nutrient contents were 1.47% N, 0.132% P, 0.577% K, 2.02% Ca, 0.915% Mg, 175.7 mg kg^{-1} Fe, 16.7 mg kg^{-1} Cu, 27.6 mg kg^{-1} Zn and 68.1 mg kg^{-1} Mn.

2.3. Plant growth measurements and fruit yield

The data were recorded on yield and different yield contributing characters. Tree volume was determined by calculating total above ground volume of each tree from height and spread method suggested by Westwood (1978) using formulae (i) for the trees taller than its width ($4/3\ \pi\ ab^2$) and (ii) for the trees wider than its height ($4/3\ \pi\ a^2b$), where $a = 1/2$ of length of major axis and $b = 1/2$ of length of minor axis. The quantity of fruit harvested was calculated for total yield (kg $tree^{-1}$). The recommended package of practices along with plant protection measures was followed to raise an ideal mango crop.