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Exploring trait relationships for enhanced apple yield: A path coefficient analysis in the Mandi district of Himachal Pradesh

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Abstract
This study was conducted to explore the connections between different traits of Apple crops and their impact on yield within the Mandi district in the year 2021. The findings from the analysis of path coefficients indicated that the factor with the strongest direct positive influence (0.535) on yield per plant was the quantity of fruits per branch. This suggests that prioritizing the enhancement of this trait, specifically total fruits per branch, would yield the most favorable outcome in terms of increased yield. Following closely were the factors of total flowers per branch (0.175) and annual shoot growth (0.104), both of which also demonstrated direct positive effects on yield. Furthermore, the study revealed that the total flowers per branch exhibited the highest positive indirect effect on yield (0.504), operating through its influence on the total fruits per branch. On the other hand, the traits with less indirect contribution to apple yield were fruit weight and the leaves per branch. The study highlighted that the most crucial components impacting apple crop yield were the total fruits per branch, the total flowers per branch, and the tree girth. These traits should be the primary focus of a targeted breeding program aimed at enhancing the yield potential of apple crops.

Keywords: Cause-effect analysis, Apple yield, Path coefficient analysis, fruiting characteristics

Introduction
Apple (*Malus domestica*) is a prominently cultivated crop in Himachal Pradesh, Jammu and Kashmir, and Uttarakhand, collectively responsible for 99.43% of India's entire apple production. The yield of apples is a multifaceted parameter influenced by a myriad of factors, both directly and indirectly, encompassing vegetative, flowering, and fruiting attributes. Relying solely on a single variable to represent yield could lead to questionable outcomes; hence, researchers must meticulously investigate numerous interconnected factors on an individual basis (Lezzoni, 1991) [5]. Path coefficient analysis, a widely utilized approach within breeding programs, plays a pivotal role in comprehending the intricate relationships between various groups and identifying pivotal components with noteworthy impacts on yield. This methodology dissects the correlation coefficient between two characteristics, thereby partitioning it into segments that measure the direct and indirect effects. This study aims to delve into the phenotypic associations between apple yield and other morphological traits, while simultaneously gauging the direct and indirect influences of these traits. Path coefficients often stand as the customary representation for each path within the model, equivalent to the standardized regression coefficient or the anticipated path coefficient converted into a standard z-score. Researchers employ standardization coefficients to scrutinize the relative influences of explanatory variables within a variable set, adjusting sample variables to impart distinct variances or diverse metrics to each. The correlation coefficients of the model effectively gauge the relative magnitude and direction of the internal causative or consequential variable's presence in the sample. In instances where the model incorporates multiple variables, standardized coefficients reveal partial regression coefficients, offering an evaluation of how one variable impacts another while factoring in the influence of the preceding variable.

Materials and Methods
In 2021, field trials were conducted in the agricultural fields located in the Mandi district, an area renowned for apple cultivation within Himachal Pradesh. A randomized selection process

was employed to choose 104 trees for the sample. Data pertaining to various attributes were collected, including yield per tree (Y), plant height (A_1), plant girth (A_2), plant spread (A_3), the leaves per branch (A_4), shoot extension growth per year (A_5), total flowers per branch (A_6), total flowers per branch (A_7) fruit weight (A_8), fruit set (A_9), and Length x Diameter ratio (A_{10}). From each trees, randomly any four branches were selected, and observations were made about the quantity of leaves, flowers, and fruits. The collected data underwent a path coefficient analysis, a statistical methodology used to evaluate direct and indirect relationships between traits and their connection to yield. As the number of traits being analyzed increases in a correlation analysis, pinpointing the specific traits contributing significantly to yield becomes more intricate. In such situations, path coefficient analysis serves to discern the direct contributions of individual traits and their secondary influences via other traits. This was accomplished by employing route coefficient analysis based on correlation values, following the methodology outlined by Dewey and Lu (1959) [1]. This method dissects the correlation coefficient into direct and indirect effects of independent variable (s) on the dependent variable. To ascertain the significance of the correlation coefficient, the estimated values were compared to tabulated values using the Fisher and Yates (1967) [3] prescribed approach. The path coefficients were derived by concurrently employing a set of equations that express the fundamental relationship between the correlation coefficient 'r' and the path coefficients (P).

$$r_{14} = P_{14} + P_{24}\, r_{12} + P_{34}\, r_{13}$$
$$r_{24} = P_{14}\, r_{21} + P_{24} + P_{34}\, r_{23}$$
$$r_{34} = P_{14}\, r_{31} + P_{24}\, r_{32} + P_{34}$$

In this context, r_{14}, r_{24} and r_{34} represent the correlations between distinct morphological attributes and the yield (dependent character), while r_{12}, r_{13} and r_{23} indicate the correlations among independent attributes.
The matrix methods were employed to determine both the direct and indirect effects.
The direct effects were calculated through the following series of equations:

$$P_{14} = C_{11}\, r_{14} + C_{12}\, r_{24} + C_{13}\, r_{34}$$
$$P_{24} = C_{21}\, r_{14} + C_{22}\, r_{24} + C_{23}\, r_{34}$$
$$P_{34} = C_{31}\, r_{14} + C_{32}\, r_{24} + C_{33}\, r_{34}$$

Where, C_{11}, C_{22}, C_{23} and C_{33} are constants and $r_{12}\, P_{24}$, $r_{13}\, P_{34}$, $r_{21}\, P_{14}$, $r_{23}\, P_{34}$, $r_{31}\, P_{14}$, $r_{32}\, P_{24}$ are indirect effects.

Results and Discussion

Information was gathered from a randomly chosen sample of 104 trees, encompassing a range of tree growth attributes and was subsequently subjected to further analyses.

Table 1: Analysis of Path Coefficients for Influential Yield charecters in Apples

Characters	A_1	A_2	A_3	X_4	A_5	X_6	A_7	A_8	A_9	A_{10}
A_1	0.087	0.031	0.035	0.023	0.067	0.050	0.047	0.004	0.024	0.019
A_2	0.006	0.016	0.008	0.005	0.008	0.006	0.005	0.001	0.002	0.004
A_3	0.041	0.048	0.101	0.026	0.041	0.043	0.038	0.016	0.014	0.024
A_4	0.018	0.021	0.018	0.069	0.023	0.024	0.020	0.012	-0.001	0.016
A_5	0.079	0.050	0.042	0.034	0.104	0.065	0.062	0.010	0.021	0.025
A_6	0.100	0.061	0.074	0.062	0.110	0.175	0.166	0.030	0.022	0.034
A_7	0.287	0.179	0.198	0.158	0.318	0.507	0.535	0.094	0.135	0.107
A_8	0.002	0.002	0.007	0.008	0.004	0.007	0.008	0.043	-0.002	0.006
A_9	0.015	0.008	0.007	-0.001	0.011	0.007	0.014	-0.002	0.054	0.010
A_{10}	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.001	0.001	0.007
Total effect	0.637	0.418	0.493	0.386	0.687	0.886	0.896	0.210	0.272	0.253

The analysis of path coefficients reveals that maximum direct impact (0.535) on yield per tree is attributed to the total fruits per branch. This suggests that emphasizing the enhancement of this trait, specifically the quantity of fruits per branch, would yield a more favorable response in terms of improved yield. Following this, the total flowers per branch (0.175) and annual shoot growth (0.104) also exhibit positive direct effects on yield, albeit to a slightly lesser degree. Moreover, the assessment indicates that the highest positive indirect influence on yield (0.504) is linked to the total flowers per branch, operating through its relationship with the total fruits per branch. Conversely, the least indirect contribution to apple yield comes from fruit weight, followed by the leaves per branch. These outcomes closely align with the findings of Verma *et al.* (2018) [8], Prasad *et al.* (1989) [7], and Milligan *et al.* (1990) [6]. In a contrasting observation, there is an indirect negative effect of fruit set (-0.002) via fruit weight and the leaves per branch. This implies that selecting these attributes simultaneously could potentially lead to improvements in fruit yield.

Conclusion

Karl Pearson's correlation coefficient was computed to assess the relationship between apple yield and diverse morphological traits. The findings indicated a positive and significant correlation between yield per tree and all morphological characteristics. As a consequence, numerous researchers have employed path coefficient analysis to comprehensively ascertain how distinct independent variables influence the dependent variable. This analytical approach assists breeders in elucidating both direct and indirect effects, proving invaluable in the realm of breeding endeavors.

References

1. Dewey DR, Lu KH. A correlation and path-coefficient analysis of components of crested wheatgrass seed production. Agronomy Journal. 1959;51:515-518.
2. FAO. FAOSTAT. Food and Agriculture Organization of the United Nations; c2020. Available online: https://www.fao.org/faostat
3. Fisher RA, Yates F. Statistical tables for Biological, Agricultural and Medical Research, Long-men Group Ltd., London; c1967.

4. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. Second Edition. John Wiley & Sons, New York, USA; c1984.
5. Lezzoni A, Pritts MP. Application of principal component analysis to horticultural research. Horti. Sci. 1991;26:334-338.
6. Milligan SB, Gravois KA, Bischoff KP, Martin FA. Crop effects on genetic relationships among sugarcane traits. Crop Sciences. 1990;30:927-931.
7. Prasad MBNV, Rao GSP. Genetic variability, correlations and path-coefficient analysis for some morphological and biochemical constituents of acid lime fruit. Scientia Hort. 1989;41:43-53.
8. Verma G, Mahajan PK, Sharma A. Correlation and path analysis between yield and different morphological characters in Kinnow Mandarin (*C. noballis* × *C. deliciosa*). Journal of Applied and Natural Science. 2018;10(2):759-764.
9. Verma G, Sharma A, Mahajan PK. Study on yield and some morphological characters for optimizing kinnow yield through multivariate statistical techniques. International Journal of Farm Science. 2018;8(2):162-165.