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# Correlation and path coefficient studies in Moringa

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**Abstract**
The association studied revealed that the fresh leaf yield was a positively associated with stem base diameter, stem girth, number of branches/plant, number of leaflets/rachis, length of rachilla/plant, canopy spread, fresh leaf weight, dry leaf weight, leaflet length, petiole length and dry matter percentage at both levels (genotypic and phenotypic). The path analysis revealed that the traits dry leaf yield, fresh leaf weight, stem base diameter, number of leaflets/rachis, dry matter percentage, length of rachilla/plant and plant height showed a positive direct effect on fresh leaf yield under studied.

**Keywords:** Moringa, character association, correlation, path coefficient

## Introduction
Drumstick (*Moringa oleifera* L.) is one of the important perennial vegetables grown in India, especially in Chhattisgarh. It is popular due to its unique flavor and attractive taste and is also known for '4F plant' (food, fodder, fuel and fertility). Pod yield is a complex variable trait and depends on many factors and their interaction to increase pod yield. Understanding the association of traits is extremely important in developing an efficient breeding program. Character Association studies provide information about the relationship between any two traits. Path coefficient studies divide the correlation coefficient into direct and indirect effects, giving relative importance to each causal factor. The present study was conducted to explore the interrelationships among different traits and the direct and indirect contributions of these traits to yield.

## Materials and Methods
The experiment was laid out in RBD with 3 replications and 9 treatments (spacing 2.5m x 1.0 m, 2.5 m x 2.5 m, 1.5 m x1.0 m, 1.0 m x 1.0 m, 2.5 m x 2.0 m, 1.3 m x 1.0 m, 3.0 m x 2.5 m, 3.0 m x 3.0 m, 1.2 m x 1.2 m) during 2021-22 at Instructional Farm, College of Agriculture and Research Station Chhuikhadan, KCG Chhattisgarh. The popular drumstick variety PKM-1 was taken during the study. Recommended agronomical practices for good crop growth were adopted. The mean of each trait was calculated from five plants selected in each replicate after 270 days after planting. The character relationship between different traits was studied according to the method given by Miller *et al.* (1958) [6] and path coefficient analysis studies suggested by Dewey and Lu (1959) [2].

## Results and Discussion
The character association correlation studies for fresh leaf yield and its component in drumstick are presented in Table 1. For most of the traits, the genotypic correlation coefficient was found higher than the phenotypic correlation coefficient indicating a strong inherent association among various attributes. Similar observations were also found by Prasanthi (2004) [7] and Kumawat *et al.* (2005) [5] indicate less influence of the environment and the main role of genetic components in the expression of symptoms.

The correlation studied revealed that the fresh leaf yield was a highly positive association with stem base diameter (0.859 and 0.843), stem girth (0.951 and 0.911), number of branches/plant (0.854 and 0.828), number of leaflets/rachis (0.803 and 970), length of rachilla/plant (0.931 and0.896), canopy spread (0.815 and 0.723), fresh leaf weight (0.848 and 0.844), dry leaf weight (0.853 and 0.844), leaflet length (0.676 and 0.555), petiole length (0.492 and 256) and dry matter percentage (0.818 and 0.665) at both the levels (genotypic and phenotypic).

Plant height expressed a positive and significant correlation with stem base diameter (0.492 and 0.428), stem girth (0.554 and 0.461), number of branches/plant (0.461 and 0.586), length of rachilla/plant (0.389 and 0.354), canopy spread (0.448 and 0.358) and fresh leaf weight (0.406 and 0.316), whereas stem base diameter was positively associated with stem girth (0.925 and 0.876), number of branches/plant (0.799 and 0.765), length of rachilla per plant (0.938 and 0.850), leaflets length (0.644 and 0.370) and petiole length (0.815 and 0.676) at both genotypic and phenotypic level respectively as reported by Hari *et al.* (2022) [3].

Stem girth expressed positive significant association with the number of branches/plant (0.811 and 0.765) and fresh leaf weight (0.957 and 0.43). On the other hand the number of branches per plant was positively correlated with the number of leaflets/rachis (0.964 and 0.943), length of rachilla/plant (1.032 and 0.866), fresh leaf weight (0.984 and 0.940), leaflet length (0.717 and 0.314) and dry matter percentage (0.854 and 0.828) at genotypic and phenotypic level respectively (Table 1). A positive and significant correlation was also reported by Ahammed *et al.* (2013) [1], Prasanthi (2004) [7] and Kumawat *et al.* (2005) [5].

Significantly positive association of canopy spread was noted with fresh leaf weight (1.019 and 0.893), leaflet length (0.581 and 0.395) and petiole length (0.863 and 0.650) at the genotypic and phenotypic level (Table 1). Fresh leaf weight expressed positive correlation with leaflet length (0.571 and 0.286) and petiole length (0.903 and 0.730) at genotypic and phenotypic levels, while dry leaf weight significant positively associated with dry leaf yield (0.870 and 0.695) and dry matter percentage (0.853 and 0.844) at the genotypic and phenotypic level. Similar results were earlier found by Jangde *et al.* (2017) [4] and Wenping *et al.* (2009) [12]. Under study, dry leaf yield was positively correlated with leaflet length (0.490 and 0.257), petiole length (0.832 and 0.700) and dry matter percentage (0.999 and 0.998) at a genotypic level and phenotypic levels. Earlier finding by Varalakshmi and Reddy (1997) [11] and Jangde *et al.* (2017) [4].

The results of the current study concerning direct and indirect effects on fresh leaf yield are presented in Table 2. This allows correlation coefficients to be divided into direct and indirect effects of traits that contribute to the dependent variable. The Path coefficient study revealed that the highest positive direct effect contributing to fresh leaf yield was observed due to dry leaf yield (1.03865), fresh leaf weight (0.66122), stem base diameter (0.09904), number of leaflets/rachis (0.091), dry matter percentage (0.06972), length of rachilla/plant (0.03179) and plant height (0.01018), whereas in parameters dry leaf weight (-0.80127), number of branches/plant (-0.0835), stem girth (-0.04929), leaflet length (-0.03841), canopy spread (-0.02042), and petiole length (-0.00828) showed a negative direct effect on yield per plant. Hence direct selection for these traits may be useful. These results are confirmed by the findings of Thakur *et al.* (2017) [10] and Singh *et al.* (2019) [9].

Table 2 exhibited that the maximum positive indirect effect on fresh leaf yield was showed from leaf petiole ratio (0.00653), leaflet length (0.00569), number of branches/plant (0.00564), stem girth (0.00501) and fresh leaf weight (0.00457), whereas the number of branches per plant exhibited a negative direct effect for fresh leaf yield (-0.0835). Similar finding was also reported by Yimer *et al.* (2021) [13] and Sabaghina *et al.* (2010) [8]. The maximum positive indirect effect of fresh leaf weight was observed for canopy spread (0.68223), number of branches/plant (0.65468) and length of rachilla/plant (0.64148) under study. The dry leaf yield showed positive direct effect on fresh leaf yield (1.03865), while, the maximum positive indirect effect was observed in stem girth (0.98724), length of rachilla/plant (0.97794), stem base diameter (0.90538), dry leaf weight (0.90251) and number of branches/plant (0.90015). Similar results were also earlier reported by Hari *et al.* (2022) [3] and Yimer *et al.* (2021) [13].

**Table 1:** Character association study among leaf yield traits in Moringa.

| | | PH | SBD | SG | NBPP | LPR | LR | CS | FLW | DLW | DLY | LLL | PL | DMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PH | P | 0.353 | 0.428* | 0.461* | 0.586** | 0.324 | 0.354 | 0.356 | 0.316 | 0.389* | 0.480** | 0.234 | 0.134 | 0.411* |
| | G | 0.416* | 0.492** | 0.554** | 0.641** | 0.393* | 0.389* | 0.448* | 0.406* | 0.452* | 0.559** | 0.298 | 0.247 | 0.477** |
| SBD | P | | 0.891** | 0.876** | 0.765** | 0.896** | 0.850** | 0.933** | 0.927** | 0.855** | 0.676** | 0.370* | 0.676** | 0.843** |
| | G | | 0.918** | 0.925** | 0.799** | 0.953** | 0.938** | 0.962** | 0.957** | 0.872** | 0.825** | 0.644** | 0.815** | 0.859** |
| SG | P | | | 0.818** | 0.765** | 0.863** | 0.709** | 0.808** | 0.803** | 0.911** | 0.594** | 0.356 | 0.610** | 0.911** |
| | G | | | 0.860** | 0.811** | 0.951** | 0.805** | 0.856** | 0.849** | 0.951** | 0.776** | 0.807** | 0.756** | 0.951** |
| NBPP | P | | | | 0.927** | 0.943** | 0.866** | 0.954** | 0.940** | 0.837** | 0.767** | 0.314 | 0.696** | 0.828** |
| | G | | | | 0.968** | 0.964** | 1.032** | 0.990** | 0.984** | 0.867** | 0.979** | 0.717** | 0.897** | 0.854** |
| LPR | P | | | | | 0.870** | 0.841** | 0.871** | 0.843** | 0.790** | 0.818** | 0.428* | 0.586** | 0.790** |
| | G | | | | | 0.919** | 0.943** | 0.899** | 0.876** | 0.804** | 0.946** | 0.705** | 0.754** | 0.803** |
| LR | P | | | | | | 0.825** | 0.933** | 0.926** | 0.904** | 0.697** | 0.385* | 0.701** | 0.896** |
| | G | | | | | | 1.008** | 0.970** | 0.967** | 0.942** | 0.893** | 0.751** | 0.874** | 0.931** |
| CS | P | | | | | | | 0.900** | 0.893** | 0.742** | 0.750** | 0.395* | 0.650** | 0.723** |
| | G | | | | | | | 1.032** | 1.019** | 0.830** | 0.965** | 0.581** | 0.863** | 0.815** |
| FLW | P | | | | | | | | 0.991** | 0.858** | 0.720** | 0.286 | 0.730** | 0.844** |
| | G | | | | | | | | 0.999** | 0.864** | 0.912** | 0.571** | 0.903** | 0.848** |
| DLW | P | | | | | | | | | 0.864** | 0.695** | 0.259 | 0.812** | 0.844** |
| | G | | | | | | | | | 0.869** | 0.870** | 0.507** | 0.922** | 0.853** |
| DLY | P | | | | | | | | | | 0.567** | 0.257 | 0.700** | 0.998** |
| | G | | | | | | | | | | 0.684** | 0.490** | 0.832** | 0.999** |
| LLL | P | | | | | | | | | | | 0.690** | 0.446* | 0.555** |
| | G | | | | | | | | | | | 0.760** | 0.596** | 0.676** |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PL | P | | | | | | | | | | | 0.101 | 0.257 |
| | G | | | | | | | | | | | 0.087 | 0.492** |
| DMP | P | | | | | | | | | | | | 0.665** |
| | G | | | | | | | | | | | | 0.818** |

*5% level of significance **1% level of significance
Ph = Plant height SBD =Stem base diameter SG= Stem girth NBPP= Number of branches/plant
LPR= Number of leaflets per rachis LR= Length of rachilla CS= Canopy spread FLW= Fresh leaf weight
DLW= Dry leaf weight DLY= Dry leaf yield LLL= leaflet length PL= Petiole length
DMP= Dry matter percentage

**Table 2:** Path coefficient study among various characters in Moringa.

| | PH | SBD | SG | NBPP | LPR | LR | CS | FLW | DLW | DLY | LLL | PL | DMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PH | 0.01018 | 0.04118 | -0.02424 | -0.04624 | 0.05838 | 0.01249 | -0.00794 | 0.29641 | -0.32535 | 0.46906 | -0.02147 | -0.00247 | 0.01721 |
| SBD | 0.00423 | 0.09904 | -0.04523 | -0.07724 | 0.07273 | 0.0303 | -0.01916 | 0.63584 | -0.76684 | 0.90538 | -0.03168 | -0.00534 | 0.05682 |
| SG | 0.00501 | 0.09089 | -0.04929 | -0.07182 | 0.07376 | 0.03022 | -0.01644 | 0.56576 | -0.68013 | 0.98724 | -0.0298 | -0.00668 | 0.05273 |
| NBPP | 0.00564 | 0.09161 | -0.04239 | -0.0835 | 0.08807 | 0.03064 | -0.02108 | 0.65468 | -0.78848 | 0.90015 | -0.03762 | -0.00594 | 0.06256 |
| LPR | 0.00653 | 0.07915 | -0.03995 | -0.08081 | 0.091 | 0.02922 | -0.01926 | 0.59422 | -0.70215 | 0.83492 | -0.03635 | -0.00584 | 0.05258 |
| LR | 0.004 | 0.09441 | -0.04686 | -0.08049 | 0.08364 | 0.03179 | -0.02059 | 0.64148 | -0.77497 | 0.97794 | -0.03432 | -0.00622 | 0.0609 |
| CS | 0.00396 | 0.09291 | -0.03968 | -0.08619 | 0.08584 | 0.03205 | -0.02042 | 0.68223 | -0.81625 | 0.86216 | -0.03708 | -0.00482 | 0.0602 |
| FLW | 0.00457 | 0.09524 | -0.04217 | -0.08267 | 0.08178 | 0.03084 | -0.02107 | 0.66122 | -0.8001 | 0.89749 | -0.03505 | -0.00473 | 0.06295 |
| DLW | 0.00414 | 0.09478 | -0.04184 | -0.08216 | 0.07974 | 0.03074 | -0.0208 | 0.66026 | -0.80127 | 0.90251 | -0.03341 | -0.0042 | 0.06431 |
| DLY | 0.0046 | 0.08633 | -0.04685 | -0.07236 | 0.07315 | 0.02993 | -0.01695 | 0.57136 | -0.69624 | 1.03865 | -0.02628 | -0.00406 | 0.05803 |
| LLL | 0.00569 | 0.08169 | -0.03824 | -0.08178 | 0.0861 | 0.0284 | -0.01971 | 0.60325 | -0.69685 | 0.71048 | -0.03841 | -0.0063 | 0.04157 |
| PL | 0.00303 | 0.0638 | -0.03977 | -0.05984 | 0.06415 | 0.02386 | -0.01187 | 0.37729 | -0.40641 | 0.50904 | -0.0292 | -0.00828 | 0.0061 |
| DMP | 0.00251 | 0.08071 | -0.03727 | -0.07492 | 0.06863 | 0.02777 | -0.01763 | 0.59705 | -0.73916 | 0.86446 | -0.02291 | -0.00072 | 0.06972 |

Residual value: -0.00026
Diagonal and bold underline figures show direct effect on fresh leaf yield
Ph = Plant height SBD =Stem base diameter SG= Stem girth NBPP= Number of branches/plant
LPR= Number of leaflets per rachis LR= Length of rachilla CS= Canopy spread FLW= Fresh leaf weight
DLW= Dry leaf weight DLY= Dry leaf yield LLL= leaflet length PL= Petiole length
DMP= Dry matter percentage

## Conclusion

The association studied revealed that the fresh leaf yield was a highly positive association with stem base diameter, stem girth, number of branches/plant, number of leaflets/rachis, length of rachilla/plant, canopy spread, fresh leaf weight, dry leaf weight, leaflet length, petiole length and dry matter percentage at genotypic and phenotypic levels. On other hand, the path coefficient analysis revealed that the highest positive direct effect contributing to fresh leaf yield was observed due to dry leaf yield, fresh leaf weight, stem base diameter, number of leaflets/rachis, dry matter percentage, length of rachilla/plant and plant height, whereas in parameters dry leaf weight, number of branches/plant, stem girth, leaflet length, canopy spread and petiole length showed a negative direct effect on yield per plant. Hence direct selection for these traits may be useful.

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