

Correlation and Path-Coefficient Analysis of Yield and Selected Yield Components of Macadamia (*Macadamia integrifolia*) Genotypes

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Received: 20.08.2018 | Revised: 16.09.2018 | Accepted: 28.09.2018

ABSTRACT

An experiment was conducted to determine correlations among important yield components using 10 macadamia genotypes (G-1, G-3, G-4, G-5, G-6, G-9, G-10, G-11, G-12, and G-13.) in existing orchards in farmer field in Gajanur village, Shivamogga district in Karnataka, India, during the year 2017-18. Ten traits viz., nut weight, shell weight, pericarp weight, kernel weight, nut volume, nut diameter, Kernel thickness, shell thickness, cluster length and nuts per cluster were evaluated for correlation and path analysis. Results depicted that yield was influenced by direct and indirect effects of different traits. Kernel weight and nut diameter of macadamia nut were the most important properties that directly increase the nut yield per tree. Kernel weight increased as shell thickness decreased. Cluster length, nut weight, and number of nuts per cluster were determined as the most important characters that directly affected the nut yield per tree. Kernel weight and yield per tree were the most important characters for macadamia breeding researches and were positively associated. Shell thickness and pericarp weight had negative effect on both the kernel weight and the yield per tree whereas kernel weight, nut weight and nut diameter had the positive direct effect on nut yield per tree. It is suggested that these properties can be used as a criteria for selection in macadamia breeding research studies.

Key words: Correlation, Kernel weight, Macadamia, Path analysis.

INTRODUCTION

Macadamia (*Macadamia integrifolia*) is an exotic fruit crop mainly cultivated for its edible nuts, belongs to family Proteaceae, originated in Subtropical Eastern Australia having a diploid chromosome number of $2n=48$. These are the world's most favoured and

expensive edible nuts. The global demand for the macadamia nuts is growing over the years and its production has not kept pace with demand due to macadamia nut varieties perform differently in different climatic situation.

Cite this article: Usha, D.S., Adivappar, N., Lakshmana, D., Shivakumar, B.S., Thippesh, D., Correlation and Path-Coefficient Analysis of Yield and Selected Yield Components of Macadamia (*Macadamia integrifolia*) Genotypes, *Int. J. Pure App. Biosci.* 6(5): 124-129 (2018). doi: <http://dx.doi.org/10.18782/2320-7051.6814>

In any crop improvement programme, it becomes necessary to have simultaneous progress of more than one character, especially in the complex character like yield which is influenced by many other traits. This is due to the physiological and linkage relationship of genes governing various characters. Hence, knowledge of correlations between different economical characters is of importance in selection programmes. Positive correlation makes simultaneous improvement in two or more attributes possible whereas, negative association indicates the need to compromise between desirable characters.

A breeder needs to identify causes of variability in yield in any given environment. Yield contributing components are interrelated with each other showing a complex chain of relationship. Correlation analysis is a tool useful in providing indication of the degree of association between variables. The simple correlation study is inadequate to measure the association as different genotypes are susceptible to environment in varying degrees. Estimates of phenotypic and genotypic correlations gave way for understanding environmental influence on heredity expression. The analysis is used to understand the complex relationships among traits. Correlation co-efficients indicate mutual association without regard to causation; while path analysis specifies the causes, measures relative importance of each cause and compensatory measures relative importance of each cause and compensatory mechanisms existing among variables.

There is no information on the association analysis through correlation and path analysis studies in macadamia nut. Hence the studies on correlation and path-coefficient analysis of yield and selected yield components of macadamia genotypes are essential.

MATERIAL AND METHODS

The experiment was conducted in farmer's field in Gajanur village in Shivamogga district of Karnataka during the year 2017-18. The experiment was laid out in randomized

complete block design with three replications and 10 genotypes: G-1, G-3, G-4, G-5, G-6, G-9, G-10, G-11, G-12, and G-13. Data recorded on nut weight, shell weight, pericarp weight, kernel weight, were measured by a digital analytical balance; whereas nut volume was recorded through water displacement method. Nut diameter, Kernel thickness, shell thickness, was measured by a digital Vernier calliper. Cluster length was measured by ordinary measuring scale and nuts per cluster were physically counted when they were fully matured and were counted as number. Nut yield was analyzed as dependent variable and all other yield attributing traits were considered as independent variables.

To determine the relationships between these traits correlation and direct-indirect path analysis were conducted¹³ using SPSS. 11. 0 computer software.

RESULTS AND DISCUSSION

Correlation co-efficient: Correlation co-efficients between the various yield attributing traits of the macadamia genotypes included in the study are given in Table 1 and 2. Significant positive correlations ($p < 0.05$) were found between nut yield per tree and kernel weight, nut diameter, kernel thickness, cluster length, nuts per cluster, nut weight, nut volume, and shell weight while the significant negative association was between pericarp weight and nut yield ($r = -0.55, -0.76$) respectively both at phenotypic and genotypic level. Similar results were also reported in hazelnut by Bostan and Islam⁵.

Nut yield per tree showed positive and significant correlation with kernel weight, nut diameter, kernel thickness, cluster length, nuts per cluster, nut weight, nut volume, and shell weight both at phenotypic and genotypic level. Since, these association characters are in the desirable direction, selection for these traits may improve the nut yield per tree. Similar results were also reported by Ghasemi *et al.*⁸, Cosmulescu and Botu⁶, Eskandari *et al.*⁷ in walnut.

Nut weight was significantly and positively associated with kernel thickness,

kernel weight, shell weight, nut volume and nut diameter both at phenotypic and genotypic level.

Nut diameter was positively and highly significantly correlated with kernel thickness, nut volume, kernel weight, cluster length, nuts per cluster, shell weight and nut weight both at genotypic and phenotypic level. Similar results were reported by Ghasemi *et al.*⁸, Eskandari *et al.*⁷ in walnut.

Kernel weight was highly significant and positively associated with kernel thickness, nut weight, nut diameter, shell weight, nut volume and cluster length both at phenotypic and genotypic level. Whereas non-significant positive association with nuts per cluster, shell thickness at genotypic level only. Kernel thickness was significant and positively associated with kernel weight, nut volume, shell weight, nut diameter, nut weight, and cluster length, both at phenotypic and genotypic level. The supporting references have been reported by Amiri *et al.*², Sharma and Sharma,¹² Ahandani *et al.*¹ in walnut.

Shell weight had a highly significant and positive correlation with nut volume, kernel thickness, nut weight, kernel weight, shell thickness and nut diameter both at phenotypic and genotypic level. Shell thickness had a highly significant and positive correlation with shell weight both at genotypic and phenotypic level, whereas significant and positive correlation with nuts per cluster, pericarp weight and nut weight only at phenotypic level. Similar findings were reported by Cosmulescu⁶, Bayazit⁴ in walnut.

Nut volume was positively and highly significantly correlated with shell weight, kernel thickness, kernel weight, nut diameter, nut weight, and cluster length, both at phenotypic and genotypic level. Similar results were reported by Arzani *et al.* in walnut, Anupa *et al.*³ in guava.

Cluster length was positively and highly significantly correlated with nuts per cluster, nut diameter, kernel weight and kernel thickness. Whereas nuts per cluster were positively and highly significantly correlated with cluster length, nut diameter both at phenotypic and genotypic level. Similar results

were reported by Gitonga *et al.*⁹ in macadamia nut.

Correlations according to genotypes were generally higher compared to their corresponding phenotypic correlations suggesting that relationships were mainly due to genetic causes. Significant positive genotypic correlations observed for all traits, it is highest for kernel weight and nut diameter. whereas pericarp weight and shell thickness shows significant neative association with nut yield. Thus kernel weight and nut diameter showed potentiality to be used as a primary component for yield improvement.

Path Co-efficient analysis: Path co-efficient analysis was based on phenotypic correlation and results are shown in Table 3.

Nut weight showed positive direct effect on nut yield per tree. Positive indirect effect through kernel thickness followed by kernel weight, shell weight, nut volume, nut diameter, cluster length, shell thickness and nuts per cluster. Nut diameter showed positive direct effect on nut yield per tree. It also exhibited positive indirect effect *via.*, kernel thickness, nut volume, kernel weight, cluster length, nuts per cluster, shell weight, nut weight, shell thickness. Kernel weight and kernel thickness exhibited positive direct effect on nut yield per tree, Positive indirect effect through nut weight, nut volume, shell weight, nut diameter, cluster length, and nuts per cluster. These results were in accordance with those of Kumar *et al.* in pecan nut. Cluster length and nuts per cluster recorded positive direct effect on nut yield per tree. They exhibited positive indirect effect through nut diameter, kernel weight, kernel thickness, shell weight, nut volume, nut weight and shell thickness. Similar findings were reported by Samal *et al.*¹¹, Madeni *et al.*¹⁰ in cashew nut.

Shell weight and nut volume showed negative direct effect on nut yield per tree and positive indirect effect through pericarp weight and nuts per cluster. Similar findings were reported by Amiri *et al.*² and Bayazit *et al.*⁴ in walnut.

Selection progress may be enhanced or retarded by the nature of inter trait

correlations. A positive relationship indicates that selection for improvement would result in parallel increases in the improvement components. Such type of relationship was recorded in most of the studied traits. From both direct influence and genetic correlation, increasing kernel weight could increase the

yield. For maximum yield to be reached selection of this character (kernel weight) is of great importance. This is because both the correlation with yield and direct effect were high. High negative direct effects on yield were recorded with pericarp weight.

Table 1: Phenotypic correlation co-efficient for different yield parameters in macadamia genotypes

Traits	1	2	3	4	5	6	7	8	9	10	r _p
1	1.0000	0.3061	0.6925**	0.1297	0.6710**	-0.1650	0.6520**	0.5745**	0.3292	0.0780	0.5318**
2		1.0000	0.4284*	0.0189	0.6133**	0.5711**	0.6864**	0.6143**	0.5881**	0.4533*	0.8103**
3			1.0000	0.1134	0.6330**	0.6093**	0.7164**	0.8143**	0.4367*	-0.0169	0.4759**
4				1.0000	-0.0897	0.2952	-0.0839	0.0538	0.0666	0.1406	-0.0106
5					1.0000	0.5891**	0.8951**	0.6347**	0.5725**	0.3172	0.8802**
6						1.0000	0.6825**	0.6215**	0.5043**	-0.1623	-0.5571**
7							1.0000	0.7912**	0.4817**	0.2093	0.7974**
8								1.0000	0.4052*	0.0087	0.5287**
9									1.0000	0.6881**	0.7555**
10										1.0000	0.5601**

*and ** indicates Significant at 5 and 1 per cent level probability respectively.

1. Nut weight (g) 3.Shell weight (g) 5. Kernel weight (g) 7.Kernel thickness (mm) 9.Cluster length (cm)
2. Nut diameter (cm) 4. Shell thickness (mm) 6. Pericarp weight (g) 8.Nut volume (cc) 10.Nuts per cluster

Table 2: Genotypic correlation co-efficient for different yield parameters in macadamia genotypes

Traits	1	2	3	4	5	6	7	8	9	10	r _g
1	1.0000	0.5466*	0.7668**	0.1428	0.8192**	-0.5665**	0.8763**	0.7395**	0.4030**	0.1079	0.6471**
2		1.0000	0.5557**	0.2719	0.7005**	-0.7630**	0.8188**	0.7140**	0.6517**	0.4926**	0.8925**
3			1.0000	0.6327**	0.6669**	-0.9346**	0.8064**	0.8610**	0.4560**	-0.0053	0.5020**
4				1.0000	0.2155	-0.6093**	0.2395	-0.3343	-0.2295	-0.6280**	-0.2417
5					1.0000	-0.8269**	0.9612**	0.6439**	0.5900**	0.3194	0.8985**
6						1.0000	-0.8733**	-0.8155	-0.7265**	-0.2178	-0.7651
7							1.0000	0.8392**	0.5296**	0.2106	0.8511**
8								1.0000	0.4215*	0.0081	0.5472**
8									1.0000	0.7011**	0.7648**
10										1.0000	0.5707**

*and ** indicates Significant at 5 and 1 per cent level probability respectively.

1. Nut weight (g) 3.Shell weight (g) 5. Kernel weight (g) 7.Kernel thickness (mm) 9.Cluster length (cm)
2. Nut diameter (cm) 4. Shell thickness (mm) 6. Pericarp weight (g) 8.Nut volume (cc) 10. Nuts per cluster

Table 3: Direct (diagonal) and indirect effects of components characters on yield in macadamia genotypes at phenotypic level

Traits	1	2	3	4	5	6	7	8	9	10	r _p
1	0.0912	0.0279	0.0632	0.0118	0.0612	-0.0150	0.0595	0.0524	0.0300	0.0071	0.5318
2	0.1251	0.4087	0.1751	0.0077	0.2507	-0.2358	0.2805	0.2511	0.2403	0.1853	0.8103
3	-0.0914	-0.0565	-0.1319	0.0150	-0.0835	0.0804	-0.0945	-0.1074	-0.0576	0.0022	0.4759
4	-0.0002	0.000	0.0002	-0.0018	0.0002	-0.0005	0.0002	-0.0001	-0.0001	-0.0003	-0.0106
5	0.3515	0.3212	0.3315	-0.4070	0.5238	-0.3085	0.4688	0.3324	0.2999	0.1661	0.8802
6	-0.0043	-0.0152	-0.0160	0.0078	-0.0155	0.0263	-0.0180	-0.0163	-0.0133	-0.0043	-0.5571
7	0.0782	0.0823	0.0859	-0.0101	0.1073	-0.0818	0.1199	0.0948	0.0577	0.0251	0.7974
8	-0.1128	-0.1206	-0.1599	-0.0106	-0.1246	0.1221	-0.1554	-0.1964	-0.0796	-0.0017	0.5287
9	0.0962	0.1718	0.1276	0.0195	0.1673	-0.1474	0.1408	0.1184	0.2922	0.2011	0.7555
10	-0.0016	-0.0093	0.0003	-0.0029	-0.0065	0.0033	-0.0043	-0.0002	-0.0141	0.0205	0.5601

Residual effect = 0.1890

1. Nut weight (g) 3. Shell weight (g) 5. Kernel weight (g) 7. Kernel thickness (mm) 9. Cluster length (cm)
2. Nut diameter (cm) 4. Shell thickness (mm) 6. Pericarp weight (g) 8. Nut volume (cc) 10. Nuts per cluster

CONCLUSION

Breeding work aims to develop new macadamia genotypes with such nut qualities as high kernel weight, thin shell and medium or big size nut reaching a high yield. Correlation and path analysis carried out in this study showed that these fundamental criteria were directly or indirectly affected by several other factors. Yet, it was noticed that other studies in general were focused on mostly kernel percentage. This is the first detail report in the literature to the best of our knowledge to have determined both path analysis and correlation methods for the first time with yield traits, which are determining criteria in macadamia breeding. Thus, correlation and path analyses involving these traits were conducted. Accordingly, the nut weight and kernel thickness were found to directly increase the kernel weight, while the kernel weight proved to increase the nut yield. Moreover, relatively lower shell thickness resulted in increases in the kernel weight. Furthermore, kernel weight, nut weight and nut diameter were found to have positive impact on the yield.

Acknowledgement

The authors are grateful to Director of Research, UAHS, Shivamogga for financial assistance under Staff Research Project (DR No. 5.12) on macadamia.

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