Electronic Journal of Plant Breeding

Research Article

Association studies in barnyard millet (*Echinochloa frumentacea* (Roxb.) Link) for early maturity and yield contributing traits at high altitude region

R. Prabu¹, C. Vanniarajan¹*, M. Vetriventhan², R. P. Gnanamalar¹, R. Shanmughasundaram³ and J. Ramalingam⁴

¹Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai – 625104, Tamil Nadu, India.
²Gene Bank, Research Program Genetic Gains, ICRISAT, Hyderabad, Telangana – 502324, India.
³Department of Soils and Environment, Agricultural College and Research Institute, Madurai – 625104, Tamil Nadu, India.
⁴Department of Biotechnology, Agricultural College and Research Institute, Madurai – 625104, Tamil Nadu, India.
*E-Mail: Vanniarajan.c@tnau.ac.in

Abstract

Barnyard millet is an under-utilized minor millet which is being popularized nowadays bestowing with high nutrient content in grains. Forty genotypes were evaluated in high altitude region to determine the correlation and path coefficient among the yield and yield attributing traits. Correlation analysis evinced that grain yield per plant had positive significant correlation with agro-morphological traits viz., plant height, days to flowering, days to maturity, number of nodes, stem diameter, length of flag leaf, width of flag leaf, length of inflorescence, width of inflorescence, length of lower racemes, number of racemes and thousand grain weight. The trait length of peduncle alone expressed negative significance with grain yield. The path coefficient estimation indicated that stem diameter had exposed high magnitude of direct effect on grain yield. Henceforth, the direct selection based on the flawless relationship between grain yield and these traits would benefit in selecting high yielding genotypes.

Key words

Correlation coefficient, Path analysis, Barnyard millet

INTRODUCTION

Millets are the oldest cultivated foods known to humans and have traditionally been the main components of the food basket of the poor people in India. Barnyard millet (*Echinochloa frumentacea* (Roxb.) Link) is one among them which is categorized as under-exploited crop for long years ago due to institutional neglect after the green revolution era. This crop can be grown in temperate, sub tropical and tropical regions of Asia and Africa as it performs well even under adverse climatic conditions Saleh et al. (2013).

In India, its cultivation expanded to Tamil Nadu, Andhra Pradesh, Telangana, Karnataka, Maharashtra, Orissa, Madhya Pradesh, Gujarat, Bihar and Uttar Pradesh (Channappagoundar et.al., 2008). It is also cultivated on the hills under double cut production system with better yield Bandypadhay (2009). It has also been utilized for the reclamation of sodicity, arsenic and cadmium problem soils (Sherief ,2007; Abe et al., 2011). Barnyard millet has a fair source of nutritional composition like carbohydrate (65.5g), protein ( 6.2g), fat(2.2g), crude fibre ( 9.8g), mineral matter ( 4.4g), calcium (20mg) and phosphorus (280mg) Gopalan et al., (2007) It is an excellent source of Fe content which ranged from 2.29 to 18.00 mg/100g (Renganathan et al., 2017).

Studies on correlation provide cognition of association among different traits and yield which results in selecting genotypes possessing desired traits for genetic improvement of yield. The Path coefficient analysis is nothing but a standardised partial regression of coefficient which splits the correlation coefficient into the measures of direct and indirect effects. In other words, it measures the direct and indirect contribution of various independent traits on a dependent character. The present research was undertaken to investigate the correlation and path analysis in different diverged genotypes of barnyard millet to develop a criterion for selection that could be effectively used for selecting the favourable genotypes for early maturity with high yield potential in future.

https://doi.org/10.37992/2020.1101.033
MATERIALS AND METHODS

Fourty germplasm accessions including 17 ICRISAT germplasm along with two check varieties MDU 1 and CO (Kv) 2 were used for the study. These genotypes were resourced from International, National Research Institutions and State Agricultural University and Colleges (Table 1). The local check varieties have good grain yield, widely cultivated by rainfed millet farmers in the state of Tamil Nadu, India. The experiment was conducted in the hilly region during summer 2019 at Idukki, Kerala which has latitude of 10.02 North and longitude of 77.35 East and the average rainfall of 1082 mm with average temperature of 21.9°C. The study utilized the experimental design of RBD (Randomized Block Design) with two replications. A single row of plants with 3 m length along with the spacing on 30 x 15 cm was maintained for each genotype as intra row and inter row spacing. Thinning and gap filling was carried out at the 20th day of sowing to maintain optimum population. Adequate irrigation and recommended fertilizer application was provided in time with proper crop management. The data were recorded for seventeen traits which contain days to flowering, days to maturity, plant height, number of nodes, length of internodes, number of basal tillers, stem diameter, flag leaf length, width of flag leaf, length of inflorescence, width of inflorescence, length of lower racemes, length of peduncle, number of racemes, Single ear head weight, Thousand grain weight and grain yield per plant. The data on the quantitative characters were recorded based on the descriptors of IPGRI (1983). All the statistical analysis was done by utilizing TNAUSTAT software.

Table 1. Details of germplasm used for the study

| Sl.No | Genotypes | Origin/Parentage | Source |
|-------|-----------|------------------|--------|
| 1     | ACM 110   | India            |        |
| 2     | ACM 161   | India            |        |
| 3     | ACM 295   | India            |        |
| 4     | ACM 331   | India            |        |
| 5     | ACM 333   | India            |        |
| 6     | ACM-15-343| A cross derivative from ACM cultures | Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai |
| 7     | ACM-15-353| A cross derivative from ACM cultures |        |
| 8     | GECH 10   | India            | All India Co-ordinated Small Millets |
| 9     | GECH 15   | India            | Improvement Project, Bangalore. |
| 10    | IEc - 52  | India            |        |
| 11    | IEc - 167 | India            |        |
| 12    | IEc - 568 | India            |        |
| 13    | IEc - 166 | India            |        |
| 14    | IEc - 672 | India            |        |
| 15    | IEc - 82  | India            |        |
| 16    | IEc - 109 | India            |        |
| 17    | IEc - 107 | India            | ICRISAT, Hyderabad |
| 18    | IEc - 108 | India            |        |
| 19    | IEc - 386 | India            |        |
| 20    | IEc - 385 | India            |        |
| 21    | IEc - 356 | India            |        |
| 22    | IEc - 350 | India            |        |
| 23    | IEc - 391 | India            |        |
| 24    | IEc - 71  | India            |        |
| 25    | IEc - 296 | India            |        |
| 26    | IEc - 396 | India            |        |
| 27    | T 5       | India            | Department of Millets, Tamil Nadu Agricultural University, Coimbatore |
| 28    | M1        | India            |        |
| 29    | M2        | India            |        |
| 30    | M3        | India            |        |
| 31    | M5        | India            |        |
| 32    | M12       | India            |        |
| 33    | M18       | India            |        |
| 34    | M27       | Mutant lines of Co (KV)-2 Variety, India |
| 35    | M28       | India            |        |
| 36    | M36       | India            |        |
| 37    | M37       | India            |        |
| 38    | M38       | India            |        |
| 39    | MDU – 1   | India            |        |
| 40    | Co (KV)- 2| India            |        |
RESULTS AND DISCUSSION

The genotypic and phenotypic correlation coefficients estimated between grain yield per plant with all quantitative traits are illustrated in Table 2. In the present investigation, the genotypic correlation coefficients were higher than the phenotypic correlation coefficient for the characters studied as observed by Johnson et al. (1955). This is because of polygene governing the traits were similar and influence of environment for the trait expression might be minimal.

Grain yield performed highly positive significant correlation with plant height, days to flowering, days to maturity, number of nodes, stem diameter, length of flag leaf, width of flag leaf, length of inflorescence, width of inflorescence, number of racemes and single ear head weight (Table 2). The highest yield was with width of flag leaf (0.8926) followed by number of racemes (0.8805), stem diameter (0.8715), days to maturity (0.8027), days to flowering (0.7934), single ear head weight (0.785), number of nodes (0.7653), length of flag leaf (0.704), length of lower racemes (0.3263) implying the attention to these traits in yield enhancement of barnyard millet. Similar results were also reported by Arunachalam et al. (2012); Gupta et al. (2009); Upadhyaya et al. (2014); Sood et al. (2015); Joshi et al. (2015) and Arya et al. (2017) in barnyard millet.

Days to flowering and days to maturity demonstrated highly significant positive genetic association with grain yield, which hinted that selecting late maturity genotypes could fruit in better yield improvement. It has similarly with the findings of Arunachalam et al. (2012) who concluded that the early maturing germplasm in barnyard millet were poor yielders and vice versa. This was supported by the investigation of Sood et al. (2016) too.

Table 2. Phenotypic (above diagonal) and genotypic (below diagonal) Correlation coefficient matrix between 17 biometric traits in 40 germplasm of high altitude region.

| NN | LON | NBT | SD | LFL | WFL | WOI | LOP | NOR | TGW | SEW | GYP |
|----|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0.8574** | 0.3704* | 0.0742 | 0.7546* | 0.7079* | 0.7547* | 0.8885* | 0.7705** | 0.3109* | -0.184 | 0.8085** | 0.2145 | 0.6864* |
| 0.88** | 0.2767* | -0.141 | 0.8836* | 0.7289* | 0.8261* | 0.7397* | 0.6857* | 0.3231* | -0.475 | 0.887* | 0.3673* | 0.8576* |
| 0.8844** | 0.2201* | -0.132 | 0.8955* | 0.7403* | 0.808* | 0.7475* | 0.6861* | 0.3646* | -0.515 | 0.8806** | 0.376* | 0.8476* |
| 1 | 0.1287 | -0.099 | 0.8427* | 0.639* | 0.7592* | 0.708* | 0.64* | 0.2365 | -0.448 | 0.7969* | 0.2472 | 0.8087* |
| 0.1644 | 1 | -0.149 | 0.216 | 0.3816* | 0.2877* | 0.4392* | 0.3719* | 0.2039 | 0.1109 | 0.2208 | 0.9837 | 0.002 |
| -0.108 | -0.2696 | 1 | -0.252 | -0.078 | -0.198 | -0.006 | 0.0076 | -0.01 | 0.3501* | -0.141 | -0.235 | -0.191 |
| 0.8855 | 0.2645 | -0.2487 | 1 | 0.7009* | 0.8593* | 0.6597* | 0.6824* | 0.3729* | -0.616 | 0.8835* | 0.3911* | 0.8524* |
| 0.7015* | 0.3843* | -0.161 | 0.7696* | 1 | 0.7704* | 0.7542* | 0.7286* | 0.3789* | -0.291 | 0.765* | 0.1844 | 0.6127* |
| 0.8129** | 0.3441** | -0.2643 | 0.9357** | 0.8405** | 1 | 0.6819* | 0.6847** | 0.2955 | -0.402 | 0.7664* | 0.3879* | 0.8863* |
| 0.7481** | 0.4939** | -0.0187 | 0.694* | 0.8041** | 0.7404** | 1 | 0.7561* | 0.3666* | -0.069 | 0.7153* | 0.0.2581 | 0.5748** |
| 0.7707** | 0.4537** | -0.0228 | 0.7974* | 0.8545* | 0.83* | 0.865* | 1 | 0.5439** | -0.156 | 0.7252* | 0.2301 | 0.5417* |
| 0.3434* | 0.3865** | -0.0668 | 0.4864** | 0.5472** | 0.3502* | 0.5115** | 0.6049** | 1 | 0.102 | 0.3218* | 0.2876* | 0.2138 |
| -0.4709** | 0.1122 | 0.3722* | -0.644** | -0.3165** | -0.4577** | -0.0806 | -0.2145 | 0.2087 | 1 | -0.432** | -0.397** | -0.584** |
| 0.8495** | 0.2567 | -0.138 | 0.8333** | 0.8112* | 0.8615* | 0.7411** | 0.8536** | 0.4371** | -0.439** | 1.2296 | 0.7982* | 0.8522** |
| 0.2656 | 0.1005 | -0.2765 | 0.4404** | 0.199 | 0.2784* | 0.2581 | 0.2375 | 0.3247* | -0.443** | 0.3169 | 1 | 0.2543 | 0.2019 |
| 0.8337* | 0.2193 | -0.219 | 0.8951** | 0.6497** | 0.7911** | 0.5939** | 0.6417* | 0.3011** | -0.599** | 0.7821** | 0.2687 | 1 | 0.7372** |

Significant at 5 % (0.275) Significant at 1 % (0.381) Degrees of freedom - 38

DF – Days to Flowering. DM – Days to Maturity. GY_P – Grain Yield per Plant. LFL – Length of Flag Leaf. LLR – Length of Inflorescence; LON – Length of Node; LOP – Length of Peduncle; NBT – Number of Basal Tillers; NN – Number of Nodes; NOR – Number of Racemes; PH – Plant Height; SD – Stem Diameter; SEW – Single Ear head Weight; TGW – Thousand Grain Weight; WFL – Width of Flag Leaf; WOI – Width of Inflor.escence

The characters such as length of nodes (0.2557) and thousand grain weight (0.2148) explicit non-significant positive correlation with grain yield. Whereas, the trait number of basal tillers showed non-significant negative association. Moreover, a significant negative companion with grain yield recorded by length of peduncle (-0.5672). These results are in accordance with the findings of Maheto et al. (2000) and Gowda et al. (2008) in finger millet.

Path coefficient analysis as outlined by Dewey and Lu (1959) was carried out to split the correlation coefficients in to measure the direct and indirect effects. The estimated coefficients were then categorized as negligible, low, moderate, high and very high based on the scales suggested by Lenka and Mishra (1973). Among the traits studied (Table 3), stem diameter was observed to have maximum direct effect on yield (1.4738) followed by number of racemes (0.7177) indicating that selection based on these traits could result in better yield (Prakash and Vanniaraajan, 2015). The characters length of inflorescence (0.1284), days to maturity (0.1262), and length of nodes (0.1166) exhibited low direct effects towards grain yield. The remaining traits showed negligible scale of direct effects on yield announcing that indirect effects of associated characters played major role on grain yield as the genotypic correlation exhibited high positive significance for majority of the traits. The residue value 0.3943 explains that 61 percent of total variability of grain yield has been accounted through this study.

https://doi.org/10.37992/2020.1101.033

194
Table 3. Path coefficient matrix expressing direct and indirect effects for 17 traits in 40 germplasm of high altitude region

| Characters | Direct and Indirect effects for the characters | Genotypic correlation with GY/P |
|-----------|---------------------------------------------|----------------------------------|
| PH        | -0.0793                                    |                                |
| DF        | -0.0629                                    |                                |
| DM        | -0.0901                                    |                                |
| NN        | -0.0293                                    |                                |
| LON       | -0.0327                                    |                                |
| LBT       | -0.0234                                    |                                |
| SD        | -0.0617                                    |                                |
| LFL       | -0.0553                                    |                                |
| LOP       | 0.0149                                     |                                |
| LOR       | -0.0617                                    |                                |
| TGRW      | -0.0496                                    |                                |
| SEW       | -0.0519                                    |                                |

Based on the correlation and path analysis, the main yield contributing characters in barnyard millet are plant height, days to flowering, days to maturity, number of nodes, stem diameter, length of flag leaf, width of flag leaf, length of inflorescence, width of inflorescence, length of lower racemes, number of racemes and thousand grains weight. The traits stem diameter and number of racemes had high direct positive effect on grain yield resulting selection based on these traits could be benefited for crop improvement programme.

ACKNOWLEDGEMENT

The authors are much grateful to ICRISAT, Hyderabad, Telangana for providing seed materials of barnyard millet germplasm accessions for research purpose.

REFERENCES

Abe, T., Fukami, M. and Ogasawara, M. 2011. Effect of hymexazol (3-hydroxy-5-methylisoxazole) on cadmium stress and accumulation in Japanese millet (Echinochloa frumentacea Link). Journal of Pesticide Science. 36(1): 48-52. [Cross Ref]

Arunachalam, P., Vanniarajan, C. and Nirmalakumari, A. 2012. Consistency of barnyard millet (Echinochloa frumentacea) genotypes for plant height, duration and grain yield over Environments. Madras Agricultural Journal. 93(1-3): 11-13.

Arya, R., Bhatt, A., Kumar, V. and Singh, D. P. 2017. Correlation analysis of some growth, yield and quality parameters of barnyard millet (Echinochloa frumentacea (Roxb.) Link) Germplasm. Journal of Pharmacognosy and Phytochemistry. 6(5): 1426-1429.

Bandyopadhyay, B. B. 2009. Yield Variation and Associated Changes in Relationship of component Characters of a Cold Sensitive Finger Millet Genotype in Subsequent Generation. Indian J. Agric. Res. 43: 32-36.

Channappagoudar, B. B., Hiremath, S. M., Biradar, N. R., Koti, R. V. and Bharagamoudar, T. D. 2008. Influence of morpho-physiological and biochemical traits on the productivity of barnyard millet. Karnataka Journal of Agricultural Sciences, 20(3).

Dewey, D. R. and Lu, K. A. 1959. Correlation and Path-Coefficient Analysis of Components of Crested Wheatgrass Seed Production 1. Agronomy journal. 51(9): 515-518. [Cross Ref]

Gopalan, C., Ramasastri BV, Balasubramanian SC. 2007. Nutritive value of Indian foods, Hyderabad, NIN, ICAR.

Gowda, J., Shet, R., Suvarna, M. and Somu, G. 2008. Genetic variability and correlation studies in interspecific crosses of finger millet [Eleusine coracana (L.) Gaertn.]. Crop. Res. 36: 239-243.

Gupta, A., Mahajan, V., Kumar, M. and Gupta, H. S. 2009. Biodiversity in the barnyard millet (Echinochloa frumentacea Link, Poaceae) germplasm in India. Genetic resources and crop evolution. 56(6): 883-889. [Cross Ref]
H.W. Johonson, H. F. Robinson, and R. E. Comostock. 1955. Genotypic and phenotypic correlations in soybeans and their implication in selection. *Agronomy Journal*. vol. 47, pp. 477–483. [Cross Ref]

IPGRI. 1983. *Echinochloa frumentacea* millet descriptors. Available at www.bioversityinternational.org/fileadmin/biover_sity/publications/pdfs 394.pdf. Google Scholar.

Joshi, R. P., Jain, A. K., Chauhan, S. S. and Singh, G. 2015. Research Article Characterization of barnyard millet (*Echinochloa frumentacea* (Roxb.) Link.) landraces for agromorphological traits and disease resistance. *Electronic Journal of Plant Breeding*. 6(4): 888-898.

Lenka, D. and Misra, B. 1973. Path-coefficient analysis of yield in rice varieties. *Indian journal of agricultural sciences*. 43(4): 376-379.

Mahto, R. N., Mahto, J. and Ganguli, D. K. 2000. Correlation and path coefficient analysis in ragi (*Eleusine coracana* (L.) Gaertn.) under rainfed condition. *Birsa Agril. Uni. J. Res.* 12: 81-83.

Prakash, R. and Vanniarajan, C. 2015. Path analysis for grain yield in barnyard millet (*Echinochloa frumentacea* (Roxb.) link). *Bangladesh Journal of Botany*. 44(1): 147- 150.[Cross Ref]

Renganathan, VG, C Vanniarajan, A Nirmalakumari, M Raveendran, S Thiyageshwari, and P Arunachalam. 2017. Association analysis in germplasm and F_{1} segregating population of Barnyard Millet (*Echinochloa frumentacea* Roxb. Link) for biometrical and nutritional traits. *Int. J. Curr. Microbiol. App. Sci.* 6 (8):3394-3400. [Cross Ref]

Saleh AS, Zhang Q, Chen J, Shen Q. 2013. Millet grains: nutritional quality, processing, and potential health benefits. Comprehensive reviews in food science and food safety. May;12(3):281-95. [Cross Ref]

Sood, S., Khulbe, R. K. and Kant, L. 2016. Optimal Yield Related Attributes for High Grain Yield using Ontogeny Based Sequential Path Analysis in Barnyard Millet (*Echinochloa spp.*). *Journal of Agricultural Science and Technology*, 18(20), 1933-1944.

Sood, Salej, Rajesh K Khulbe, Arun Kumar, Pawan K Agrawal, and Hari D Upadhyaya. 2015. Barnyard millet global core collection evaluation in the submontane Himalayan region of India using multivariate analysis. *The Crop Journal*. 3 (6):517-525. [Cross Ref]

Upadhyaya, H. D., Dwivedi, S. L., Singh, S. K., Singh, S., Vetriventhan, M. and Sharma, S. 2014. Forming core collections in barnyard, kodo, and little millets using morphoagronic descriptors. *Crop Science*. 54(6): 2673-2682. [Cross Ref]