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Association of genetic variability studies in drumstick genotypes (*Moringa oleifera* L.)

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Abstract
Analysis of variance revealed that the mean sum of squares due to genotypes were significant for all the characters indicating existence of sufficient variability among the genotypes. The GCV and PCV was observed highest for leave length followed by number of pod per plant, plant height, pod girth, length of pod, number of branches per plant, number of leave per rachis, number of flower per inflorescence, number of seeds per pod, number of leave per rachis, yield per plant and stem girth, which is an indicative of the genetic variability exists in the drumstick germplasm accessions. High heritability coupled with high genetic advance as percentage of mean was observed for plant height followed by leave length, length of pod, number of pod per plant, number of branches per plant, pod girth, stem girth number of flower per inflorescence number of seeds per pod which indicated that the predominance of additive gene action in the expression of these characters which could be utilized for the development of high yielding drumstick genotypes. Correlation studies revealed that the yield per plant showed the maximum significant positive correlation with number of leave per rachis follow by number of branches per plant, number of pods per plant number of flower per inflorescence stem girth, leave length, may be advantageous for selecting the high yielding genotype in drumstick from the available germplasm accessions. The path coefficient study show that the highest positive direct effect contributing to yields per plant was observed due to number of branches per plant followed by length of pod, leave length, pod girth, number of pod per plant, pod weight.

Keywords: Correlation, path analysis, variability, heritability, Moringa

Introduction
Moringa oleifera Lam. belonging to the family Moringaceae, native to India, is fast growing, drought tolerant and easily adapted to varied ecosystems and farming systems. It occupies a unique and consistent position in the Indian vegetable industry. A Moringa, an indigenous plant, is now valued for providing the fruits for vegetable with nutraceutical traits. Leaf, flower, bark, root and even wood are also used. It is also known as 4F plant (Food, Fodder, Fuel and Fertility). Popularly known as ‘‘Drumstick’’ tree, horseradish tree, or Ben tree, *M. oleifera* is a deciduous-to-evergreen shrub or small tree with a height of 5 to 10 m (Morton, 1991) [1]. Almost every part of the moringa plant has nutritional value. The pod is cooked as a vegetable and exported to many countries as fresh or canned. The root can be used as substitute for horse radish. Foliage is eaten as greens, boiled, fried, in soups or for seasoning. Dried leaf powder can be added to any kind of meal as a nutritional supplement. The seed can be roasted and eaten like a peanut. In order to do develop cultivars for increased the yield, genetic variability is the prerequisite since it is the source of variation and base for yield improvement. Assessment of genetic variability is also needed for efficient parental selection in breeding program (Rahman *et al*., 2011) [2], long term selection gain and exploitation of heterosis (Rahman *et al*., 2012) [3]. Furthermore, characters associated with yield are to be determined by correlation and path coefficient analysis to assist selection in yield improvement work. Though correlation analysis indicates the association pattern of component traits with yield, it also represents the overall influence of a particular trait on yield rather than providing cause and effect relationship. The path coefficient analysis technique facilitates the partitioning of genotypic correlation into direct and indirect contribution of various characters on yield (Mahbub *et al*., 2015) [4]. Such information would be of great value in enabling the breeder to specifically identify the important component traits of yield and utilize the genetic stock for improvement in a planned way.

Materials and Methods

The present investigation was carried out at Department of Vegetable Science, Pt. K.L.S. College Horticultural of and Research Station, Rajnandgaon (C.G.) during 2018 -2019. Twenty accessions of Moringa collected from various parts of Chhattisgarh and other state were collected, evaluated for different quantitative traits. Observations on quantitative characters *viz*., plant height (cm), number of branches per plant, stem girth (cm), leaf length (cm), number of leaves per rachis, length of leaf rachis (cm) number of flowers per inflorescence, length of pod (cm), pod girth (cm), pod weight (g), number of pods per plant, number of seeds per pod, yield per plant (kg), contents were recorded. The variability for different quantitative traits was estimated as per procedure suggested by GCV and PCV as per Sivasubramanium and Madhavamenon (1973) [5], heritability according to Burton and Devane (1953) [6] and genetic advance as per Johnson *et al*. (1955) [7] Correlation coefficient was worked out as per Miller *et al*. (1958) [8] and path coefficient analysis was done according to formula given by Dewey and Lu (1959) [9]

Results and Discussion

Genetic variability, heritability and genetic advance

Genotypic and phenotypic coefficient of variation

Genotypic and phenotypic coefficients of variation of different characters are presented in Table 1. High degree of genotypic (GCV) and phenotypic coefficient of variations (PCV) were recorded for traits *viz* for leaf length (39.70% and 40.81%), number of pod per plant (37.62% and 39.10%), plant height (37.39 and 37.49%), pod girth (35.10% and 37.53%), number of branches per plant (30.27% and 31.91%), number of seeds per pod (30.25% and 33.62%), length of pod(29.64% and 30.74%), number of leave per rachis (28.38 and 37.82%), number of flower per inflorescence (27.31% and 30.61%), yield per plant (21.65% and 26.55%) and stem girth (20.80% and 24.70%) suggested the substantial improvement on drumstick through selection for these traits.

The moderate genotypic coefficient of variation were also observed for length of leave rachis (19.24%) and pod weight (13.35%) which is an indicative of the genetic variability exists in the drumstick germplasm accessions. Related result were also reported by Venkatesan *et al*. (2003) [2, 77], Nigude *et al.* (2004) [3, 46], Prasanthi (2004) [4, 52] and Kumawat *et al.* (2005) [5, 36].

Heritability

In the present investigation, high degree of heritability was recorded for most of characters. The highest heritability was recorded for plant height (99.48%), leaf length (94.62%), length of pod (92.96%), number of pods per plant (92.59%), number of branches per plant (89.96%), pod girth (87.47%), number of seeds per pod (80.99%) number of flower per inflorescence (79.57%) stem girth (70.89%) and moderate heritability was noticed for length of leave rachis (69.14%) and yield per plant (66.54%) and number of leave per rachis (56.33%) and low heritability was observed in pod weight (37.65%). The similar findings were also reported by Venkatesan *et al.* (2003) [2, 77] Sheela *et al.* (2006) [65], Sharma *et al.* (2007) [64], Choudhary *et al*. (2010) [25].

Genetic advance as percentage of mean

Genetic advance as percentage of mean was observed high for leave length (79.55%), plant height (76.83%), number of pods per plant (74.58%), pod girth (67.63%), number of branches per plant (59.14%), length of pod (58.87%) number of seeds per pod (56.09%), number of flower per inflorescence (50.18%), number of leave per rachis (43.89%) yield per plant (36.39%), stem girth (36.07%), Length of leave rachis (32.96%).

In the present investigation, high degree of heritability along with high degree of genetic advance as percent of mean was noted for Plant height, leave length, number of pod per plant, length of pod, number of Branches per plant, pod girth, number of seeds per pod, number of flower per inflorescence, number of leave per rachis and stem girth indicated that the additive gene action is involve for these traits. Similar results were also reported by Venkatesan *et al.* (2003) [2, 77], Sheela *et al.* (2006) [65], Sharma *et al.* (2007) [64], Choudhary *et al.* (2010) [25].

Table 1: Genetic variability studies in Drumstick genotypes

Characters	Mean	Range		GCV%	PCV%	h^2% (bs)	Genetic Advance	GA as % of mean
		Min	Max					
Plant height (m)	4.37	2.30	7.52	37.39	37.49	99.48	3.36	76.83
Number of Branches per Plant	14.29	8.24	22.54	30.27	31.91	89.96	8.45	59.14
Stem girth (cm)	21.27	13.81	28.28	20.80	24.70	70.89	7.67	36.07
Leave length (cm)	35.30	16.44	62.04	39.70	40.81	94.62	28.08	79.55
Number of leave per rachis	48.72	21.63	78.34	28.38	37.82	56.33	21.38	43.89
Length of leave rachis (cm)	13.85	8.73	18.34	19.24	23.14	69.14	4.56	32.96
Number of flowers per inflorescence	29.51	12.89	42.67	27.31	30.61	79.57	14.81	50.18
Length of pod (cm)	47.43	18.61	67.21	29.64	30.74	92.96	27.92	58.87
Pod girth (cm)	7.88	3.55	12.86	35.10	37.53	87.47	5.33	67.63
Pod weight (g)	30.87	21.97	40.00	13.35	21.76	37.65	5.21	16.88
Number of pods per plant	61.39	18.91	98.05	37.62	39.10	92.59	45.79	74.58
Number of seeds per pod	15.39	7.86	23.85	30.25	33.62	80.99	8.63	56.09
Yield per plant (kg)	2.56	1.56	3.56	21.65	26.55	66.54	0.93	36.39

Conclusions

This evaluation of variance has proven that the sum of square due to genotype became significant for all of the studied characters. This indicates the existence of variability among the genotype for various traits. In present investigation M-8, M-12, and M-20 was superior among all the treatment (genotypes) for most of the traits *viz*.. plant height, number of branches per plant, length of leaf rachis, leaf length, number of leaves per rachis, stem girth, number of flower per inflorescence, pod weight and yield per plant etc. can be utilized for multiplication trials in different location in Chhattisgarh. Genotype M-8, M-12, and M-20 become advanced among all of the treatments (genotypes) for most of the characters *viz*.. plant height, number of branches

consistent with plant, length of leaf rachis, leaf length, quantity of leaves per rachis, stem girth, range of flower according to inflorescence, pod weight and yield per plant and many others. Excessive degree of genotypic and phenotypic coefficient of variations have been discovered for trends *viz* for leaf length), number of pod consistent with plant, plant height and, pod girth, range of branches according to plant, number of seeds in keeping with pod, length of pod, number of leaves according to rachis, number of flower in keeping with inflorescence, pod yield in keeping with plant and stem girth counseled the genetic development of drumstick may be done through choice of these traits. Excessive degree of heritability along with excessive degree of genetic advance as percentage of imply become noted for plant height, leaf length, 43 number of pod in keeping with plant, length of pod, quantity of branches in per plant, pod girth, number of seeds per pod, quantity of flower consistent with inflorescence, number of leaves per rachis and stem girth indicated that the additive gene movement is involve for above traits. Association studies indicated that yield in keeping with plant extensively definitely correlated with number of leaves per rachis, number of branches in step with plant, number of pods per plant, quantity of flower in keeping with inflorescence, stem girth and leaf length, while pod yield per plant showed terrible and exceptionally drastically correlation with plant height at genotypic and phenotypic degrees. Therefore, direct selection of those characters can be used to improve the production of high-yielding genotypes of drumsticks.. Path coefficient studied expressed that the number of branches per plant followed by length of pod, leaf length, pod girth, number of pod per plant, pod weight showed high positive direct effect with pod yield per plant.

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