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# Variability in perennial moringa (*Moringa oleifera* Lam.) genotypes for quantitative and qualitative traits

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**Abstract**
A study was carried out at the Department of Vegetable Science, Horticultural College and Research Institute, Periyakulam, during 2019-20 to assess the genetic variability, heritability and genetic advance of important quantitative and qualitative traits in fifty-two perennial moringa genotypes. Analysis of variance revealed a significant differences for all traits. High genotypic and phenotypic coefficients of variation were noticed for pod yield, the number of pods per tree, total carotenoids, iron and pod weight indicating maximum variability among the different genotypes. High estimates of heritability coupled with high genetic advance obtained for all the traits except crude fibre content indicating the presence of additive gene effect which showed the effectiveness of selection for these traits. Presence of high heritability coupled with moderate genetic advance for crude fibre content revealed that the straight selection has a limited scope for further improvement of the trait. Among fifty two genotypes PKM MO-55 has the highest iron content (7.20mg/100g), number of pods/tree (306.50) and pod yield (36.47 kg/tree).

**Keywords**
*Moringa oleifera*, iron, Genetic variability, Heritability, Genetic advance.

## INTRODUCTION

*Moringa oleifera*, native to India, grows in the tropical and subtropical regions of the world. It is popularly called as "Miracle tree" is a monogenetic plant in the family *Moringaceae*. Moringa is rich in nutrition with presence of a variety of essential phytochemicals present in its leaves, pods and seeds. It has seven times higher value of vitamin C in oranges, 10 times higher values of vitamin A in carrots, 17 times higher value of calcium in milk, nine times higher value of protein in yoghurt, 15 times higher value of potassium in bananas and 25 times higher value of iron in spinach (Rockwood *et al*., 2013). The main use of *M. oleifera* has been reported as the consumption of the tender pods as a vegetable (D'Souza and Kulkarmi., 1993). It has several medicinal values which are known by Egyptians, Romans, Greeks and Hindus during the 17$^{th}$ century used to cure chlorosis which is called as green disease, a condition often resulting from the iron deficiency. In late 1932, discovered iron is used for hemoglobin synthesis and oxygen transport (Underwood *et al*., 1999). Present world affected by iron deficiency because of low bioavailability of iron and low iron intake in our daily food. (Abbaspour *et al*., 2014). There is a need for the high bioavailability source of nutrients from plants. Moringa has rich in nutrients source but it has largest genetic diversity, hence the identification of ideal genotypes for commercial cultivation is very important. Crop improvement can be possible through the selection method if the crop will have the widest genetic variability (Salesh kumar *et al*, 2010). Wide range of variability observed in moringa cultivated throughout the nation which can helpful for the improvement of elite genotypes (Resmi *et al.,* 2006; Madinur, 2007). Crop improvement is based both on understanding which genes are involved in a phenotype, as well as the degree of environmental variation (Subramanian *et al.,* 2010). A well understanding of their genetic variability is the only way to bring successful varieties for commercial cultivation through the different breeding programme such as selection, pedigree selection and hybridization. Heritability is an index for calculating the relative influence of environment on expression of genotypes. It becomes very much essential to judge how much of variability is heritable and is non-heritable. There are several variability studies in moringa (Sheetal *et al.,* 2015; Selvakumari *et al*., 2017; Karunakar *et al*., 2018; Lakhsmi *et al*., 2019) but very little work was made in quantitative along with qualitative traits such as ascorbic acid, total carotenoids, crude fibre, iron and calcium. Hence the present investigation was made with fifty two moringa genotypes collected from various parts of Tamilnadu and Andhra Pradesh to know the variability for nutrient contents.

## MATERIALS AND METHODS

This study was taken up in the research block of Department of Vegetable Science, Horticultural College and Research Institute, Periyakulam, Tamilnadu Agricultural University. Fifty two genotypes (Table.1) were studied in a randomized block design (RBD) with two replications. Observation were recorded for five morphological characters *viz*., pod length, pod girth, pod weight, the number of pods/tree and pod yield/tree and five biochemical characters *viz*., ascorbic acid, total carotenoids, crude fibre, iron and calcium. The mean values were calculated from randomly selected plants from each replication and recorded. The data collected on all the characters were subjected to standard methods of analysis of variance (ANOVA) (Panse and Sukhatme, 1985). Estimation of biochemical analysis *viz*., ascorbic acid, total carotenoids and iron is done according to procedure given in the book Official methods of analysis (Chemists, 1975). Crude fibre was done by procedure given by Maynard (1970) and estimation of calcium done according to procedure given by Jackson (1973). Genotypic and phenotypic co-efficient of variation were estimated according to Burton (1952) GCV and PCV were classified by Sivasubramanian and Madhamenon (1973). Heritability and genetic advance as per cent of mean was calculated based on Johnson *et al*., (1955).

## RESULT AND DISCUSSION

The analysis of variance revealed the existence of significant differences among the genotypes for all the traits (Table 3), indicating the presence of considerable genetic variability among the experimental material under study. Thus, there is a plenty of area and scope for the improvement of different quantitative and qualitative traits through selection. Similar finding on presence of significant variability for various characters in the moringa genotypes was also reported by many researchers in their study (Karunagar *et al.*, 2018; Laxmi *et al.*, 2019). The mean (Table 2) and range values (Table 4) for all the traits evaluated are presented**.** On recording pod length ranged from 17.40cm (PKM MO 35) to 94.70cm (PKM MO 26). The general mean for pod length was 53.30 cm and twenty genotypes were exceeded the general mean value. In various germplasm, pod girth ranged from 4.36cm (PKM MO 35) to 8.28 cm (PKM MO 13). Twenty three germplasm had higher the general mean (6.70cm). The highest and lowest pod weight was recorded in PKM MO 26 (166.15g), PKM MO 35 (37.49g) respectively. Twenty two germplasm had the higher general mean value that is 76.56g. The wide range of variation was observed in the number of pods/tree and pod yield/tree. Number of pods/tree was highest in PKM MO 55 (306.50) and lowest in PKM MO 35(24.00). The general mean of this trait was 113.44 numbers and twenty one genotypes had the higher general mean value. The highest and lowest value of pod yield/tree was observed in PKM MO 55(36.47kg/tree) and PKM MO 35(1.13 kg/tree) respectively. The general mean of this trait is 9.47kg/tree which were higher than the seventeen germplasm. These kind of similar variability studies were done by Sheetal *et al* (2015); Selvakumari *et al* (2017); Karunakar *et al* (2018).

The qualitative trait ascorbic acid ranged from 39.96mg/100g (PKM MO 14&PKM MO 41 to 133.20mg/100g (PKM MO 26) and Twenty six genotypes had higher value than the general mean(85.21mg/100g). The total carotenoids was highest and lowest in PKM MO 47 (28.70 mg/100g) and PKM MO 9 (4.64mg/100g) respectively. Twenty one genotypes had higher value than general mean 13.77mg/100g. The range of crude fibre was 18.20 percent (PKM MO 55) to 28.95 percent (PKM MO 20). Thirty genotypes had lower value than the general mean (22.85 percent). The iron content of genotypes ranged from 1.43 mg/100g (PKM MO 52) to 7.20 mg/100g (PKM MO 55). The general mean of iron content is 3.80mg/100g. Twenty six germplasm exceeded the general mean. Calcium content ranged from 0.88 percent (PKM MO 54) to 3.44 percent (PKM MO 34). Twenty two genotypes had higher value than the general mean of calcium is 2.06 percent. A similar finding was observed by Karunagar *et al* (2018) in moringa.

Genotypic and phenotypic coefficient of variation are simple measure of variability, these measures are commonly used for the assessment of variability (Salesh kumar *et al*, 2010). Genotypic and phenotypic coefficients of variation of different characters are presented in Table 4. High magnitude of genotypic as well as phenotypic coefficient of variations were recorded for characters *viz*., pod yield/tree (79.14 and 80.03%), the number of pods/tree (53.27 and 53.80%), total carotenoids (44.65 and 45.09%), iron (38.77 and 39.05%), pod weight (32.60 and 32.96%), calcium (26.82 and 30.70%), ascorbic acid (26.70 and 28.12%) and pod length (25.77 and 25.97%) suggested that substantial improvement on moringa through the selection for these traits. Moderate GCV and PCV recorded for pod girth (12.66 and 13.08) suggested the existence of considerable variability in the population. Selection for these traits may also be given the importance for improvement programme. Low GCV was recorded for crude fibre (8.83%). The estimates of phenotypic coefficient of variation (PCV) were higher than genotypic coefficient of variation (GCV) for all the traits studied which is an indicator of additive effect of the environment on the expression of the trait. Similar finding were also reported in moringa by Raja and Bagle (2005), Selvakumari *et al* (2017) in moringa and Tejaswini *et al* (2017) in amaranth.

**Table 1. List of moringa genotypes used in present study.**

| Assessions no | Vernacular name | Place of collection |
|---|---|---|
| PKM MO 1 | Long poded Perennial type | Kamatchipuram |
| PKM MO 2 | Otu Karrumpu Murungai | Kaveiyampatty-murungai |
| PKM MO 3 | Yalpanamurungai | Kaveiyampatty |
| PKM MO 4 | KappalapattyMurungai | Idayarkottai |
| PKM MO 5 | Karumpumurungai- 9 | Idayarkottai |
| PKM MO 6 | Karumpumurungai | Periyakottai |
| PKM MO 7 | Kutchiimurungai -11 | Kaamatchipuram |
| PKM MO 8 | Kutchimurungai -12 | Kamatchipuram |
| PKM MO 9 | Malaimurungai | Murugamazhai hills |
| PKM MO 10 | Kattumurungai | Murugamazhai hills |
| PKM MO 11 | Saemmurungai | Murugamalai hills |
| PKM MO 12 | Kutchimurungai | Rajathanikottai |
| PKM MO 13 | Semmurungai | Kamatchipuram |
| PKM MO 14 | Karumpumurungai | Sadayapatty |
| PKM MO 15 | Karumpumurungai | Sadayapatty |
| PKM MO 18 | Malaimurungai- 29 | Murugamalai |
| PKM MO 19 | Malaimurungai | Murugamalai hills |
| PKM MO 20 | NattuMurungai | Harur |
| PKM MO 21 | Chedimurungai | Vedasandur |
| PKM MO 23 | Nattumurungai | Kamatchipuram |
| PKM MO 24 | Kattumurungai | Perumparai |
| PKM MO 25 | Kutchimurungai | Usilampatti |
| PKM MO 26 | Vayalmurungai | Kunnam |
| PKM MO 27 | Medium poded | Cholavanthan |
| PKM MO 28 | Long poded | Warangal |
| PKM MO 29 | Long poded | Malyal,Warangal |
| PKM MO 30 | Medium Poded | Warangal, Ghanpur |
| PKM MO 31 | Short Poded | Pedapalli, Karimnagar |
| PKM MO 32 | Short Poded | Armor, Nizamabad |
| PKM MO 33 | Short Poded | Nandipeta, Nizamabad |
| PKM MO 34 | Short Poded. | Basaraa, Nirmal |
| PKM MO 35 | Short poded | Adilabad |
| PKM MO 36 | Medium Poded | Amaravathi, Manchiriyal |
| PKM MO 37 | Short Poded | Doragiripalli, Manchiriyal |
| PKM MO 38 | Medium Poded | Kyanthanpalli, Manchiriyal |
| PKM MO 40 | Maramurungai | Sinnamalaikundru |
| PKM MO 41 | KappalpattiMurungai | R.Vellodu |
| PKM MO 42 | NoolMurungai | Puthupai |
| PKM MO 43 | MoolanurNettai | Kijilamparai |
| PKM MO 44 | Bitter Type | NBPGR |
| PKM MO 45 | Coimbatore Long Type | Alambadi |
| PKM MO 46 | Mutant of PKM 1 | Periyakulam |
| PKM MO 47 | ValayapattiMurungai | Aundipatti |
| PKM MO 48 | KarumbuMurungai | Moolachatram |
| PKM MO 49 | YalpanamMurungai | Valliammalpuram |
| PKM MO 50 | Medium Podded | Usilampatti |
| PKM MO 51 | Medium Podded | Palamedu |
| PKM MO 52 | KuttaMurungai | Aundipatti |
| PKM MO 53 | Azhagiyavilai | Kadayachapuram |
| PKM MO 54 | NattuMurungai | Kadayachapuram |
| PKM MO 55 | KarumbuMurungai | Devdhanapatti |
| Check (PKM MO 22) | Nattumurungai -34 | Kamatchipuram |

Table 2. Mean performance of quantitative and qualitative characters.

| Genotypes | Pod length (cm) | Pod girth (cm) | Pod weight (g) | No.of Pods/ Tree | Pod Yield/ Tree (Kg) | Ascorbic acid (mg/100g) | Total Carotenoids (mg/100g) | Crude Fibre (%) | Iron (mg/ 100g) | Calcium (mg/ 100g) |
|---|---|---|---|---|---|---|---|---|---|---|
| **PKM MO 1** | 52.20 | 8.24 | 61.90 | 46.50 | 2.86 | 66.60 | 7.00 | 26.40 | 4.52 | 2.16 |
| **PKM MO 2** | 58.85 | 7.55 | 110.32 | 110.00 | 14.09 | 59.94 | 8.08 | 27.15 | 4.32 | 2.00 |
| **PKM MO 3** | 49.90 | 6.83 | 118.95 | 61.50 | 6.85 | 116.55 | 14.18 | 20.95 | 5.38 | 1.52 |
| **PKM MO 4** | 68.25 | 6.97 | 121.98 | 221.00 | 27.32 | 88.83 | 21.66 | 20.75 | 6.30 | 1.25 |
| **PKM MO 5** | 71.75 | 7.48 | 115.52 | 156.50 | 23.10 | 75.69 | 22.98 | 20.25 | 6.16 | 2.48 |
| **PKM MO 6** | 63.40 | 8.00 | 77.87 | 233.50 | 19.09 | 119.88 | 24.36 | 19.95 | 4.61 | 2.56 |
| **PKM MO 7** | 35.50 | 6.67 | 59.62 | 133.50 | 6.55 | 63.27 | 8.32 | 23.40 | 2.22 | 2.00 |
| **PKM MO 8** | 47.70 | 7.27 | 75.46 | 138.50 | 11.50 | 79.92 | 7.39 | 22.45 | 5.03 | 1.92 |
| **PKM MO 9** | 50.70 | 6.33 | 91.15 | 109.50 | 8.71 | 123.21 | 4.64 | 24.60 | 2.74 | 1.52 |
| **PKM MO 10** | 52.30 | 7.07 | 72.66 | 79.00 | 5.83 | 86.58 | 9.12 | 24.05 | 6.31 | 1.44 |
| **PKM MO 11** | 49.65 | 7.52 | 61.79 | 52.50 | 4.66 | 96.57 | 27.16 | 23.55 | 4.30 | 2.08 |
| **PKM MO 12** | 41.80 | 7.07 | 103.84 | 89.00 | 7.96 | 93.24 | 13.20 | 20.30 | 4.20 | 2.64 |
| **PKM MO 13** | 54.60 | 8.28 | 62.06 | 47.00 | 3.75 | 59.94 | 16.25 | 22.80 | 4.41 | 2.00 |
| **PKM MO 14** | 39.55 | 7.62 | 45.86 | 49.50 | 2.80 | 39.96 | 14.19 | 22.25 | 4.36 | 1.28 |
| **PKM MO 15** | 41.55 | 6.32 | 51.54 | 59.00 | 3.50 | 73.26 | 11.25 | 22.45 | 6.12 | 1.92 |
| **PKM MO 18** | 51.10 | 7.40 | 63.61 | 57.50 | 3.06 | 97.85 | 11.16 | 24.80 | 5.04 | 2.04 |
| **PKM MO 19** | 46.25 | 6.48 | 71.92 | 138.50 | 8.76 | 123.21 | 6.47 | 22.60 | 6.51 | 1.52 |
| **PKM MO 20** | 47.30 | 7.00 | 74.88 | 96.50 | 6.29 | 69.93 | 6.13 | 28.95 | 4.67 | 1.68 |
| **PKM MO 21** | 82.75 | 5.30 | 114.13 | 141.00 | 15.81 | 113.22 | 15.64 | 19.80 | 4.66 | 2.00 |
| **PKM MO 23** | 57.95 | 7.05 | 71.60 | 91.50 | 7.60 | 67.04 | 8.70 | 23.55 | 3.94 | 1.77 |
| **PKM MO 24** | 41.30 | 6.43 | 48.37 | 66.00 | 3.38 | 69.93 | 12.68 | 24.15 | 4.17 | 1.52 |
| **PKM MO 25** | 51.55 | 4.70 | 50.22 | 95.50 | 5.91 | 86.58 | 15.34 | 23.00 | 2.28 | 0.96 |
| **PKM MO 26** | 94.70 | 6.37 | 166.15 | 188.50 | 32.20 | 133.20 | 13.46 | 18.60 | 4.45 | 2.48 |
| **PKM MO 27** | 48.95 | 7.70 | 82.85 | 70.50 | 5.24 | 78.59 | 6.80 | 21.45 | 2.73 | 2.88 |
| **PKM MO 28** | 91.90 | 6.38 | 102.03 | 190.00 | 22.50 | 126.54 | 27.09 | 19.60 | 2.58 | 2.08 |
| **PKM MO 29** | 38.50 | 5.18 | 62.27 | 134.00 | 8.30 | 93.24 | 13.49 | 22.55 | 3.09 | 1.92 |
| **PKM MO 30** | 49.45 | 5.72 | 96.36 | 59.50 | 5.75 | 109.89 | 6.53 | 22.75 | 2.37 | 2.56 |
| **PKM MO 31** | 55.20 | 6.30 | 79.07 | 105.50 | 7.08 | 73.26 | 14.68 | 22.25 | 4.40 | 1.58 |
| **PKM MO 32** | 42.00 | 6.03 | 44.72 | 116.50 | 5.97 | 96.57 | 13.61 | 21.50 | 2.72 | 2.64 |
| **PKM MO 33** | 56.15 | 8.15 | 89.15 | 46.50 | 3.46 | 58.25 | 12.75 | 26.00 | 3.27 | 1.75 |
| **PKM MO 34** | 37.50 | 5.70 | 67.73 | 262.00 | 18.81 | 116.55 | 20.67 | 18.90 | 5.87 | 3.44 |
| **PKM MO 35** | 17.40 | 4.36 | 37.49 | 24.00 | 1.13 | 69.93 | 6.88 | 25.20 | 2.70 | 1.52 |
| **PKM MO 36** | 29.70 | 6.14 | 41.63 | 128.00 | 4.05 | 53.28 | 12.24 | 19.70 | 4.29 | 2.48 |
| **PKM MO 37** | 46.90 | 6.15 | 77.07 | 123.00 | 8.97 | 76.59 | 14.23 | 24.70 | 2.44 | 1.68 |
| **PKM MO 38** | 59.95 | 8.20 | 80.18 | 90.00 | 5.55 | 71.80 | 11.65 | 22.45 | 2.01 | 2.96 |
| **PKM MO 40** | 54.25 | 7.10 | 90.54 | 60.50 | 5.79 | 69.93 | 9.70 | 20.10 | 2.46 | 2.24 |
| **PKM MO 41** | 49.90 | 6.40 | 69.06 | 82.00 | 5.37 | 39.96 | 21.05 | 24.40 | 3.20 | 1.52 |
| **PKM MO 42** | 62.50 | 6.40 | 61.26 | 35.00 | 2.02 | 99.90 | 14.23 | 22.35 | 2.07 | 2.32 |
| **PKM MO 43** | 67.10 | 6.50 | 96.18 | 89.00 | 8.96 | 56.06 | 10.15 | 21.60 | 2.87 | 2.56 |
| **PKM MO 44** | 51.65 | 7.18 | 54.30 | 40.50 | 3.24 | 116.55 | 15.12 | 21.30 | 5.82 | 2.64 |
| **PKM MO 45** | 52.10 | 6.10 | 69.40 | 91.50 | 5.97 | 69.93 | 5.26 | 25.55 | 3.14 | 3.20 |
| **PKM MO 46** | 50.75 | 6.14 | 70.99 | 138.00 | 8.89 | 103.23 | 18.86 | 22.45 | 5.01 | 2.32 |
| **PKM MO 47** | 52.45 | 6.16 | 65.74 | 136.00 | 9.66 | 66.60 | 28.70 | 26.05 | 3.47 | 3.20 |
| **PKM MO 48** | 55.85 | 6.12 | 71.00 | 180.50 | 12.82 | 53.28 | 7.38 | 25.95 | 2.47 | 1.92 |
| PKM MO 49 | 53.00 | 6.40 | 82.55 | 128.00 | 9.56 | 109.89 | 13.74 | 27.90 | 2.18 | 1.44 |
| **PKM MO 50** | 66.75 | 6.82 | 93.59 | 92.00 | 9.75 | 69.93 | 18.92 | 22.70 | 2.31 | 1.28 |
| **PKM MO 51** | 50.20 | 6.58 | 63.10 | 215.00 | 13.45 | 86.58 | 9.77 | 25.40 | 1.64 | 3.20 |
| **PKM MO 52** | 38.10 | 6.28 | 61.88 | 179.50 | 12.00 | 86.58 | 10.97 | 21.90 | 1.43 | 2.08 |
| **PKM MO 53** | 55.90 | 6.67 | 48.04 | 111.00 | 6.01 | 106.56 | 19.11 | 24.50 | 2.50 | 1.52 |
| **PKM MO 54** | 60.90 | 6.25 | 38.24 | 91.00 | 4.06 | 103.23 | 12.79 | 20.95 | 1.98 | 0.88 |
| **PKM MO 55** | 74.75 | 7.65 | 108.49 | 306.50 | 36.47 | 93.87 | 27.20 | 18.20 | 7.20 | 2.33 |
| **Check (PKM MO 22)** | 51.10 | 7.65 | 85.09 | 112.00 | 10.05 | 69.93 | 13.06 | 22.95 | 2.64 | 2.00 |
| **Mean** | 53.30** | 6.70** | 76.56** | 113.44** | 9.47** | 85.21** | 13.77** | 22.85** | 3.80** | 2.06** |
| **SEd** | 1.70 | 0.22 | 3.76 | 8.53 | 1.13 | 7.51 | 0.87 | 1.89 | 0.18 | 0.31 |
| **CD(0.05)** | 3.40 | 0.44 | 7.55 | 17.13 | 2.26 | 15.07 | 1.75 | 3.80 | 0.35 | 0.62 |
| **CV%** | 3.18 | 3.27 | 4.91 | 7.52 | 11.90 | 8.81 | 6.32 | 8.29 | 4.66 | 14.93 |

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**Table 3. Analysis of variance for experimental design for important characters**

| S.No | Character | Mean sum of squares | | |
|---|---|---|---|---|
| | | Replication (df=1) | Treatment (df=51) | Error (df=51) |
| 1 | Pod length(cm) | 1.06 | 380.38** | 2.88 |
| 2 | Pod girth (cm) | 0.06 | 1.49** | 0.05 |
| 3 | Pod weight (g) | 5.82 | 1259.93** | 14.15 |
| 4 | Number of pods/tree | 6.50 | 7377.58** | 72.79 |
| 5 | Pod yield/tree (kg) | 0.10 | 113.56** | 1.27 |
| 6 | Ascorbic acid (mg/100g) | 1.30 | 1091.87** | 56.34 |
| 7 | Total carotenoids (mg/100g) | 0.19 | 76.33** | 0.76 |
| 8 | Crude fibre (%) | 1.92 | 11.73** | 3.58 |
| 9 | Iron (mg/100g) | 0.02 | 4.37** | 0.03 |
| 10 | Calcium (mg/100g) | 0.31 | 0.70** | 0.09 |

* Significant at 5 percent level;
**Significant at 1 percent level.

High magnitude of heritability was recorded for most of the traits. The highest heritability was recorded for the traits iron content (98.57%), pod length (98.50%), the number of pods/tree (98.05%), total carotenoids (98.04%), pod yield/tree (97.79%), pod weight (97.78%), pod girth (93.75%), ascorbic acid (90.19%) and calcium (76.34%). This indicates the lesser influence of environment in expression of these characters and prevalence of additive gene action in their inheritance hence, suitable for selection. The low heritability was recorded for crude fibre (53.18%).

Heritability estimates along with genetic advance is more useful than the heritability value alone for selecting the best individual. High heritability coupled with high genetic advance was observed for pod yield/tree, the number of pods/tree, total carotenoids, iron, pod weight and pod length indicating that most likely the heritability is due to additive gene action and it is suggested that simple selection could be effective for the improvement of these traits. Heritability values were high than those of genetic advance for most of the traits which indicated that they were least influenced by the environment and shows that the phenotypes were true representative of their genotypes and selection based on phenotypic performance would be reliable. Similar findings were also recorded by Raja and Bagle (2005) in annual moringa, Salesh kumar *et al*.(2010) in okra, Selvakumari *et al*.(2017); Karunagar *et al*.,2018 in perennial moringa and Tejaswani *et al*.(2017) in amaranth.

**Table 4. Genetic parameters of variability for its quantitative and qualitative characters in moringa**

| Characters | Mean | Range | | Coefficient of variation | | Heritability (%) | GA | GA(%) of mean |
|---|---|---|---|---|---|---|---|---|
| | | Min | Max | GCV | PCV | | | |
| Pod length | 53.30 | 17.40 | 94.70 | 25.78 | 25.97 | 98.50 | 28.09 | 52.70 |
| Pod girth | 6.70 | 4.36 | 8.28 | 12.66 | 13.08 | 93.75 | 1.69 | 25.26 |
| Pod weight | 76.56 | 37.49 | 166.15 | 32.60 | 32.96 | 97.78 | 50.84 | 66.40 |
| Number of pods/tree | 113.44 | 24.00 | 306.50 | 53.27 | 53.80 | 98.05 | 123.28 | 108.67 |
| Pod yield/tree | 9.47 | 1.125 | 36.47 | 79.14 | 80.03 | 97.79 | 15.27 | 161.21 |
| Ascorbic acid | 85.21 | 39.96 | 133.20 | 26.70 | 28.12 | 90.19 | 44.51 | 52.24 |
| Total carotenoids | 13.77 | 4.64 | 28.70 | 44.65 | 45.09 | 98.04 | 12.54 | 91.07 |
| Crude fibre | 22.85 | 18.20 | 28.95 | 8.83 | 12.11 | 53.18 | 3.03 | 13.27 |
| Iron | 3.80 | 1.43 | 7.20 | 38.77 | 39.05 | 98.57 | 3.01 | 79.30 |
| Calcium | 2.06 | 0.88 | 3.44 | 26.82 | 30.70 | 76.34 | 0.99 | 48.28 |

Selection would be depending on pod yield, the number of pods/tree, high iron and pod weight content may bring out the genetic improvement in the moringa because they showed a high value of GCV, PCV, heritability and genetic gain. Hence the selection will be effective for these traits. These traits can be improved through mass selection, progeny selection, or any other modified selection procedures. It can be concluded that PKM MO 55 has the highest number of pods/tree, pod yield/tree, high iron content among fifty two perennial genotypes.

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