RESEARCH ARTICLE

Genetic Variability Studies and Character Association for Yield and Quality Traits in Curry leaf (*Murraya koengii* (L.) Spreng.)

Indhumathi. K[1]*, D.Vidhya[2], K. Gurusamy[1], P. Paramaguru[1] and V.P. Santhi[1]

[1]Horticultural College and Research Institute for Women, Tamil Nadu Agricultural University, Tiruchirapalli, India

[2]Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, India

OPEN ACCESS JOURNEL

Check for updates

Citation: Indhumathi. K, D.Vidhya, K. Gurusamy, P. Paramaguru and V.P. Santhi (2020). Genetic Variability Studies and Character Association for Yield and Quality Traits in Curry leaf (*Murraya koengii* (L.) Spreng.) . *Chemical Engineering*. v01i01, 164 -171. http://dx.doi.org/10.53709/CHE.2020.v01i01.023

DOI: http://dx.doi.org/10.53709/CHE.2020.v01i01.023

Corresponding Author:
Indhumathi. K
indhumathi.k@tnau.ac.in

Received on: September 14, 2020
Revised on: November 25, 2020
Accepted on: December 29, 2020

ABSTRACT

The genetic variability studies in twenty curry leaf genotypes were carried out in the present investigation. The results revealed that there were prominent variations among the genotypes in growth yield and quality traits. The genotypes showed considerable difference among the morphological characters such as petiole colour, leaflet number and leaflet shape. The genotype MK 02 recorded highest plant height (157.00 cm), stem girth (6.67 cm), number of primary branches (3.67) , number of secondary branches (9.33), leaf area (68.13 cm2) and yield per plant (706.10 g). The chlorophyll-a (0.29 mgg-1), chlorophyll-b (0.05 mgg-1) and total chlorophyll content (0.43 mgg-1) were higher in genotypes MK 03. The shelf life under ambient condition (2.20 days), refrigerated condition (4.00 days) and essential oil content (0.83 %) was highest in MK 02. The yield and quality traits of curry leaf genotypes groups the curry leaf genotypes under two major clusters and four subclusters. The highest plant height was recorded in cluster 1a and lowest in cluster 1 b. Similar, trend was recorded in leaf number, leaf area, fresh leaf weight, dry leaf weight, yield and shelf life. The number of branches and chlorophyll-b content was highest in cluster 2b and cluster 1b. The chlorophyll-a and total chlorophyll was highest in and lowest in cluster 2a and cluster 2b. The essential oil content was highest in cluster 1a and lowest in cluster 2b. The correlation between the yield and quality traits showed positive correlation among themselves except for leaflet number. The shelf life of the curry leaf genotypes showed positive correlation with the growth and yield traits. Principal component analysis showed that the first component has positive association with most of the yield and quality traits. Grouping of the curry leaf genotypes and the presence of variation among them has indicated the strong scope of breeding program in curry leaf.

Keywords: *Curry leaf, Murraya koenigii, cluster analysis, correlation, genetic variability*

INTRODUCTION

Curry leaf is an important spice crop in Asian cooking, well-known for its pungent, aromatic leaves. It is a shrub or small tree and is semideciduous, aromatic, and pubescent. It grows to about 3-5 m high and the stem is slender but strong and woody (Joseph and Peter, 1985). It is native to India and Srilanka. Burma, China, Nepal, Pakisthan, Thailand, Australia and the Pacific Islands are the known habitats of curry leaf worldwide [1]. In India it is cultivated in Tamilandu, Karnataka, Kerala and Telangana. In Tamilnadu it is cultivated in an area of about 2200 hectare which is concentrated only in few districts *viz.* Coimbatore, Salem and Thoothukudi [2]. Curry leaves are highly aromatic rich in nutrients, minerals and phytochemicals with medicinal properties [3]. The plant can be used for preparation of tonic and in stomach problems. Curry leaf has rich medicinal importance in aurveda and unani systems. Leaves and roots are used in treating piles [4]. Bark and

roots are used as stimulants and leaves are said used in treatment of dysentery [5].

[6] has reported that the germplasm rich regions of curry leaf in India is divided into six zones which are distributed from Himalayas to Andaman & Nicobar Islands. Curry leaf breeding is still to be explored area when compared to its wide genetic diversity and only two varieties *viz.* DWD 1 and DWD 2 has been released by UAS Dharwad. There is enormous scope for the breeding in curry leaf which possesses vast diversity in various native genotypes which has to be collected and evaluated for various yield and quality characteristics based on the requirements. [7] insisted that efforts are needed in collection, characterization, conservation and efficient utilization of the curry leaf genotypes. Also he has stated that insight into germplasm variability and distribution as prerequisites. With this background, the present study was conducted at Horticultural College and Research Institute for Women, Tiruchirapalli to study the variability among 20 genotypes of curry leaf.

MATERIALS AND METHODS

The present study was carried out on twenty curry leaf genotypes collected from various parts of Tamilnadu and Kerela and maintained at Horticultural College and Research Institute for Women, Tiruchirapalli. Observations were recorded for growth, yield and quality parameters in the collected genotypes during 2019-20. Eleven morphological characteristics of curry leaf are recorded and classified under different groups as below:

Plant habit	:	Upright , Spreading
Branch angle	:	Narrow , Medium, Wide
Petiole – anthocyanin colouration	:	Slightly coloured, Intermediate, Strongly coloured
Leaflet numbers	:	9-11, 13-15, >15
Leaflet shape	:	Ovate lanceolate, Ovate
Leaflet lamina length	:	3.0 -4.0 cm, 4.0-5.0 cm, >5.0 cm
Leaf let lamina width	:	<1.0 cm, 1.0-2.0 cm, >2.0 cm
Leaf blade - shape at base	:	Oblique, Acute
Leaf blade – angle of apex	:	Moderately obtuse, Obtuse
Leaf blade – incisions of margin	:	Slightly serrate, Moderately serrate
Leaf colour	:	Light green, Green, Dark green

Different growth and yield traits plant height, stem girth, number of branches, leaf number, leaflet number, fresh leaf weight, dry leaf weight and fresh yield per plant were recorded in three replicates and the experiment was laid in randomized complete block design. Each plant selected from one genotype is considered as one replication. Estimation of dry leaf weight was determined by collecting and shade drying the leaf samples. The estimation of chlorophyll-a, chlorophyll-b and total chlorophyll content was done following the procedure by [8]. For shelf life studies, the leaves were harvested during the early morning hours. Fresh curry leaves were washed and air-dried to remove the surface moisture. The shelf life was evaluated in ambient conditions and packed in polyethylene bags with 5 % ventilation under refrigerated condition. The data were analyzed by comparing means using one way ANOVA and significance was determined by Duncan's Multiple Range Test. The clustering of cultivars was performed through XLSTAT software.

RESULTS AND DISCUSSION

The yield and quality traits in the twenty curry leaf genotypes showed significant variation and the frequency distribution of the morphological characteristics are presented in Figure 1. The growth habit of 14 genotypes is upright and 6 genotypes fall under spreading growth habit. Similar characterization was done by [9-10] in apricot and apple genotypes respectively. [11] mentioned that the growth habit of the genotpyes describes the stem length and branching habit. It becomes very important in curry leaf as the economic part is leaves, the better the branching and more is the vegetative growth and hence yield. So the growth habit with a spreading habit is preferable in case of selection though more percentage of the genotpyes fall under upright growth habit. Sixteen genotypes fall under medium branching angle, one under narrow and two wide angled.

The petiole colour of seven genotypes is green and remaining are light orange to deep orange red coloured. Among the coloured petiole typed genotypes 6 are slightly coloured, 4 intermediate and three strongly coloured. The petiole colour of curry leaf gains importance as the market preference is for *'senkammpu' ie.* orange red colour petioled genotypes. Hence the petiole

http://dx.doi.org/10.53709/CHE.2020.v01i01.023

colour is one of the important quality traits to be considered in the curry leaf breeding program. The number of leaflets in majority of genotypes fall between 13 -15, though fewer genotypes had lesser and greater number of leaflets per compound leaf. The leaf let shape was mostly ovate lanceolate in 16 genoptyes and is ovate in 4 genotypes. Of the 20 genotypes the leaflet length and width of 15 genotypes ranged between 2.0 -3.0 cm and 1.0 -2.0 cm respectively. The leaf base of 16 genotypes is oblique where as the others showed acute leaf base. Generally the leaflet apex is moderately obtuse except 4 genotypes which showed obtuse leaflet apex. Only three genotypes showed moderately serrate margins where as in others the serration was inconspicuous. Seventeen genotypes fall under green coloured leaves, 5 genotypes had very dark green leaves and 2 genotypes had light green coloured leaves. [12] reported three morphotypes in curry leaf in Uttarkand *viz.* brown, regular and dwarf (DF) based on colour, size of leaves and plant habit. They also recorded variations among the morphotypes in antioxidant and biochemical activities. This confirms that curry leaf shows wide diversity in growth, morphological and physicochemical characteristics. [13] found variation in the leaf characteristics of apple and they mentioned that it may be due to the genetic makeup and interaction with environment. The same reasons can be attributed to the variation in morphological characteristics of curry leaf in the present study.

The twenty curry leaf genotypes were assessed for growth and yield attributes. The variability among the growth and yield characteristics of the curry leaf genotypes are presented in the Table 1. The highest plant height was recorded in MK 02 (157.00 cm) followed by MK 09 (133.00 cm). The lowest plant height was recorded in MK 19 (37.00 cm). The plant girth was highest in MK 02 (6.67 cm) followed by MK 09 (4.27 cm). The lowest plant girth was recorded by MK 15 (1.67 cm). Branching depicted by number of primary and secondary branches was significantly highest in MK 01 followed by MK 02. It was reported that the number of secondary branches is an important character directly proportional to yield in curry leaf (Sudha *et al*., 2010). In the present study also the genotype MK 02 showing highest number of secondary branches recorded the highest leaf yield per plant.

xxxThe number leaflets in the compound leaf ranged from 11 to 15 though there is no significant difference among the treatments. The leaf area was also highest in MK 02 (68.13 cm^2) followed by MK 03 (63.86 cm^2). The fresh leaf weight and dry leaf weight showed similar trend. The fresh leaf weight was highest in MK 02 (2.34 g) followed by MK 03 (2.32 g). The dry leaf weight was highest in MK 02 (1.28 g) followed by MK 03 (1.16 g). The leaf yield per plant was highest in MK 02 (706.11 g) followed by MK 03 (572.70 g). Similar variability in growth and yield parameters of curry leaf genotypes were reported by [14]. They mentioned that the number of matured shoots and the number of compound leaves per shoot showed highest phenotypic and genotypic variation and hence can be used as viable selection traits.

The variability among the growth and yield characteristics of the curry leaf genotypes are presented in the Table 2. The chlorophyll-a, chlorophyll-b and total chlorophyll content varied among the genotypes. The highest chlorophyll content was recorded in MK 04 followed by MK 03. The lowest content was reported in the genotype MK 20. [15] recorded wide variation in chlorophyll contents of wheat genotypes. Many other workers had reported that chlorophyll content is an important indicator of the photosynthetic efficiency and stress tolerance ability in various crops *viz*. Amaranthus, Wheat and Melon [16-18]. Hence they may be used as viable selection criteria for crop breeding programs.

The shelf life of the genotypes showed significant variations and genotype MK 02 showed highest shelf life under ambient conditions and under refrigerated conditions followed by MK 13 and MK 09. Though influence of genotype is not on the shelf life characteristic in Carrot as reported [19] contradictory reports supporting the present study in given by [20-21] in Brocolli. [22] reported that the shelf life of broccoli especially the post harvest yellowing is determined by the genotype. The yield and quality traits of curry leaf genotypes falls under two major clusters (Figure 2). The cluster wise listing of genotypes based according to the growth, yield and quality traits are given in Table 3 and cluster wise summary mean of the traits were given in Table 4. The plant height varied between 64.21 and 113.11 cm among the genotypes. The highest plant height was recorded in cluster 1a and lowest in cluster 1b.

http://dx.doi.org/10.53709/CHE.2020.v01i01.023

Similar trend was recorded in leaf number, leaf area, fresh leaf weight, dry leaf weight, yield and shelf life. The stem girth was in the range of 2.93 and 5.53 cm among the clusters. The highest and lowest was recorded in cluster 2b and cluster 1b respectively. Correspondingly number of branches and chlorophyll-b content was highest in cluster 2b and cluster 1b. The chlorophyll-a and total chlorophyll was highest in and lowest in cluster 2a and cluster 2b. The essential oil content was highest in cluster 1a (0.74 %) and lowest in cluster 2b (0.13 %).

The correlation between the yield and quality traits of curry leaf genotypes is presented in Table 5. Most of the growth and yield traits showed positive correlation among themselves except for leaflet number. The leaflet number showed negative correlation with the plant height, leaf number and yield. The major trait of interest *ie.* yield per plant is strongly in correlation with plant height (0.730), stem girth (0.776), number of secondary branches (0.650) and leaf number (0.959). [23] reported that increase number of secondary branches improved the yield in curry

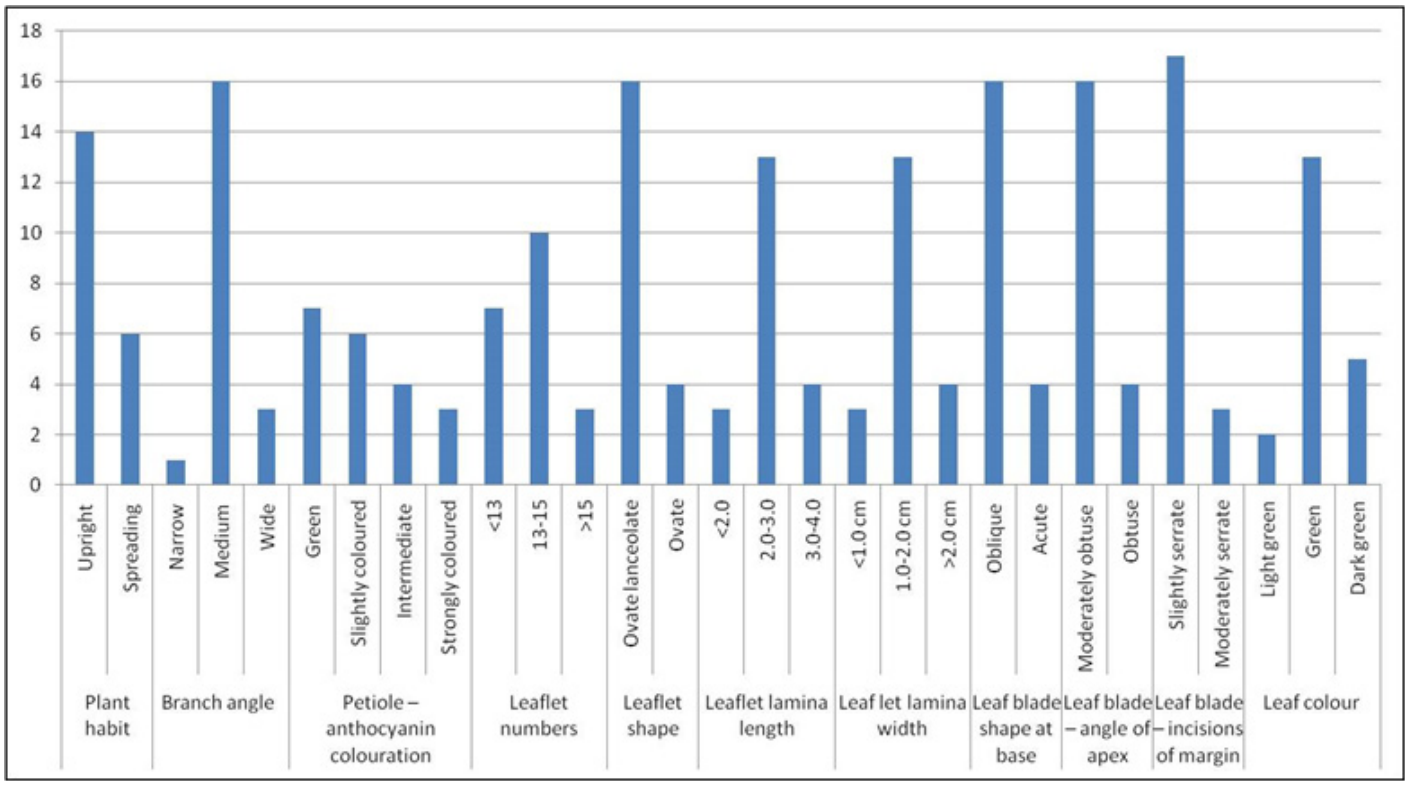

Figure 1. Frequency distribution of curry leaf cultivars based on morphological characters

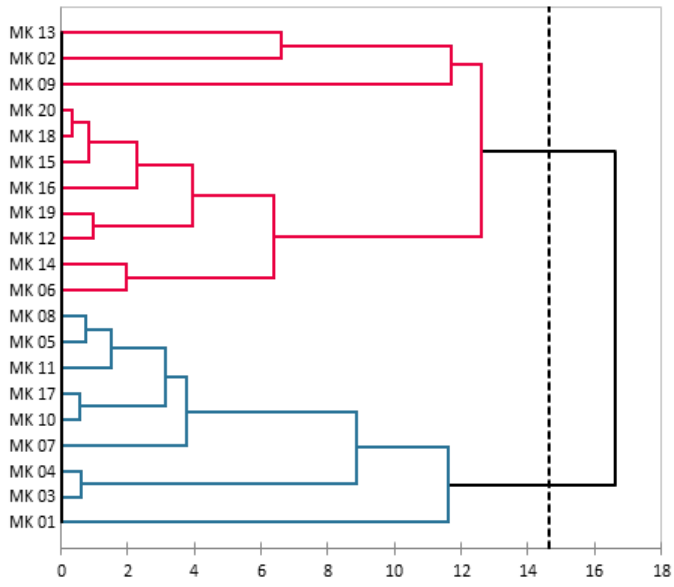

Figure 2. Dendrogram based on yield and quality characteristics of curry leaf genotypes

leaf significantly. Also the significant contribution of growth characteristics to yield was recorded in many workers.

The shelf life of the curry leaf genotypes showed positive correlation with almost all traits under study. It showed a very strong correlation with the dry leaf weight. In contrast the other quality traits, essential oil content showed negative correlation with most of the growth traits except for leaflet number, leaf area and yield. It is correlated positively with the shelf life both under ambient and refrigerated conditions. The best genotype is the one with higher yield associated with good shelf life. The trait variability contribution among the principal components was presented in the Table 6. The first component has positive association with most of the yield and quality

http://dx.doi.org/10.53709/CHE.2020.v01i01.023

traits. In particular the first component is highly associated with the yield per plant (0.312) and the refrigerated shelf life (0.306). The second component showed positive association with most of the characters. Similar results on the association of growth characteristics on yield in curry leaf were reported by [24]. The genetic relationships among the genotypes in terms of various traits were strongly explained by the principal component analysis and correlation studies in various crops *viz.* Apricot, Apple and Jamun [25-27]. Grouping of the curry leaf genotypes and the presence of variation among them has indicated the strong scope of breeding program in curry leaf. The two major clusters and the four subclusters show distance between the genotypes vary and according the selection of genotypes for desirable traits can be well executed. The genotypes in the subcluster 1a showed better growth, yield and quality traits and this characterization of the curry leaf cultivars will be hence useful for further breeding program.

Table 1. Variation of growth and yield traits in curry leaf genotypes

Geno-type	Plant Height (cm)	Plant Girth (cm)	No of Primary branch-es	No of sec-ondary branches	No. of com-pound leafs per branch	No of leaf lets / leaf	Leaf area (cm^2)	Fresh leaf weight	Dry leaf weight (g)	Yield per plant (g)
MK 01	91.33	5.53	3.33	12.67	38.67	15.00	33.55	1.79	0.79	357.07
MK 02	157.00	6.67	3.67	9.33	75.67	14.89	68.13	2.34	1.28	706.10
MK 03	99.33	4.60	3.33	7.67	40.67	14.22	63.86	2.32	1.16	572.70
MK 04	120.33	5.97	3.00	7.00	53.67	14.11	45.34	1.91	0.79	520.90
MK 05	82.00	3.40	2.67	3.00	44.33	10.78	45.37	1.35	0.75	437.53
MK 06	101.00	4.67	2.67	9.67	66.33	13.33	20.05	1.53	0.79	619.63
MK 07	80.33	4.77	1.67	3.67	41.33	12.00	65.70	2.22	1.03	381.87
MK 08	73.00	3.97	2.00	2.00	42.33	8.78	52.64	1.70	0.90	409.67
MK 09	133.00	4.27	1.67	4.67	72.33	7.78	29.93	1.41	0.79	664.90
MK 10	65.67	3.60	2.00	5.00	32.67	12.33	32.25	1.43	0.66	326.27
MK 11	43.67	2.50	2.33	0.67	21.67	13.33	35.65	1.41	0.48	229.33
MK 12	35.00	2.40	2.67	3.67	26.67	15.00	18.07	1.35	0.71	265.67
MK 13	49.33	2.47	2.00	2.67	33.00	13.78	64.14	2.01	1.04	327.37
MK 14	57.33	3.63	2.67	3.33	47.00	15.33	16.52	1.30	0.69	455.67
MK 15	132.33	1.67	2.00	1.33	23.67	13.89	39.54	1.82	0.70	232.37
MK 16	64.67	3.73	2.00	5.67	48.67	14.44	50.19	2.31	1.05	459.53
MK 17	38.33	2.50	2.00	2.33	24.67	12.56	39.46	1.64	0.79	253.40
MK 18	54.33	2.23	2.00	0.00	33.67	12.44	44.98	1.70	0.86	334.13
MK 19	37.00	2.77	2.00	0.00	27.00	15.56	30.75	1.85	0.79	221.93
MK 20	40.00	2.37	2.00	0.00	23.00	12.67	40.18	1.60	0.75	247.37
S.Ed	9.40	0.27	0.19	0.87	5.48	0.88	0.38	0.07	0.05	13.54
CD (0.05)	42.54	1.23	0.85	3.95	21.23	-	1.74	0.34	0.24	61.28

http://dx.doi.org/10.53709/CHE.2020.v01i01.023

Table 2. Variation of physiological and quality traits in curry leaf genotypes

Genotype	Chlorophyll-a (mg/g of fresh weight)	Chlorophyll-b (mg/g of fresh weight)	Total Chlorophyll (mg/g of FW)	Shelf life (ambient condition) Days	Shelf life (under refrigeration) Days	Essential oil content (%)
MK 01	0.18	0.13	0.31	1.20	3.20	0.13
MK 02	0.23	0.05	0.35	2.20	4.00	0.83
MK 03	0.29	0.05	0.43	1.40	3.40	0.13
MK 04	0.28	0.04	0.41	1.20	3.60	0.17
MK 05	0.18	0.05	0.28	1.20	2.80	0.17
MK 06	0.19	0.04	0.29	1.40	3.40	0.30
MK 07	0.24	0.05	0.37	1.40	3.80	0.33
MK 08	0.18	0.05	0.28	1.20	2.60	0.20
MK 09	0.14	0.04	0.22	1.60	3.40	0.63
MK 10	0.19	0.05	0.30	1.40	3.80	0.43
MK 11	0.21	0.04	0.31	1.20	2.60	0.23
MK 12	0.10	0.03	0.17	1.20	2.40	0.67
MK 13	0.07	0.06	0.15	2.00	3.80	0.77
MK 14	0.10	0.03	0.15	1.20	2.20	0.23
MK 15	0.07	0.03	0.12	1.20	2.20	0.20
MK 16	0.12	0.04	0.20	1.40	3.40	0.43
MK 17	0.18	0.05	0.28	1.40	3.20	0.53
MK 18	0.09	0.04	0.16	1.20	2.20	0.23
MK 19	0.08	0.04	0.14	1.40	3.20	0.70
MK 20	0.04	0.04	0.09	1.20	2.00	0.33
S.Ed	0.009	0.008	0.014	0.033	0.052	0.004
CD (0.05)	0.016	0.04	0.025	0.074	1.002	0.008

Table 3. Cluster wise grouping of curry leaf genotypes based on growth, yield and quality traits

Clusters	Sub cluster	Genotypes
Cluster 1	Cluster 1a	MK 02, MK 09, MK 13
	Cluster 1b	MK 06, MK12, MK 14, MK 15, MK 16, MK 18, MK 19, MK 20
Cluster 2	Cluster 2a	MK 03, MK 04, MK 05, MK 07, MK 08, MK 10, MK 11, MK17
	Cluster 2b	MK 01

Table 4. Cluster wise summary mean of growth, yield and quality traits

Traits	Cluster 1		Cluster 2	
	Cluster 1a	Cluster 1b	Cluster 2a	Cluster 2b
Plant height (cm)	113.11	65.21	75.33	91.33
Stem girth (cm)	4.47	2.93	3.91	5.53
No of Primary branches	2.45	2.25	2.38	3.33
No of secondary branches	5.56	2.96	3.92	12.67
No. of leaves per branch	60.33	37.00	37.67	38.67
No of leaf lets per leaf	12.15	14.08	12.26	15.00
Leaf area (cm2)	54.07	32.54	47.53	33.55
Fresh leaf weight	2.05	1.69	1.75	1.79
Dry leaf weight (g)	1.14	0.79	0.83	0.81

http://dx.doi.org/10.53709/CHE.2020.v01i01.023

Continued..

Yield per plant (g)	566.12	354.54	391.46	357.07
Chlorophyll-a (mg/g of fresh weight)	0.15	0.10	0.22	0.18
Chlorophyll-b (mg/g of fresh weight)	0.05	0.04	0.05	0.13
Total Chlorophyll (mg/g of FW)	0.24	0.17	0.33	0.31
Shelf life (ambient condition - Days)	1.93	1.20	1.30	1.20
Shelf life (under refrigeration - Days)	3.73	2.63	3.23	3.20
Essential oil content (%)	0.74	0.39	0.27	0.13

Table 5. Correlation matrix among different traits of curry leaf

Variables	PH	SG	PB	SB	LN	LLN	LA	FLW	DLW	FY	Ch a	Ch b	TC	SL	RSL	EO
PH	1	0.658	0.415	0.57	0.724	-0.148	0.277	0.263	0.245	0.730	0.441	0.087	0.431	0.354	0.379	-0.065
SG		1	0.628	0.82	0.771	0.043	0.294	0.335	0.404	0.776	0.722	0.388	0.736	0.337	0.635	-0.049
PB			1	0.709	0.362	0.499	0.085	0.162	0.003	0.463	0.499	0.352	0.504	0.16	0.181	-0.14
SB				1	0.619	0.238	0.061	0.266	0.224	0.650	0.56	0.572	0.596	0.268	0.564	-0.075
LN					1	-0.218	0.124	0.161	0.387	0.959	0.398	0.009	0.385	0.477	0.499	0.162
LLN						1	-0.1	0.301	0.057	-0.193	-0.081	-0.087	-0.077	0.066	0.026	0.108
LA							1	0.821	0.732	0.216	0.362	0.155	0.399	0.508	0.453	0.076
FLW								1	0.805	0.232	0.222	0.19	0.264	0.568	0.559	0.221
DLW									1	0.341	0.114	0.129	0.159	0.672	0.601	0.414
FY										1	0.509	0.003	0.494	0.453	0.491	0.058
Ch a											1	0.211	0.994	0.083	0.566	-0.293
Ch b												1	0.297	0.064	0.289	-0.165
TC													1	0.112	0.605	-0.276
SL														1	0.674	0.751
RSL															1	0.401
EO																1

PH - Plant Height (cm); SG - Plant Girth (cm); PB - No of Primary branches; SB - No of secondary branches; LLN - No. of leaves per branch; LLN - No of leaf lets / leaf; LA - Leaf area (cm^2); FLW - Fresh leaf weight; DLW - Dry leaf weight (g); FY - Yield per plant (g); Ch a – Chlorophyll-a (mg/g of fresh weight); Ch b – Chlorophyll-b(mg/g of fresh weight); TC - Total Chlorophyll (mg/g of FW); SL Shelf life (ambient condition) Days; RSL - Shelf life (under refrigeration) Days; Essential oil content (%)

REFERENCES

1. Arnon, D. (1949). Copper enzymes isolated chloroplasts, polyphenoloxidase in Beta vulgaris. Plant Physiology. 24: 1-15

2. B.M. Dhanpal, K. Lakshmi, B.V.S. (2018). A review on curry leaves (Murraya koenigii): versatile multi-potential medicinal plant. International Journal of Advances in Pharmacy Medicine and Bioallied Sciences.6(1):31-41

3. Dhangarh, V.K., Joydip Mandal and Pramanik, K. (2007). Studies on chlorophyll content in Amaranth. Journal of Asian Horticulture 3(4):284-28

4. Giulia Conversa, Corrado Lazzizera, Anna Bonasia and Antonio Elia. (2020). Harvest Season and Genotype Affect Head Quality and Shelf-Life of Ready-to-Use Broccoli. 10: 527. doi:10.3390/agronomy10040527

5. Joseph, S. and Peter, K.V. 1985. Curry leaf (*Murraya koenigii*), perennial, nutritious, leafy vegetable. In: Economic Botany, 39(1), 1985, pp. 68-73 New York Botanical Garden, Bronx, NY 10458

6. Khodadadi, M., Dehghani, H., Fotokian, M.H. and Rain, B. (2014). Genetic diversity and heritability of chlorophyll content and photosynthetic indexes among some Iranian wheat genotypes Journal of Biodiversity and Environmental Sciences. 4(1): 12-23

7. Lichtenthaler, H.K. (1987). Chlorophylls and carotenoids: pigments of photosynthetic biomembranes. Methods Enzymol. 148:350–382.

http://dx.doi.org/10.53709/CHE.2020.v01i01.023

8. Mir J.I., Jan Aafa, Rashid, M, Singh D.B., Raja W.H., Sharma O.C., Sharma A., Lal S., Kmawat, K.L., Nabi Sajad Un, Chand Lal. (2020). Genetic variability studies for various morphological and quality traits in apple. Indian Journal of Horticulture. 77(2): 227-236

9. Mir, J.I. Naqash, S., Rashid, M., Singh, D.B., Sharma, O.C., Sharma, A., Kumawat, K.L., Raja, W.H. Nabi, S.U., Masoodi, , L., Sheikh, M.A. and Kirmani.S.N. (2019). Distinctiveness, uniformity and stability testing of apricot genotypes based on morphological traits. Indian Journal of Horticulture. 76(4): 590-595

10. Oliveira, F.I.C., Fiege, D.E., Leonardo B.C., Elaine F.C., Innecco, Renato, Nunes, Glauber H.S. and Fernando A.S. (2017). Screening of melon genotypes for resistance to vegetable leafminer and your phenotypic correlations with colorimetry. *Anais da Academia Brasileira de Ciências*, *89*(2): 1155-1166

11. Onyia,V.N., Chukwudi, U.P., Ogwudu, V.C., Atugwu,A.I., Eze, S. C., Ene, C. O. and Ume,S. (2019). Evaluation of tomato genotypes (*Solanum lycopersicum* L.) for fruit shelf-life and tomato leaf curl disease. Journal of Agricultural Science and Technology. 21: 143-152

12. Ping, L., Pute, W.U. and Jianli Chen.(2012). Evaluation of flag leaf chlorophyll content index in 30 spring wheat genotypes under three irrigation regimes. Australian Journal of Crop Science. 6(6):1123-1130

13. Ragu, B.R. (2020). Diversity and Distribution of Curry Leaf in India. Journal of Horticultural Science. 15(1) : 1-8

14. Rahayu, S.T., Soedomo, P. Azwani, N. and Asgar,A. (2019). Evaluation of shelf life of various carrot genotypes planted on three different highlands. IOP Conf. Series: Earth and Environmental Science. 299 011001

15. Sivakumar, ChV. and Meera, I. (2013). Anti-oxidant and biochemical activities of three morphotypes of *Murraya koenigii* L. from Uttarakhand. Journal of Food Processing Technology. 4: 1000246

16. Skipper, E.S. (2010) Investigating the genetic control of postharvest shelf life and vitamin C content in broccoli *(Brassica oleracea* var. *italica).* PhD thesis, University of Warwick

17. Subha, R., Jansirani, P. and Raja Babu, C. (2010). Studies on crop regulation in curry leaf (*Murraya koenigii* Spreng.) during offseason. International Journal of Plant Sciences, 5(1): 269-273

18. Singh, S., Singh, L. B., Singh, D. R., Chand, S., Ahmed, S. Z., Singh, V. N., & Roy, S. D. (2018). Indigenous underutilized vegetables for food and nutritional security in an island ecosystem. *Food Security*, *10*(5), 1173-1189.

19. Asowata-Ayodele, A. M. (2015). *Pharmacological studies of foeniculum vulgare (mill.) and Lippia javanica (burm. F.) Spreng. used as spices in Nkonkobe Municipality of the Eastern Cape province, South Africa* (Doctoral dissertation, University of Fort Hare).

20. Devi, A. (2020). Microscopical analysis of some honeys from kangra and adjoining areas of Himachal Pradesh.

21. Al-Ani, L. K. T. (2019). The Importance of Endophytic Fungi from the Medicinal Plant: Diversity, Natural Bioactive Compounds, and Control of Plant Pathogens. In *Medically Important Plant Biomes: Source of Secondary Metabolites* (pp. 189-238). Springer, Singapore.

22. Gahukar, R. T. (2018). Management of pests and diseases of important tropical/subtropical medicinal and aromatic plants: A review. *Journal of applied research on medicinal and aromatic plants*, *9*, 1-18.

23. Singh, Shrawan, L. B. Singh, D. R. Singh, Subhash Chand, SK Zamir Ahmed, V. N. Singh, and S. Dam Roy. "Indigenous underutilized vegetables for food and nutritional security in an island ecosystem." *Food Security* 10, no. 5 (2018): 1173-1189.

24. Sreekala, K., Harinarayanan, C. M., Deepak, M., & Balachandran, I. (2016). Pharmacognostic evaluation of simple effective healthcare traditions using Murraya koenigii (L.) Spreng for digestion and digestive disorders. *Int J Pharmacognosy*, *3*(11), 491-95.

 http://dx.doi.org/10.53709/CHE.2020.v01i01.023