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Evaluation of underutilized leafy vegetables for growth and yield

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Abstract
The green leafy vegetables play an important role in the life of rural people as they form an important part of food and nutrition of local population as many of them are traditionally been esteemed for their utilization. Greens are the leafy vegetables in which their leaf and stem portions are edible. Vegetable crops are neither grown commercially on large scale nor traded widely and consumed locally are called underutilized crops. Among various green leafy vegetables many are remain underutilized and unexplored. With an objective to compare the growth and yield performance of fifteen different leafy vegetable viz., *Acalypa indica, Alternanthera brasiliana, Alternanthera bettzickiana, Alternanthera sessilis, Cardiospermum helicacabum, Celosia argentea, Chenopodium album, Centella asiatica, Coccinia grandis, Hibiscus cannabinus, Ipomoea aquatica, Pisonia alba, Sauropus androgynous, Talinum fruticosum, Solanum trilobatum* were collected. Growth performance of the underutilized green leafy vegetables showed that plant height and leaf breadth was maximum in G_{10} (*Hibiscus cannabinus)* at 90 DAP, number of leaves /plant recorded maximum in G_4 (*Alternanthera sessilis*), leaf length was maximum in G_{14} (*Talinum fruticosum*). Leaf area and yield was maximum in G_3 (*Alternanthera bettzickiana*) at 90 DAP.

Keywords: Leafy vegetables, underutilized, growth, yield

Introduction
Mother earth has provided umpty number of leafy plants and many of which are known to be edible and used as vegetable either as salad or consumed after cooking. Vegetables play an immense role in human diet throughout the world as they are rich sources of nutritional, mineral, vitamins and therapeutical content. A good living should have a regular supply of vegetables in any form either fresh or processed. Being a tropical developing country and availability of diversed climatic regions viz., tropical plains, mountaineous subtropical and hilly temperate regions, all sort of major vegetables can be cultivated in Indain subcontinent. Besides the major vegetables, leafy vegetables also have vital role of Indian cuisine due to higher nutritional, mineral, dietary fiber content and low calorific value. Vegetable amaranth serves as an alternative source of nutrition for people in developing countries since it is a rich and inexpensive source of carotenoid, protein, vitamins and dietary fibre (Prakash and Pal, 1991; Shukla *et al*., 2003) [8].

The vegetable greens are rapidly growing plants and are ready for market in a short period of time. The outer leaves are harvested over an extended period, without any adverse effects to the plant. These leaves are usually used in salads in various combinations, making an attractive display of colour and texture.

A large number of leaves from different sources such as perennial trees, aquatic plants and terrestrial annuals are consumed especially in rural areas. These vegetables are an economic source to ensure the micronutrient intake. Green Leafy Vegetables are seasonal and also highly perishable due to their high water content. Even though they are rich in minerals and nutrients due to lack unavailability of sufficient storage, transport and proper processing facilities at the production point (Pande *et al.,* 2000) [6]. Some of the leafy vegetables are also recognized for their medicinal value too. In general, edible green leafy vegetables appear to be under-utilized or utilized by regional specific peoples/tribes throughout the world and may in some areas even be diminished in use.

With this background, surveys were conducted at local vegetable markets of Theni district of Tamilnadu for selecting the underexploited leafy vegetables, with a view to document the growth and yield performance of selected underutilized leafy vegetables.

Materials and methods
The field experiment was conducted in the field of Western block, Department of Vegetable Crops, Horticultural College and Research Institute, Periyakulam. Geographically, it is located

at 10.126' North latitude, 77.58 East longitude and at an altitude of 426.76 m above MSL. Fifteen underutilized greens were collected from different places of Theni district of Tamil Nadu and used as a planting materials for this study. The details of the leafy vegetables used were given in the table. The selected field was ploughed three times and well decomposed Fram yard manure was incorporate during the last ploughing @ 20t/ha and soil bought to fine tilth. The raised beds of 20 cm height, 1.2 cm width and 28 m length were prepared at a spacing of 60 cm between the raised beds. Two rows of 16 mm inline drip laterals were laid on the bed for irrigation at a spacing of 60 cm between the laterals. The plots were randomized as per Randomized Block Design and the plants were planted as per the treatments with three replications each. In each plot the selected planting materials viz., seeds/cuttings were planted at a spacing of 60 x 60 cm. Irrigation was provided through drip irrigation system immediately after sowing/transplanting and after as when required. Inorganic nutrients in the forms of water soluble fertilizers (19:19:19) was applied to the plants through fertigation system @ 2 kg/ha at fortnight interval. The research plots were kept weed free by hand weeding at regular intervals. Harvesting of green leaves was done with the help of secateurs at the intervals of 30, 60, 90 DAP. Five plants in each plot were randomly selected and tagged for recording growth and yield observations to work out the mean value. The data recorded were subjected to statistical analysis as per the method suggested by Panse and Sukhatme (1995) [7].

Results and discussion

Growth Parameters

Among the fifteen different underutilized leafy vegetables evaluated, G_1 (*Acalypa indica)* recorded highest plant height of about 43.60 cm at 30 DAP but G_{10} (*Hibiscus cannabinus)* recorded maximum height of 126.41cm and 137.21cm in 60 and 90 DAP respectively. Ahamad *et al*., (2012) [1] evaluated twenty two amaranth genotypes and recorded the maximum plant height was 127.25 cm.

More number of branches/plant was recorded in G_8 (*Centella asiatica*) which was about 17.50 during 30DAP and in G_2 (*Alternanthera brasiliana*) during 60 and 90 DAP showed 20.90 and 24.40 branches/plant respectively. More number of branches/ plant was recorded in Amaranthus by Joshi *et al.*, (2011) [4].

More number of leaves/plant also recorded in G_4 (*Alternanthera sessilis*) as reported by Dixit (2007) [3] in Amaranthus. Leaf length and leaf breadth was one of the major for yield contributing characters. Highest leaf length was recorded in different species at different growing stage viz., G_{12} (*Pisonia alba)* at 30 DAP (10.02 cm), G_6 *Celosia argentea* at 60 DAP(13.02 cm) and G_{14} (*Talinum fruticosum*) at 90 DAP(16.98 cm). This is in line with the findings of Celine *et al.*, (2002) [2] in Amaranthus genotypes.

Leaf breadth was recorded highest in G_9 (*Coccinia grandis*) which was about 5.74 cm at 30 DAP and G_{10} (*Hibiscus cannabinus*) recorded highest leaf breadth 5.83 cm and 13.48 cm during 60 and 90 DAP. Oboh (2007) [5] studied 16 accession of Amaranthus hybrid and reported that leaf breadth was ranged from leaf width from 7.00 to 12.40 cm. SimilarlyPetiole length recorded highest value for G_{10} (*Hibiscus cannabinus*) at 30,60 and 90 DAP respectively. Plant spread was showed maximum value at 30, 60 and 90 DAP G_{11} (*Ipomoea aquatica).* Since this plant having fast growing character with striking roots in its every node, the plant spread was higher in all growing stages.

Highest leaf area was obtained in G_3 (*Alternanthera bettzickiana*) at 30, 60 and 90 DAP of about 2671.49 cm², 6057.98 cm², 24583.56 cm². Though the leaf length and leaf breadth of G_3 (*Alternanthera bettzickiana*) is comparitively lesser than other greens tested, the total leaf area was higher in this species because more number of leaves present in G_3 (*Alternanthera bettzickiana*). Total chlorophyll content recorded highest in G_{13} (*Sauropus androgynous*) which was 2.493 (mg/100g) at 30 DAP.G_5 (*Cardiospermum helicacabum)* recorded maximum at 60 DAP which was about 3.893 (mg/100g).

Yield attributes

The highest fresh leaf yield was obtained in the green G_{14} (*Talinum fruticosum*) of about 1.6 kg/plot at 30 DAP which might be due to the maximum leaf length and succulent leaf type. At 60 DAP and 90 DAP G_3 (*Alternanthera bettzickiana*) showed highest yield of about 2.2 kg/plot and 2.9 kg/plot which may be due to highest leaf area and more number of leaves. Shukla *et al.*, (2006) [3] tested 29 strains of *Amaranthus tricolor* and reported highest yield of about 5.06 kg plot^{-1} in AV-38 followed by AV-23 (4.70 kg plot^{-1}). Since leafy vegetables are mainly grown for fresh leaves, the number of leaves per plant along with leaf size determines total yield. The leaf length of amaranthus increased gradually in different stages of growth, which was found to be important for yield contributing characters of amaranthus. Similar results were obtained by Prakash *et al.*, (2010). Sarker *et al*., (2014) [12] also reported that foliage yield had significant relation with plant height, leaves per plant, leaf area among thirty vegetable amaranthus.

Table 1: Details of the underutilized leafy vegetables

Greens	Common name/ local name	Botanical name	Source
G_1	Kuppaimeni	*Acalypa indica*	Kamatchipuram
G_2	Siggapu Ponnanganni keerai	*Alternanthera brasiliana*	Endapuli
G_3	Pacchai Ponnanganni keerai	*Alternanthera bettzickiana*	Uzhavarsanthai, Theni
G_4	Vayakattu Ponnanganni keerai	*Alternanthera sessilis*	Uzhavarsanthai, Theni
G_5	Mudakathan keerai	*Cardiospermum helicacabum*	Vaduga pati
G_6	Magili keerai(Pannai keerai)	*Celosia argentea*	Kamatchipuram
G_7	Chakkaravarthy keerai	*Chenopodium album*	Kamatchipuram
G_8	Valarai	*Centella asiatica*	HC&RI,PKM
G_9	Kovakai	*Coccinia grandis*	Theni
G_{10}	Pulicha keerai	*Hibiscus cannabinus*	Villupuram
G_{11}	Valla keerai	*Ipomoea aquatica*	Farmer field, Theni
G_{12}	Lachakottai keerai	*Pisonia alba*	HC&RI,PKM
G_{13}	Chekkurmanis	*Sauropus androgynous*	HC&RI,PKM
G_{14}	Nandukal Pasalai	*Talinum fruticosum*	Farmer field, Theni
G_{15}	Thuthuvalai	*Solanum trilobatum*	Farmer field, Theni

Table 2: Performance of underutilized green leafy vegetables for plant height, number of branches/plant, number of leaves/ plant

Greens	Plant Height(cm)			Number Of Branches/ Plant			Number Of Leaves/ Plant		
Days After Planting	30DAP	60DAP	90DAP	30DAP	60DAP	90DAP	30DAP	60DAP	90DAP
G_1	43.60	53.80	62.43	15.10	18.20	18.50	190.26	405.86	564.25
G_2	21.97	30.19	39.37	11.30	20.90	24.40	282.50	1207.58	1220.56
G_3	24.93	46.83	65.73	6.20	7.70	15.10	192.82	277.97	662.89
G_4	46.76	63.71	68.50	8.00	14.00	22.40	408.36	2317.00	4054.40
G_5	42.78	113.26	120.49	5.00	7.20	18.80	165.76	421.06	1252.08
G_6	10.60	55.07	71.44	1.70	3.60	14.60	15.81	69.48	367.92
G_7	12.74	27.57	35.87	6.40	6.40	9.20	74.88	164.48	250.24
G_8	7.60	16.14	26.93	17.50	19.60	17.20	17.50	68.60	168.56
G_9	35.23	82.25	88.16	2.30	3.80	8.30	30.72	77.90	214.14
G_{10}	23.90	126.41	137.21	12.10	13.80	17.30	36.30	211.14	392.71
G_{11}	75.40	122.88	170.66	5.50	7.20	19.70	61.05	95.76	433.40
G_{12}	27.02	31.49	35.43	2.60	3.70	4.70	25.74	48.10	65.80
G_{13}	22.76	31.31	37.96	8.40	10.30	13.00	100.80	202.91	388.70
G_{14}	19.50	33.21	41.91	4.90	8.40	11.20	143.65	249.48	406.56
G_{15}	13.70	41.90	53.16	6.90	7.70	10.60	31.74	46.20	126.14
SE (d)	0.55	1.29	1.51	0.25	0.32	0.25	3.29	20.61	18.70
CD (0.05%)	1.13	2.65	3.10	0.52	0.65	0.51	6.74	42.22	38.32

Table 3: Performance of underutilized green leafy vegetables for leaf length and leaf breadth, Petiole length

Greens	Leaf Length (cm)			Leaf Breadth (cm)			Petiole Length (cm)		
Days After Planting	30DAP	60DAP	90DAP	30DAP	60DAP	90DAP	30DAP	60DAP	90DAP
G_1	3.53	3.96	4.63	2.65	3.59	4.13	3.24	3.60	3.81
G_2	3.68	6.38	7.26	2.43	3.14	3.68	0.50	2.18	1.63
G_3	3.37	4.39	5.96	1.33	2.17	3.88	0.16	1.26	1.18
G_4	5.36	6.32	7.48	2.38	3.34	3.67	1.90	2.50	3.97
G_5	3.47	4.70	5.83	1.55	3.72	4.83	1.80	2.39	3.39
G_6	5.30	13.02	15.90	1.30	2.52	5.90	1.90	2.94	3.94
G_7	5.99	6.62	7.84	2.66	3.51	5.26	1.42	2.18	2.75
G_8	4.73	5.18	4.35	2.98	3.48	4.04	3.22	4.87	4.53
G_9	4.72	5.88	6.92	5.74	6.46	4.36	1.82	2.18	2.80
G_{10}	5.54	7.46	8.38	5.28	13.48	5.83	5.88	6.97	7.10
G_{11}	7.63	8.95	9.94	2.42	3.69	5.50	4.10	5.34	5.14
G_{12}	10.02	11.04	12.45	3.80	4.62	4.39	0.76	2.32	2.43
G_{13}	4.75	4.81	5.98	1.62	2.75	3.75	0.20	1.27	0.95
G_{14}	7.72	16.98	9.26	2.10	3.15	4.17	0.30	1.17	1.37
G_{15}	3.53	10.85	5.91	3.33	3.92	3.34	2.66	3.47	3.84
SE (d)	0.12	0.19	0.20	0.06	0.10	0.09	0.04	0.07	0.10
CD (0.05%)	0.25	0.40	0.41	0.12	0.21	0.19	0.09	0.14	0.22

Table 4: Performance of underutilized green leafy vegetables for plant spread, leaf area and chlorophyll content

Greens	Plant Spread (cm^2)			Leaf area (cm^2)			Total chlorophyll content (mg/100g)		
Days After Planting	30DAP	60DAP	90DAP	30DAP	60DAP	90DAP	30DAP	60DAP	90DAP
G_1	493.02	1567.00	1972.35	1105.54	1820.37	2976.27	0.687	1.395	2.104
G_2	1466.49	1695.10	2132.56	1287.21	1865.59	11862.09	0.933	1.824	2.716
G_3	1049.90	1419.30	1698.36	2671.49	6057.98	24583.26	0.838	1.376	1.916
G_4	4190.28	2172.80	2897.65	739.02	1210.38	1210.39	0.826	1.432	2.629
G_5	2454.98	2727.26	2975.86	285.65	771.38	2324.70	0.539	2.359	3.893
G_6	130.00	489.60	642.30	45.91	121.46	1030.40	0.261	2.011	3.484
G_7	254.36	696.58	968.23	584.56	800.59	1904.75	0.272	1.414	2.568
G_8	424.95	2536.94	3656.32	76.27	204.47	468.06	0.525	1.565	2.858
G_9	902.55	1166.20	1453.26	526.28	694.89	1759.79	0.090	2.159	3.794
G_{10}	276.94	478.95	698.32	396.58	538.02	4437.14	0.409	1.031	1.974
G_{11}	4947.87	6165.45	9139.00	976.40	1474.76	1474.77	0.243	1.582	2.756
G_{12}	453.44	576.24	765.32	599.69	911.85	1441.21	0.658	0.985	1.313
G_{13}	250.82	910.47	1242.56	365.10	713.75	1734.39	2.493	2.249	2.006
G_{14}	917.00	1480.86	1878.35	1382.47	1473.85	3924.37	0.493	1.358	2.223
G_{15}	105.55	379.95	486.37	207.21	333.13	501.76	0.490	1.818	3.146
SE (d)	33.61	53.41	37.18	27.59	20.79	176.05	0.024	0.038	0.032
CD (0.05%)	68.96	109.40	76.16	56.51	42.58	360.63	0.049	0.078	0.066

Table 5: Performance of underutilized green leafy vegetables for yield per plant and yield per plot

Greens	Yield Per Plant				Yield Per Plot			
Days After Planting	**30DAP**	**60DAP**	**90DAP**	**Total**	**30DAP**	**60DAP**	**90DAP**	**Total**
G_1	1.35	2.17	2.99	6.51	37.8	60.67	83.72	182.19
G_2	43.5	66.47	89.44	199.41	1218	1861.07	2504.32	5583.39
G_3	53.66	78.80	103.94	236.4	1502.48	2206.40	2910.32	6619.2
G_4	11.89	12.83	13.77	38.49	332.92	359.33	385.56	1077.81
G_5	3.45	5.77	8.09	17.31	96.6	161.47	226.52	484.59
G_6	6.52	7.93	9.34	23.79	182.56	222.13	261.52	666.21
G_7	_	25.40	26.3	51.7	_	711.20	736.4	1447.6
G_8	_	1.63	1.92	3.55	_	45.73	53.76	99.49
G_9	5.67	6.57	7.47	19.71	158.76	183.87	209.16	551.79
G_{10}	29.36	38.30	47.24	114.9	822.08	1072.40	1322.72	3217.2
G_{11}	9.12	10.07	11.02	30.21	255.36	281.87	308.56	845.79
G_{12}	_	2.50	2.82	5.32	_	70.00	78.96	148.96
G_{13}	_	2.97	3.21	6.18	_	83.07	89.88	172.95
G_{14}	58.56	63.47	68.38	190.41	1639.68	1777.07	1914.64	5331.39
G_{15}	_	2.13	2.65	4.78	_	59.73	74.2	133.93
SE (d)	0.42	0.64	0.61	1.67	11.86	20.45	34.43	66.74
CD (0.05%)	0.86	1.32	1.26	3.44	24.31	41.90	70.53	136.74

Conclusion

Among the underutilized leafy vegetables tested highest fresh leaf yield was obtained in the *Talinum fruticosum*, *Alternanthera bettzickiana*. Different leafy vegetables may require different ratio of nutrient requirement that can be studied and standardized in future. Besides, documentation of nutritional profile will also helpful for selection of particular green leafy vegetables for particular purpose.

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