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Organic leaf production of Moringa (*Moringa oleifera* Lam.) cv. PKM-1 for higher leaf yield and quality parameters under Ultra High Density planting system

Abstract

An experiment was conducted to study the "Standardization of Ultra high density planting system for organic leaf production in Moringa at Tamil Nadu Agricultural University during 2015-2016. The experiment was laid out in split plot design with five main plot treatments (spacing) *viz.,* M_1 - 10 x 15cm (6.66 lakh plants/ha), M_2 - 15 x 15cm (4.44 lakh plants/ha), M_3 -20 x 10cm (5 lakh plants/ha), M_4 - 20 x 20cm (2.5 lakh plants/ha), M_5 - 40 x 20cm (1.25lakh plants/ha) and five subplot treatments (organics) S_1 - FYM 25t/ha, S_2 - Vermicompost 12.5 t/ha, S_3 - Sheep manure 25t/ha, S_4-Humic acid 20 kg/ha, S_5 - Control with three replications. First harvest of leaves was commenced at 60 days after sowing; subsequent leaf harvest was done at 45 days interval. After harvest, subplot treatments (Organics) as per the schedule were applied on the concerned main plots. Among the different plant density, plant density of 40 x 20cm (1.25lakh plants/ha) resulted in increased plant height, leaflets per plant, branches per plant, fresh leaf yield per plant and leaf yield per plot. Among the different organics, humic acid @ 20 t/ha registered the better performance of yield parameters of increased plant height, leaflets per plant, branches per plant, fresh leaf yield per plant, leaf yield per plot. The enhanced quality parameters also viz., Ascorbic acid, crude fibre, beta – carotene, iron, calcium, magnesium, manganese and zinc content were observed in treatment combination of M_5 S_4 (40 x 20cm with humic acid 20kg/ha). The treatment combination of 40 x 20cm with humic acid 20kg/ha recorded the better yield and quality parameters under high density planting system.

Keywords: moringa, ultra high dnsity planting system, yield and quality traits

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Abbreviations: DAS: days after sowing; AAS: atomic absorption spectrophotometer; KG: kilo gram; g: gram; FYM: farm yard manure; Ha: hectare; CM: centi meter; CV: cultivar; T: tones; HA: humic acid.

Introduction

Moringa (*Moringa oleifera* Lam.) belongs to the family 'Moringaceae' is a fast growing multipurpose miracle tree extensively grown in tropics and subtropics of India and Africa.[1] It is also widely distributed in India, Egypt, Philippines, Sri Lanka, Thailand, Malaysia, Burma, Pakistan, Singapore, West Indies, Cuba, Jamaica and Nigeria. In eastern and southern regions of India moringa is widely used vegetable and grown commercially for its edible pods and leaves. Its popularity is increasing steadily because of its nutritional, medicinal value and particular taste. Both perennial and annual Moringa are cultivated in Tamil Nadu. At Horticultural college and Research Institute Periyakulam, Tamil Nadu Agricultural University, two renowned varieties viz., PKM 1 and PKM 2 were released during 1989 and 2000 respectively and after this, commercial cultivation gained momentum in our state and elsewhere in the country and world. Vijayakumar et al.,[2] reported that moringa is a multipurpose tree, wherein the leaves, flowers and pods are used for culinary and medicinal purposes. Invention and release of annual moringa cv. PKM-1 is a milestone in the research on moringa by which the area and productivity were greatly increased. It has occupied considerable area in adjoining states like Karnataka and Andhra Pradesh. Since it is a seed sown crop and annual in nature, it responds markedly to seasonal changes. Recently, in India, moringa leaf products especially leaf powder are becoming increasingly popular because of its outstanding indigenous nutritive value. Plant density plays a vital role in determining the yield per unit area. Optimum plant population for any crop varies considerably due to environment under which it is grown. Very little research work has been attempted on intensive leaf production and drying of moringa leaves in India. Moringa leaf production can be a viable economic venture to meet the growing demand for moringa leaf products.[3] He also reported that high density mono cropping of moringa gives the highest leaf yield and returns per unit area. Keeping these points in view, the present study on annual seed moringa cv. PKM-1 was designed with the objective of standardize the ultra-high density planting system for high leaf yield and quality in moringa.

Materials and methods

The research was undertaken at College Orchard, Department of Vegetable crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2015-2016, with an objective to standardize the ultra-high density planting for high leaf yield and quality parameters in moringa cv. PKM-1. The experiment was laid out in split plot design with five main plot treatments (spacing) *viz.,* M_1 -10 x 15cm (6.66 lakh plants/ha), M_2 -15x15cm (4.44 lakh plants/ha), M_3 -20 x 10cm (5lakh plants/ha), M_4 - 20 x 20cm (2.5 lakh plants/ha), M_5 - 40x20cm (1.25lakh plants/ha) and five subplot treatments (organics) S_1 - FYM 25t/ha, S_2 - Vermicompost 12.5t/ha, S_3- Sheep manure 2t/ha, S_4 -Humic acid 20kg/ha, S_5 - Control with three replications.

Morphological attributes

Plant height was measured from the base of the plant at ground level to tip of main stem at monthly interval and expressed in centimeters. The branches arising from main stem in each plant was recorded on 90 and 120 DAS and the mean was expressed in numbers. The number of leaf lets per plant was recorded on 30 and 60 DAS and mean value is expressed as numbers. Total leaf yield per plant was recorded in randomly selected plants in different harvest and the cumulative mean was expressed in grams per plant. Total leaf yield per plot and dry leaf yield per plot was recorded in different harvest and the cumulative mean value was expressed in kilograms per plot.

Quality parameters

a) Ascorbic acid content

The ascorbic acid content was estimated as per the method described by Harris (1935) and expressed in mg per 100 g of leaf sample.

b) **Crude fibre:** The crude fibre content was estimated as percentage crude fibre (AOAC, 1975).

c) **β- Carotene:** Beta-carotene was estimated as described in mg per 100g (AOAC, 1975).

d) **Iron content:** The leaf samples were estimated colorimetric ally from aliquot of digested triple acid extract of the plant material and concentration of iron was recorded using the Atomic Absorption Spectrophotometer (AAS). The OD value is used for calculated and expressed as mg 100 g^{-1} of leaf sample by using the formula of Iron content (mg/100) = absorbance of sample / weight of sample (g) x100 as suggested by Ezeonu et al., 2002).

e) **Ca content:** The leaf samples were estimated for Ca content following approved method as suggested by Muthuvel and Udhayasooriyan, 1999 and calculated and expressed as percentage of leaf sample by using the formula of

$$Amount\ of\ Ca\ present\ =\ 0.0004\ \times\ volume\ of\ 0.02N\ EDTA\ used\ \times\ In\ the\ sample\ \left(\%\right)\ =\ 100/10\ \times\ Weight\ of\ sample\ taken$$

Mg content: The Mg content of leaf samples were estimated as the method suggested by Muthuvel and Udhaya sooriyan, 1999 by employing the formula.

$$Amount\ of\ Mg\ present\ =\ in\ the\ sample\ \left(\%\right)\ =\ 0.00024\ x\ \left(volume\ of\ 0.02N\ EDTA\ used\ for\ Ca+Mg\right)\ x\ 100/\ 10\ x\ 100/1$$

Manganese and zinc: The manganese and zinc content was estimated as per the method of Muthuvel and Udhayasooriyan, 1999

Results and discussion

The data recorded were analyzed as per the statically method.[4]

Yield parameters

Plant height at 30 and 60 days after sowing (Table 1): There were significant differences among the treatments for plant height at 30 and 60 days after sowing (DAS). The main plot spacing treatment of wider spacing M_5 (40 x 20cm) recorded the highest plant height at 30 and 60 DAS (39.26, 108.76cm) followed by M_1 (10 x 15cm) of 36.39cm at 30 DAS. Whereas, the treatment M_2 (15 x 15cm) recorded of 95.39cm at 60 DAS compared to closer spacing. Similar result was found in bell pepper by Shivakumar et al.,[5] Efficient metabolism, greater photosynthetic mobilization thereby increased sink capacity might have helped better morphological growth characters.[6] Similar findings were also reported by Singh[7] in onion. Among the different organics, the subplot treatment of organics S_3 (sheep manure 25t/ha) exhibited the highest plant height of 38.43cm at 30 DAS followed by S_2 (vermicompost 12.5t/ha) of 36.92cm and this treatment was on par with the treatment S_1 (FYM 25t/ha) of 36.52cm. The subplot treatment S_2 (vermicompost 12.5 t/ha) shows the highest plant height of 96.90cm at 60 DAS .The treatment S_5 (control) registered the lowest plant height at 30 and 60 DAS (31.82 and 77.02cm). This enhanced plant height might be due to the role of organic fertilizer (vermicompost) which would have improved the physical properties of the soil, such as they would have provided more nitrogen and phosphorus in the soil. Similar results were also found in summer squash by Taha et al.[8]

Table 1 Influence of ultra high density planting and organics on plant height (cm) at 30 and 60 DAS in moringa cv. PKM-1

Treatments	Plant height(cm) 30 DAS						Plant height (cm) 60 DAS					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
S1	38.84	35.39	38.25	35.23	34.89	36.52	79.8	90.21	80.27	88.16	115.73	90.84
S2	38.13	33.31	35.77	36.12	41.28	36.92	90.87	102.45	89.45	107.23	94.51	96.9
S3	35.51	38.03	40.81	36.04	41.8	38.43	83.39	104.24	91.73	58.49	111.35	89.84
S4	37.19	35.05	25.49	30.98	43.22	34.38	70.23	103.62	73.51	94.76	127.35	93.89
S5	32.31	31.21	28.31	32.15	35.13	31.82	63.91	76.43	70.29	79.62	94.84	77.02

Table Continued....

Treatments	Plant height(cm) 30 DAS						Plant height (cm) 60 DAS					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
Mean	36.39	34.59	33.72	34.1	39.26	35.62	77.64	95.39	81.05	85.65	108.76	89.69
	M	S	M@S	S@M		SE(d)	M	S	M@S	S@M		
SE(d)	0.92	0.72	1.7	1.6		CD @ 5%	1.65	1.9	4.15	4.26		
CD @ 5%	2.12**	1.45**	3.58**	3.24**		CD @ 1%	3.81**	3.85**	8.58**	8.60**		
CD @ 1%	3.08**	1.94**	4.93**	4.33**			5.54**	5.15**	11.65**	11.51**		

Main plot (Spacing)			Sub plot (Organics)
M1	10 x 15cm	S1	FYM 25t/ha
M2	15 x 15cm	S2	Vermicompost 12.5t/ha
M3	20 x 10cm	S3	Sheep manure 25t/ha
M4	20 x 20cm	S4	Humic acid 20kg/ha
M5	40 x 20cm	S5	Control

The interaction effect of influence of spacing and organics for this growth trait was significant among the treatments. The treatment combination of M_5S_4 (spacing of 40 x 20cm with organic humic acid 20kg/ha) recorded the highest plant height of 43.22 and 127.35 cm at 30 DAS and 60 DAS respectively. Followed by the treatment M_5S_3 (spacing of 40 x 20cm with sheep manure 25t/ha) of 41.80cm registered the higher plant height at 30 DAS and M_5S_1 (spacing of 40 x 20cm with FYM 25t/ha) of 115.73cm at 60 DAS respectively. This might have been attributed due to the presence and enhanced activity of gibberellins like substances in humic acid as reported by Vaughan and Malcom,[9] The enhanced plant height might be also due to efficient metabolism and effective source sink relationship.[10]

Number of leaf lets per plant (Table 2): Influence of spacing had significant difference among the treatments for number of leaflets per plant at 30 and 60 DAS. The main plot treatment M_5 (40 x 20cm) recorded more number of leaflets of 6.16 and 9.43 at 30 and 60 DAS followed by M_3 (20 x 10cm) of 5.66 at 30 DAS and M_4 (20 x 20 cm) of 7.91 at 60 DAS respectively. The subplot treatment S_4 (humic acid 20kg/ha) recorded the highest number of leaflets of 5.79 followed by S_2 (vermicompost 12.5t/ha) of 5.61 at 30 DAS and S_2 (vermicompost 12.5t/ha) recorded the highest number of leaflets of 8.84 at 60 DAS and followed by treatment S_4 (humic acid 20kg/ha) of 8.21. The interaction effect of influence of spacing and organics were significant among the treatments. The treatment combination of M_5S_2 (spacing of 40 x 20cm with vermicompost 12.5t/ha) recorded the highest number of leaflets per plant of 6.61 at 30 DAS and the treatment M_5S_4 (spacing of 40 x 20 cm with humic acid 20kg/ha) with the values of 11.27 per plant at 60DAS. The trails are in progress and further harvesting is in progress. The biochemical, physiological and quality parameters are being assessed.

Table 2 Influence of ultra high density planting and organics on number of leaflets per plant at 30 and 60 DAS in moringa cv. PKM-1

Treatments	Leaflets per plant at 30 DAS						Leaflets per plant at 60 DAS					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
S1	5.21	5.02	5.22	4.98	5.53	5.02	6.81	6.87	6.32	7.26	8.03	7.38
S2	4.44	5.35	5.81	5.83	6.61	5.61	6.73	8.27	10.75	9.33	9.12	8.84
S3	4.04	4.87	6.36	5.9	6.32	5.49	7.21	7.01	7.89	8.56	10.35	8.2
S4	5.23	5.99	5.78	5.46	6.49	5.79	7.49	7.92	6.91	7.45	11.27	8.21
S5	4.49	4.34	5.13	5.31	5.87	5.02	7.98	6.83	6.74	6.95	8.4	7.05
Mean	4.68	5.11	5.66	5.49	6.16	5.42	7.24	7.38	7.72	7.91	9.43	7.94
	M	S	M@S	S@M		M	S	M@S	S@M			

Table Continued....

Treatments	Leaflets per plant at 30 DAS						Leaflets per plant at 60 DAS					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
SE(d)	0.11	0.11	0.26	0.25	SE(d)	0.14	0.14	0.32	0.31			
CD @ 5%	0.27*	0.23*	0.54*	0.52*	CD @ 5%	0.32*	0.29*	0.66**	0.64**			
CD @ 1%	0.39**	0.31**	0.73*	0.69*	CD @ 1%	0.47**	0.38**	0.89**	0.86**			

Main plot (Spacing)		Sub plot (Organics)
10 x 15cm	S1	FYM 25t/ha
15 x 15cm	S2	Vermicompost 12.5t/ha
20 x 10cm	S3	Sheep manure 25t/ha
20 x 20cm	S4	Humic acid 20kg/ha
40 x 20cm	S5	Control

Number of branches per plant (Table 3): Influence of spacing i.e. plant density had significant difference among the treatments for number of branches at 90 DAS and 120 DAS. The main plot treatment M_4 (20 x 20 cm) recorded more number of branches of 3.08 at 90 DAS followed by the treatment M_5 (40 x 20cm) of 2.69. Whereas, the main plot treatment M_5 (40 x 20cm) recorded more number of branches of 3.54 at 120 DAS. This treatment was on par with M_4 (20 x 20cm) of 3.28. More number of branches per plant under the wider spacing might be attributed to high leaf area, better utilization of water and nutrients in comparison to closer spacing. Plants spaced at wider spacing get the advantage of harvesting better sunshine and optimum space for uptake of nutrients as compared to close spaced plants. The above results are in line to Kumar et al.,[11] in okra. Increased number of branches per plant and ultimately increased the number of leaves per plant. These observations are in agreement with the finding of Singh[12] in okra. The subplot treatment S_1 (FYM 25 t/ha) and S_2 (Vermicompost 12.5t/ha) exhibited the highest number of branches at 90 and 120 DAS (2.84 and 3.49) and followed by the treatment S_3 (Sheep manure 25t/ha) of 2.83 and 3.34 at 90 and 120 DAS. This might be due to direct addition and slow release of nutrients through vermicompost,[13] thus enriching available nutrient pool of the soil which resulted in more number of leaves per plant. Higher number of moringa leaves might be also due to increased number of branches per plant. The effect of vermicompost on plant growth could be attributed to presence of plant growth regulators and humic acid in vermicompost, which are produced by increased activity of microbes such as fungi, bacteria, yeasts, actinomycetes and algae.[14] The available microbes are also capable of producing auxins, cytokinins and gibberellins during vermicomposting,[14,15] which affects plant growth appreciably.[14,16] These results corroborate with results of Vadiraj et al.,[17] in cardamom. The interaction effect of Influence of spacing and organics were significant among the various treatments. The treatment combination of M_5S_4 (spacing of 40 x 20cm with organic humic acid 20 kg/ha) recorded the highest number of branches per plant of 3.75 and 4.25 at 90 & 120 DAS. Similar results were also obtained by Birbal et al.,[18] & Singh[12] in okra.

Table 3 Influence of ultra high density planting and organics on number of branches per plant at 90 and 120 DAS of moringa cv. PKM-1

Treatments	Number of branches per plant at 90 DAS						Number of branches per plant at 120 DAS					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
S1	2.65	2.76	3	3.02	2.75	2.84	3.12	3.45	3.22	3.42	3.45	3.33
S2	3.15	2.71	2.43	2.45	2.85	2.72	3.39	3.09	3.49	3.45	4.01	3.49
S3	2.34	3.02	2.59	3.45	2.74	2.83	3.51	2.92	3.15	3.95	3.15	3.34
S4	2.49	2.37	2.26	2.72	3.75	2.53	3.11	3.15	3.05	3.09	4.25	3.33
S5	2.33	2.01	2.08	2.81	2.28	2.49	2.32	2.23	2.28	2.48	2.85	2.43
Mean	2.59	2.57	2.47	3.08	2.69	2.68	3.09	2.97	3.04	3.28	3.54	3.18
	M	S	M@S	S@M	SE(d)	M	S	M@S	S@M			
SE(d)	0.027	0.026	0.06	0.06	CD @ 5%	0.033	0.033	0.075	0.075			

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Table Continued....

Treatments	Number of branches per plant at 90 DAS						Number of branches per plant at 120 DAS					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
CD @ 5%	0.064*	0.054*	0.125**	0.121**	CD @ 1%	0.077*	0.067*	0.156**	0.151**			
CD @ 1%	0.093*	0.072*	0.171**	0.162**		0.112*	0.090*	0.212**	0.203**			

Main plot (Spacing)		Sub plot (Organics)
10 x 15cm	S1	FYM 25t/ha
15 x 15cm	S2	Vermicompost 12.5t/ha
20 x 10cm	S3	Sheep manure 25t/ha
20 x 20cm	S4	Humic acid 20kg/ha
40 x 20cm	S5	Control

*Significant **Highly significant NS- Non significant

Fresh leaf yield per plant (Table 4): Spacing had significant difference among the treatments for fresh leaf yield per plant. The main plot treatment M_5 (40 x 20cm) registered the maximum leaf yield per plant of 60.77g per plant followed by the treatment M_4 (20 x 20cm) of 37.30 g per plant. This could be attributed to wider space available for vegetative growth and less competition for nutrients, sun light and aeration. These results are in agreement with the finding of Mane et al.,[19] who also reported higher green yield under wider spacing in palak. Similar results were also reported by Bradley et al.,[20] in spinach. The subplot treatment S_4 (Humic acid 20kg/ha) recorded the maximum yield per plant of 44.84g per plant followed by the treatment S_2 (Vermicompost 12.5 t/ha) of 41.98g per plant. The interaction effect of Influence of spacing and organics were significant among the different treatments. The treatment combination of M_5S_4 (spacing of 40 x 20cm with humic acid 20kg/ha) registered the maximum per plant yield of 83.19g per plant followed by M_5S_2 (spacing of 40 x 20cm with Vermicompost 12.5t/ha) of 50.12g per plant respectively. This might be due to high organic matter content, presence of available macro and micronutrients which would have increased the yield. This might also be due to improved plant height, number of leaves, leaf area and LAI. Supportive evidence comes from Prabhu et al.,[21] in *Ocimum sanctum.*

Table 4 Influence of ultra high density planting and organics on fresh leaf yield per plant (g) in leaves of moringa cv. PKM-1

Treatments	M_1	M_2	M_3	M_4	M_5	Mean
S1	50	29.02	30.9	27.55	50.22	37.54
S2	31.94	30.22	30.48	43.72	73.52	41.98
S3	27.52	22.9	33.58	39.96	67.36	38.27
S4	30.18	35.01	37.57	38.26	83.19	44.84
S5	33.63	33.6	33.01	37.02	29.58	33.37
Mean	34.66	30.15	33.11	37.3	60.77	39.2

Fresh leaf yield per plot (Table 5): Spacing had significant difference among the treatments for fresh leaf yield per plot. The main plot treatment M_5 (40 x 20cm) registered the maximum leaf yield per plot of 62.07kg followed by the treatment M_1 (10 x 15cm) of 39.27kg per plot. The subplot treatment S_4 (Humic acid 20kg/ha) recorded the maximum yield per plot of 75.08 kg followed by the treatment S_3 (Sheep manure 25t/ha) of 57.40 kg. The interaction effect of Influence of spacing and organics were significant among the different treatments. The treatment combination of M_5S_4 (spacing of 40 x 20cm with humic acid 20kg/ha) registered the maximum per plot yield of 20.21kg followed by M_5S_3 (spacing of 40 x 20cm with Sheep manure 25t/ha) of 20.09 kg respectively. This could be attributed to comparative wider space available for vegetative growth and less competition for nutrients, sun light and aeration. The results are in agreement with the finding of Mane et al.,[19] who also reported higher green yield under wider spacing in Palak. Similar results were reported by Maya et al.,[22] in capsicum.

Table 5 Influence of ultra high density planting and organics on fresh leaf yield per plot (kg) in leaves of moringa cv. PKM-1

Treatments	M_1	M_2	M_3	M_4	M_5	Mean
S1	4.53	5.25	5.64	5.74	12.48	33.63
S2	8.5	8.04	8.11	11.63	19.56	55.83
S3	8.26	6.87	10.08	11.99	20.09	57.4
S4	20	11.61	12.36	11.02	20.21	75.08
S5	2.52	2.52	2.48	2.78	2.22	12.51
Mean	39.27	29.04	33.02	37.42	62.07	200.82

Dry leaf yield per plot (Table 6): Spacing had significant difference among the treatments for dry leaf yield per plot. The main plot treatment M_5 (40 x 20cm) registered the maximum dry leaf yield per plot of 22.37kg followed by the treatment M_1 (10 x 15cm) of 13.14kg per plot. The subplot treatment S_4 (Humic acid 20kg/ha) recorded the maximum yield per plot of 22.56kg followed by the treatment S_3 (Sheep manure 25t/ha) of 17.19 kg. The interaction effect of Influence of spacing and organics were significant among the different treatments. The treatment combination of M_5S_4 (spacing of 40 x 20cm with humic acid 20kg/ha) registered the maximum per plot dry leaf yield of 6.06 kg followed by M_5S_3 (spacing of 40 x 20 cm with Sheep manure 25t/ha) of 6.03 kg respectively.

Table 6 Influence of ultra high density planting and organics on dry leaf yield per plot (kg) in leaves

Treatments	M_1	M_2	M_3	M_4	M_5	Mean
S1	1.36	1.58	1.69	1.72	3.74	10.09
S2	2.55	2.41	2.43	3.49	5.87	16.75
S3	2.48	2.06	3.02	3.6	6.03	17.19
S4	6	3.48	3.71	3.31	6.06	22.56
S5	0.76	0.76	0.74	0.83	0.67	3.76
Mean	13.14	10.29	11.6	12.95	22.37	70.35

Main plot (Spacing)		Sub plot (Organics)
10 x 15cm	S1	FYM 25t/ha
15 x 15cm	S2	Vermicompost 12.5t/ha
20 x 10cm	S3	Sheep manure 25t/ha
20 x 20cm	S4	Humic acid 20kg/ha
40 x 20cm	S5	Control

Biochemical parameters: The leaves of *M. oleifera* have been reported to be a valuable source of both macro and micronutrients, rich source of β-carotene, protein, calcium, potassium and act as a good source of natural antioxidants such as ascorbic acid, flavonoides, phenolics and carotenoids.[23–25] Ascorbic acid is very important element to improve the absorption of iron in human diet. Influence of planting density has significant influence for ascorbic acid content. The main plot treatment M_5 (40 x 20cm) recorded increased ascorbic acid content of 123.07mg/100g followed by the treatments M_3 (20 x 10cm) of 112.65mg/100g. The subplot treatment S_4 (humic acid 20kg/ha) registered the higher ascorbic acid content of 116.90mg/100g and followed by the treatments S_1 (FYM 25t/ha) and S_3 (Sheep manure25t/ha) of 114.84 and 113.73mg/100g respectively. The interaction effect of influence of spacing and organics were significant among the treatments. The treatment combination of M_5S_4 (spacing of 40 x 20cm with humic acid 20kg/ha) registered the higher ascorbic acid content of 133.63mg/100g and this treatment was on par with the treatment combination M_5S_3 (spacing of 40 x 20 cm with sheep manure 25t/ha) of 129.27mg/100g. The increase in ascorbic acid content in humic acid treated plants might be ascribed to better availability and uptake of required plant nutrients and also favourable conditions resulted by the applied organics, which helps in the synthesis of chlorophyll and enhanced ascorbic acid content. Increased ascorbic acid content due to application of FYM or organic manures was also reported by Petkov,[26] Chavan et al.,[27] & Shashidhara[28] in capsicum and Patil et al.,[29] & Sable et al.[30] in tomato. Influence of spacing was significant among the treatments for leaf crude fibre content. The main plot treatment M_5 (40 x 20cm) exhibited the higher crude fibre content of 13.00 per cent followed by the treatments M_3 (20 x 10cm) of 12.52 per cent.The subplot treatment S_4 (humic acid 20kg/ha) recorded the higher crude fibre content of 13.48 per cent and followed by the treatment S_3 (Sheep manure 25t/ha) of 13.03 per cent. The interaction effect of influence of spacing and organics were significant among the different treatments. The treatment combination of M_5S_4 (spacing of 40 x 20cm with humic acid 20kg/ha) recorded the maximum crude fibre content of 14.22 per cent and it was followed by the treatment M_1S_4 (spacing of 10 x 15cm with humicacid 20kg/ha) of 13.55 per cent. This may be attributed due to plants spaced at wider spacing get the advantage of better sunshine and optimum space for uptake of nutrients as compared to close spaced plants. The above results are similar to Kumar et al.,[11] in okra. Beta-arotene is the most potent precursor to viamin A. Supplementation of diets with both iron and Vitamin A may increase the iron status as measured by haemotological indices like haemoglobin and haemocrit.[31] Influence of spacing was significant among the treatments for β carotene content. The main plot treatment M_5 (40 x 20cm) recorded increased β carotene content of 14.46mg/100g followed by the treatments M_2 (15 x 15cm) and M_3 (20 x 10cm) of 13.67 and 13.38mg/100 g respectively. The subplot treatment S_4 (humic acid 20kg/ha) registered the highest β carotene content of 14.08 mg/100g followed by the treatment S_2 (vermicompost12.5t/ha) of 13.74mg/100g. The treatment S_2 (vermicompost 12.5t/ha) was on par with the treatments S_1 (FYM 25t/ha) and S_3 (Sheep manure25t/ha) of 13.73 and 13.53 mg/100g respectively. The interaction effect of influence of spacing and organics were significant among the treatments. The treatment combination of M_5S_4 (spacing of 40 x 20cm with humic acid 20kg/ha) had the increased β carotene content of 15.57mg/100 g and followed by the treatment M_5S_2 (spacing of 40 x 20cm with vermicompost 12.5 t/ha) of 15.06 mg/100g. Influence of spacing was significant effect among the various treatments for Fe content. The main plot treatment M_5 (40 x 20cm) resulted with the higher Fe content of 66.6 mg/100g followed by the treatments M_1 (10 x 15cm) of 65.9mg/100g followed by the treatment M_2 (15 x 15cm) of 64.20 mg/100g.The subplot treatment S_4 (Humic acid 20kg/ha) recorded the highest Fe content of 70.1 mg/100g followed by the treatment S_2 (vermicompost 12.5t/ha) of 69.30 mg/100g.

The interaction effect of influence of spacing and organics were significant among the different treatments. The treatment combination of M_5S_4 (spacing of 40 x 20cm with humic acid 20kg/ha) registered the higher Fe content of 96.8mg/100g and followed by the treatment M_4S_2 (spacing of 20 x 20cm with Vermicompost 12.5t/ha) of 86.20mg/100g (Figure 1). Increasing iron content in leaves, which might have attributed to improved synthesis of precursors of chlorophyll and enzymes such as catalase, peroxidase and cytochrome oxidase thereby resulting in marked increase of iron content in tomato.[32] It is well documented that humic acid not only increased the macro-nutrient contents, but also enhanced micro-nutrient contents of the plant organs. The study assumes that humic substances play a major critical role in plant nutrient uptake and growth and quality parameters in crop plants. Humic acid have a great potential to increase the performance, growth and mineral contents in plant. Humic acid may be put to good use as natural fertilizer for vegetable production in sustainable and ecological agricultural systems.[33] Similar results were reported in summer squash.[8] The important components of *Moringa* like calcium found to be suitable for exploitation by many developing regions of world where malnutrition is a major concern, especially for the children.[34] Influence of spacing was significant among the treatments for calcium content. The main plot treatment M_1 (10 x 15cm) recorded increased calcium content of 1843.2mg/100g followed by the treatments M_2 (15 x 15cm) and M_3 (20 x 10cm) of 1664.6 and 1597.0 mg/100 g respectively. The subplot treatment S_3 (Sheep manure 25t/ha) registered the highest calcium content of 1721.4mg/100g followed by the treatment S_1 (vermicompost12.5t/ha) of 1741.2mg/100g. The treatment S_2 (vermicompost 12.5t/ha) was on par with the treatments S_4 (FYM 25t/ha) of 1597.6 and 1570.6 mg/100g respectively. The interaction effect of influence of spacing and organics were significant among the treatments. The treatment combination of M_1S_4 (spacing of 10 x 15cm with humic acid 20kg/ha) had the increased calcium content of 2052mg/100 g and followed by the treatment M_1S_2 (spacing of 10 x 15 cm with vermicompost 12.5t/ha) of 2028mg/100g (Table 6). Thus, Dried Moringa leaves are available as a good source of Ca to farm animals or humans.[35,36] Influence of spacing was significant among the treatments for magnesium content. The main plot treatment M_1 (10 x 15cm) recorded increased calcium content of 313.2 mg/100 g followed by the treatments M_2 (15 x 15 cm) and M_3 (20 x 10cm) of 311.6 and 302.4 mg/100 g respectively. The subplot treatment S_4 (Humic acid 20kg/ha) registered the highest magnesium content of 339.2mg/100 g followed by the treatment S_2 (vermicompost12.5t/ha) of 316.4mg/100g. The interaction effect of influence of spacing and organics were significant among the treatments. The treatment combination of M_1S_4 (spacing of 10 x 15 cm with humic acid 20kg/ha) had the increased magnesium content of 400 mg/100 g and followed by the treatment M_2S_4 (spacing of 15 x 15cm with Humic acid 20kg/ha) of 366 mg/100g.

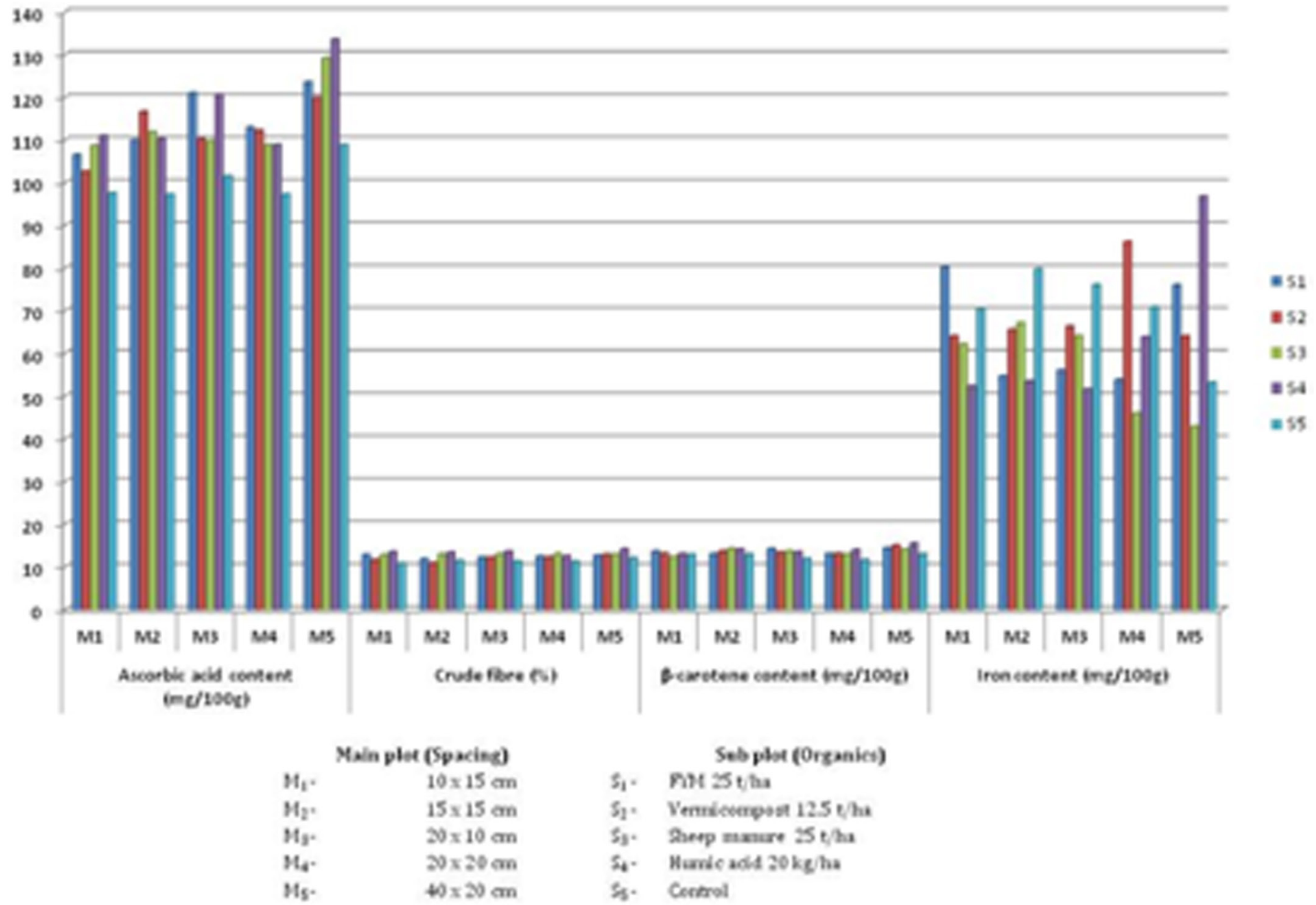

Figure 1 Influence of ultra high density planting and organics on ascorbic acid content (mg/100g,) crude fibre (%), β-carotene content (mg/100) and Iron content (mg/100g) in leaves of moringa cv.PKM-1.

Influence of spacing was significant among the treatments for manganese content. The main plot treatment M_1 (10 x 15cm) recorded increased manganese content of 4.42mg/100 g followed by the treatments M_5 (40 x 20 cm) and M_2 (15 x 15cm) of 4.41 and 4.37mg/100g respectively. The subplot treatment S_4 (Humic acid 20kg/ha) registered the highest manganese content of 5.44 mg/100 g followed by the treatment S_1 (FYM 25 t/ha) of 4.54 mg/100g. The interaction effect of influence of spacing and organics were significant among the treatments. The treatment combination of M_4S_4 (spacing of 20 x 20 cm with humic acid 20 kg/ha) had the increased manganese content of 6.12mg/100g and followed by the treatment M_4S_1 (spacing of 20 x 20cm with FYM 25 t/ha) of 5.92 mg/100g. The presence of zinc in high amounts is of special interest in view of the importance of the inclusion of Zn in the diet of animals and humans. Influence of spacing was significant among the treatments for zinc content. The main plot treatment M_1 (10 x 15cm) recorded increased zinc content of 4.01mg/100 g followed by the treatments M_2 (15 x 15 cm) and M_3 (20 x 10cm) of 3.12 and 3.02mg/100 g respectively. The subplot treatment S_1 (FYM 25 t/ha) registered the highest zinc content of 3.79mg/100 g followed by the treatment S_4 (Humic acid 20kg/ha) of 3.47mg/100g. The interaction effect of influence of spacing and organics were significant among the treatments. The treatment combination of M_1S_1 (spacing of 10 x 15cm with FYM 25t/ha) had the increased zinc content of 7.14 mg/100 g and followed by the treatment M_1S_4 (spacing of 10 x 15cm with Humic acid 20 kg/ha) of 4.40mg/100g (Figure 2).

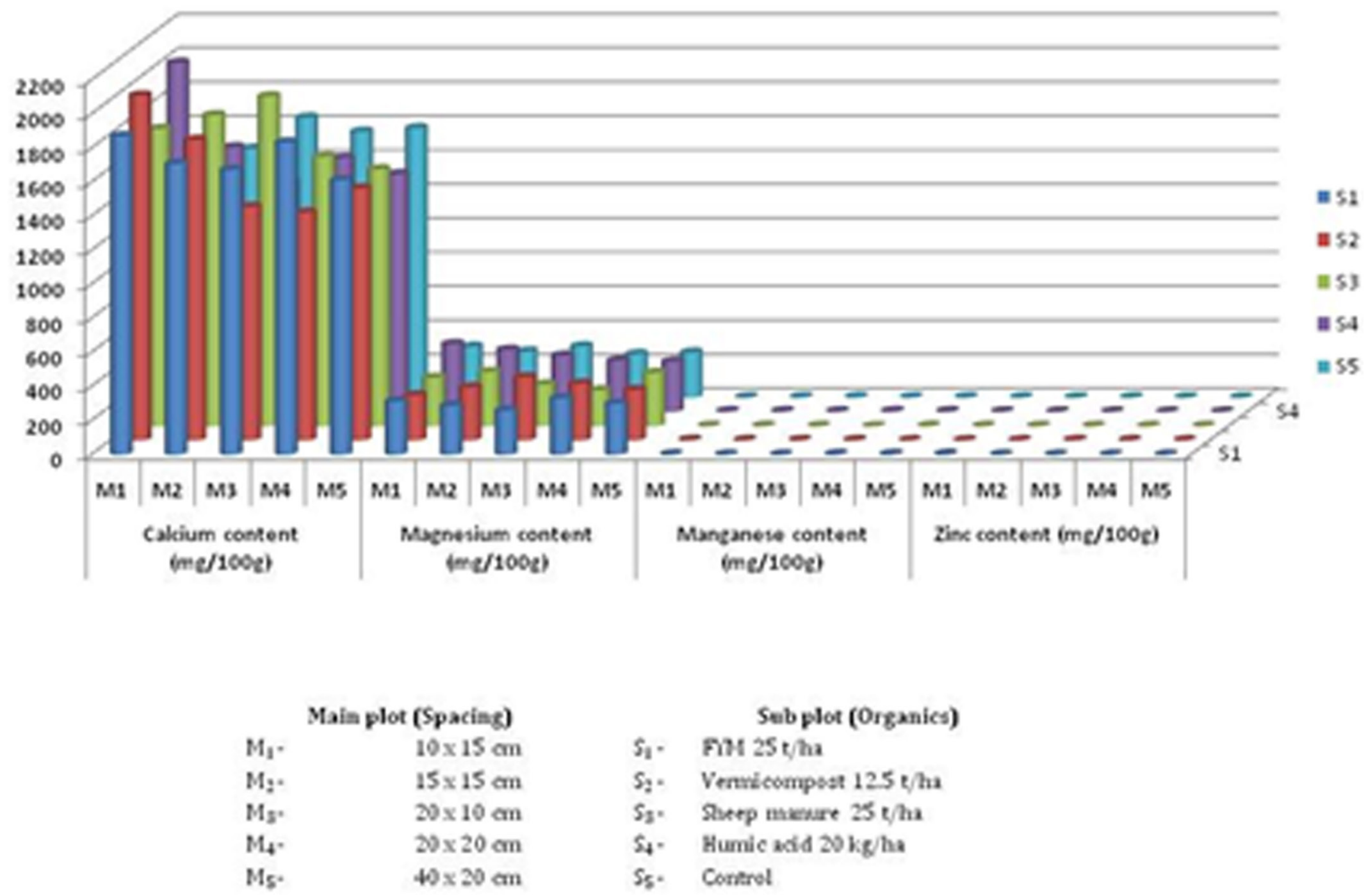

Figure 2 Influence of ultra high density planting and organic on calcium content (mg/100g,) magnesium content (mg/100g,) & Zinc content (mg/100g) in leaves of moringa cv.PKM-1.

Conclusion

Spacing is very important factor in vegetable crop production. Proper spacing between plants is required for better growth and higher yield. In this study, the optimum plant density of 40 x 20 cm is to be maintained for achieving the maximum production and productivity invariably in all crops. Likewise, the application of different organic manure in this study the humic acid plays a major role to increase the leaf yiels and quality characters of moringa. Humic acid (HA), the major component of soil organic matter, are the subject of study in various areas of agriculture, such as soil chemistry, fertility, plant physiology as well as environmental sciences, because of the multiple roles played by these materials that can greatly benefit plant growth. The beneficial effects of HA on plant growth may be related to their indirect (increase of fertilizer efficiency or reducing soil compaction), or direct (improvement of the overall plant biomass) effects. The dried moringa leaves is a good source of important nutrients and thus, the plant might be explored as a viable supplement in both animal and human food. High nutritional content of ascorbic acid, beta-carotene, crude fibre, iron, calcium, magnesium, manganese and zinc content were found in the dried leaves are important nutritional indicators of the usefulness of the plants as a likely feed resource. Drying the assists to concentrate the nutrients, facilitate conservation and consumption, as such, it can be transported to areas where it is not cultivated. It is suggested that moringa should be consumed in the powder form. Results imply that β-carotene from drumstick leaves was effective in overcoming vitamin A deficiency. It was therefore concluded that in the developing countries like India, sources of vitamin A such as drumstick leaves are valuable in overcoming the problem of vitamin A deficiency.

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Conflicts of interest

As the case desired by you – Individual does not interested in spending by own.

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