



## Influence of planting density on vegetative morphomatrix, yield and economics of drumstick (*Moringa oleifera*) cv. PKM 1 under rainfed condition of semi-arid ecosystem

RAJ KUMAR<sup>1</sup>, KANAK LATA<sup>2</sup>, B S KHADDA<sup>3</sup>, J K JADAV<sup>4</sup>, A K RAI<sup>5</sup> and S KHAJURIA<sup>6</sup>

ICAR-Krishi Vigyan Kendra-Panchmahals, ICAR-CIAH, Godhra-Vadodara Highway, Vejalpur, Gujarat 389 340

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### ABSTRACT

A field study was carried on drumstick (*Moringa oleifera* Lam) cv. PKM 1, to evaluate the effect of different planting density on vegetative morphomatrix, yield and economics under semi-arid rainfed conditions of western India. This experiment was laid out at the Krishi Vigyan Kendra-Panchmahal (ICAR-CIAH), Godhra, Gujarat. The objective of the study was to determine the best plant spacing for increased revenue. Among the evaluated different planting distance, the highest plant height was recorded in T<sub>5</sub> (2m×2m), having the maximum number of plant per unit area. However, the highest stem girth, plant spread (East-West) and (North-South), was recorded in T<sub>1</sub>. However, the highest yield per plant recorded with 6m×4m distance, but on per unit area basis, T<sub>5</sub> (2m×2m) exhibited almost triple the yield over planting distance (6m×4m). The plant densities had considerable influence on flower emergence, flowering period, number of panicles/plant, number of flowers/panicle, % flower, number of fruits/panicle at harvest, number of fruits/plant at harvest, fruit weight, fruit length (cm), fruit girth (cm). The highest net returns (₹ 247 081.45) and cost benefit ratio (3.67) was computed in T<sub>5</sub> followed by T<sub>4</sub> (₹ 191 950.40 and 3.52), T<sub>2</sub> (₹ 147 359.30 and 3.33), T<sub>3</sub> (Rs. 99 677.40 and 3.05) and T<sub>1</sub> (₹ 72 169.10 and 2.87). Based on the observations, it can be concluded that the closer planting (2m×2m) had better productivity and income than the under spacing (6m×4m) per unit area under the rainfed condition of semi-arid ecosystem.

**Key words:** Economics, *Moringa oleifera*, Planting distance, Rainfed, Yield

Drumstick (*Moringa oleifera* Lam), a multi-purpose tree (MPTS) has gained a lot of popularity because of its many varied uses, viz. medicinal applications, industrial, sanitary and nutritional. It has very high nutritional properties that would be useful as a food supplement, especially in those marginalized communities. Besides, its nutritional and medicinal applications, drumstick is very useful as an alley crop in the agro-forestry industry (Dash and Gupta 2009) to reduce soil erosion and improve soil conservation. According to further studies, it can be used as an important browser for goats in the drier ecological areas of the world, being are important sources of meat, milk, manure, income etc in these climatically marginalized households (Sereshine and Marapana 2011). It is also an effective water clarifier using the seed, thus providing millions of people with clean drinking water along the Nile River (Yarahmadi *et al.* 2009). In view of these diversified significant applications and its impact on improved livelihoods and health. The production under a range of climatic and edaphic conditions, various management regimes and different variables such

as establishment methods, plant spacing, plant density, harvesting frequency and intensity, indicated that the values attained varied (Gutteridge and MacArthur 1998).

The planting density play important role to increase yield and net return per unit area, making it economically more viable. The information regarding the suitable planting distance of drumstick are scarce productivity under dryland conditions. High density planting with combination of planting systems has been successfully demonstrated in mango (Singh *et al.* 2001), litchi (Rathore *et al.* 2003), aonla (Singh *et al.* 2007) and guava (Mahajan *et al.* 2005). Considering the condition, manipulation in the spacing seems to be an important tool to obtain higher production, productivity and net return. Keeping these facts in view, an attempt was made to see the potential of different planting distance on growth, yield and economics of drumstick cultivation under semi-arid ecosystem of western India.

### MATERIALS AND METHODS

The field experiment was conducted at Krishi Vigyan Kendra-Panchmahal (CIAH), Godhra, Gujarat during 2011 and 2015. The location of the experiment site is 113 m above msl on latitude 22° 41' 38" N and longitude 73° 33' 22" E. The climate of the area is characterised by hot semi-arid climate and falls under hyperthermic soil regime.

<sup>1</sup>Subject Matter Specialist (e mail: rajhortches@gmail.com),  
<sup>2</sup>kanak1966@redif.com, <sup>3</sup>SMS (e mail: khadda74@gmail.com),  
<sup>4</sup>SMS (e mail: jksmskvk@gmail.com), <sup>5</sup>SMS (e mail: ajayrai74@gmail.com), <sup>6</sup>SMS (e mail: shaktikhajuria@gmail.com).

The annual rainfall is mainly confined to three months (July-September) and actual mean precipitation is about 650 mm, and the total number of rainy days about 27. The mean annual maximum and minimum temperatures vary from 42 - 47<sup>o</sup> C (May) and 6 - 9<sup>o</sup> C (January), respectively. The soil type of study area was clay-to-clay loam with available N (121.22-148.40 kg/ha), P (6.45 kg/ha) and K (152.60 kg/ha) and organic carbon (0.33%), while EC and pH, bulk density and hydraulic conductivity of soil were 0.13 dS/m, 7.85, (1.42 g/cc) and (0.26 cm/hr) respectively. The soil depth ranges from 0.75-1.25 m derived from mixed alluvial basalt, quartzite, granite and layers of limestone.

The experiment was started during *kharif* season 2011. The genuine seed of drumstick cv. PKM 1 was procured from Tamil Nadu Agricultural University, Periyakulam (Andhra Pradesh). The healthy seedlings were raised and transplanted to the field in five planting density as treatments, viz. T<sub>1</sub> (6m×4m), T<sub>2</sub> (4m×4 m), T<sub>3</sub> (6m×2m), T<sub>4</sub> (4m×2m) and T<sub>5</sub> (2m×2m) by accommodating 417, 625, 833, 1250 and 2500 plants/ha, respectively and 6, 9,12,18 and 36m plants/plot (size 144m<sup>2</sup> each plot). The plot size for each treatment was 12m×12m and replicated four times. The data were statistically analyzed as per method given by Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

### Plant growth parameters

Vegetative variables drumstick showed significant difference in response to higher planting density. The plants were planted at wide distance were more vigorous as comparison to closer distances. Plant height at first branch and panicle emergence ranged from 43.85 cm - 48.15 cm and 86.22-93.66 cm, being the maximum in T<sub>5</sub> at 2m×2m and the minimum T<sub>1</sub> at 6m×4m distance (Table 1). In general, plants grown under wide spacing (6m×4 m) showed more vegetative growth than those grown under narrow spacing. The maximum plant height was recorded in T<sub>5</sub> (5.91m) followed T<sub>4</sub> (5.57 m), T<sub>3</sub> (5.33m), T<sub>2</sub> (4.93m) and it was minimum in T<sub>1</sub> (4.72m). The range of stem girth was recorded 37.63-63.12 cm, the maximum was observed in T<sub>1</sub> followed by T<sub>2</sub> (54.33cm), T<sub>3</sub> (46.15 cm), T<sub>4</sub> (42.82 cm) and the same was minimum in T<sub>5</sub>. The maximum

plant spread (East-West) 4.75m and (North-South) 4.32m was recorded in T<sub>1</sub> followed by T<sub>2</sub> (4.22m and 3.93m), T<sub>3</sub> (4.05m and 3.82m), T<sub>4</sub> (3.88m and 3.66m) and the same was minimum in T<sub>5</sub> (2.86m and 2.72m). The maximum number of primary (12.88) and secondary branches (18.24) was noted in T<sub>1</sub> followed by T<sub>2</sub> (12.45 and 17.22), T<sub>3</sub> (8.16 and 12.55), T<sub>4</sub> (6.65 and 9.88) and minimum in T<sub>5</sub> (5.25 and 8.62). It is generally expected that in closer spacing plants will have tendency to grow tall and the plants in wider distance had optimum space for lateral growth. It is clear from the study that the increasing plant population per unit area significantly increase in tree height may be due to the competition for light and limitation in availability of spaces for spreading of branches. Vigorous growth in the plants of wider spacing may be due to increase in the availability of light resulting in higher rate of photosynthesis and ultimately more carbohydrate reserves. These results are in accordance with the findings of earlier workers in drumstick (Goss 2012), in anola (Singh *et al.* 2014), in guava (Chundawat *et al.* 1992 and Mahajan *et al.* 2005) in tropical fruits (Bose *et al.* 1992) and in *Vernonia hymenolipis* (Mih *et al.* 2008).

### Flowering attributes

The data presented in Table 2 reveals that the panicle emergence and period of flowering was significantly affected by planting densities. The panicle emergence was recorded during I<sup>st</sup> to III<sup>rd</sup> week of September, it was earliest in T<sub>4</sub> and T<sub>5</sub> (I<sup>st</sup> week of September) followed by T<sub>2</sub> and T<sub>3</sub> (II<sup>nd</sup> week of September) and T<sub>1</sub> (III<sup>rd</sup> week of September). This may be due to the plants at closer distance emerge flowers early as comparison to wider distance. The flowering period in T<sub>1</sub> was recorded during III<sup>rd</sup> of September -II<sup>nd</sup> week of October, in T<sub>2</sub> (II<sup>nd</sup> week of September-II<sup>nd</sup> week of October), in T<sub>3</sub> (II<sup>nd</sup>-IV<sup>th</sup> week of September), in T<sub>4</sub> and T<sub>5</sub> (I<sup>st</sup>-III<sup>rd</sup> week of September). The flowering period under closer distance are long as comparison to wider distance plantation due to more favourable environment in plants planted at closer distance. The similar findings are also reported in aonla Singh *et al.* (2011) and Singh *et al.* (2014). The number of panicles and flowers/panicle was significantly affected by plant densities. The maximum number of panicles 204.21 per plant was recorded in T<sub>1</sub> followed by T<sub>2</sub> (192.56), T<sub>3</sub> (188.36), T<sub>4</sub> (173.62) and it was minimum in T<sub>5</sub> (162.43).

Table 1 Effect of plant spacing on growth parameters of drumstick cv. PKM 1

Treatment	Plant height at I <sup>st</sup> branch emergence	Plant height at I <sup>st</sup> panicle emergence	Plant height after 4 year (m.)	No of primary branches	No of secondary branches	Stem girth (cm)	Plant spread(m)	
	(cm)	(cm)					E-W	E-W
T <sub>1</sub>	33.85	86.22	4.72	12.88	18.24	62.12	4.75	4.32
T <sub>2</sub>	34.66	87.52	4.93	12.45	17.22	54.33	4.22	3.93
T <sub>3</sub>	36.55	88.25	5.33	8.16	12.55	46.15	4.05	3.72
T <sub>4</sub>	37.20	90.66	5.57	6.65	9.88	42.82	3.88	3.66
T <sub>5</sub>	38.15	93.66	5.91	5.25	8.62	37.63	2.83	2.72
SEm±	0.283	0.256	0.047	0.078	0.166	0.302	0.302	0.022
CV	1.572	0.575	1.796	1.721	2.502	1.244	1.244	1.242
CD (P = 0.05)	0.874	0.790	0.146	0.240	0.514	0.932	0.932	0.070

Table 2 Effect of plant spacing on flowering parameters of drumstick cv. PKM-1

Treatment	Panicle emergence	Flowering period	No of panicles/plant	No of flowers/panicle
T <sub>1</sub>	III <sup>rd</sup> week of September	III <sup>rd</sup> of September -II <sup>nd</sup> week of October	204.21	82.35
T <sub>2</sub>	II <sup>nd</sup> week of September	II <sup>nd</sup> of September-II <sup>nd</sup> week of October	192.56	76.33
T <sub>3</sub>	II <sup>nd</sup> week of September	II <sup>nd</sup> -IV <sup>th</sup> week of September	188.36	71.22
T <sub>4</sub>	I <sup>st</sup> week of September	I <sup>st</sup> -III <sup>rd</sup> week of September	173.62	68.76
T <sub>5</sub>	I <sup>st</sup> week of September	I <sup>st</sup> -III <sup>rd</sup> week of September	162.43	60.32
SEm±			0.431	0.455
CV			0.468	1.260
CD (P = 0.05)			1.330	1.402

The range of flowers/panicle 60.32-82.35 was recorded but the maximum in T<sub>1</sub> followed by T<sub>2</sub> (76.33), T<sub>3</sub> (71.22), T<sub>4</sub> (68.76) and minimum in T<sub>1</sub> (162.43). This may be due to more favourable environment in high density planting as comparison to wider densities. The numbers of panicles are significantly affected by vigour and canopy of plant, hence the vigour and canopy are higher in the plants planted at wider densities. The more or less similar findings are also reported by Singh *et al.* (2007) in aonla.

#### Yield and yield attributing characteristics

The yield and yield attributing characters are significantly influenced by different planting distances. The number of fruits/panicle at the time of harvesting is main contributing factor of yield, it was ranged from 1.12 to 1.28 fruits/panicle, the minimum (1.12) was recorded in T<sub>5</sub> and maximum (1.28) T<sub>1</sub> and rest treatments have least difference T<sub>2</sub> (1.24), T<sub>3</sub> (1.21) and T<sub>4</sub> (1.18). There is great difference among the treatments for number of fruits/plant at harvest, the maximum (196.39) was recorded in T<sub>1</sub> followed by T<sub>2</sub> (181.77), T<sub>3</sub> (132.92), T<sub>4</sub> (92.87), and it was

minimum (58.92) in T<sub>5</sub>. This may be due to wider spacing plants had comparatively higher vegetation, resulted into more area under canopy. Such an increase in number of fruits/plant has been demonstrated in guava by Chundawat *et al.* (1992), in aonla Singh *et al.* (2007), in mango Ram and Sirohi (1991), in satsuma mandarin Tachibana (1990) and in guava Kumar and Singh (2000).

Perusal of data presented in Table 3 revealed that the maximum fruit weight (143.55), length (144.22) and girth (5.23cm) were recorded in T<sub>1</sub> planted at wider distance followed by T<sub>2</sub> (143.48g, 141.25cm, 5.15cm), T<sub>3</sub> (142.22g, 140.36cm, 4.96cm), T<sub>4</sub> (140.25g, 137.54cm and 4.91cm) and T<sub>1</sub> (138.34, 136.88 cm and 4.88 cm respectively. This may be due to the tree with bigger vegetative dimension normally giving larger number of fruits/tree. The present findings are in close conformity with the results reported by Anbu *et al.* (2001) in mango, Singh *et al.* (2011) in aonla and Raja *et al.* (2013) in drumstick.

Yield among planting density ranged between 14.46 to 22.72 kg/plant, being the maximum in T<sub>1</sub> (22.72 kg/plant) followed by T<sub>2</sub> (21.43), T<sub>3</sub> (20.19), T<sub>4</sub> (18.27) and it was minimum in T<sub>5</sub> (14.46). The highest yield (q/ha) (378.55) was recorded T<sub>5</sub> followed by T<sub>4</sub> (226.33), T<sub>2</sub> (177.87), T<sub>3</sub> (125.15) and it was minimum in T<sub>1</sub> (93.57) having wider distance (6m×4m). This is due to higher plant population per unit area in T<sub>5</sub> accommodate more (2500) plants/ha followed by T<sub>4</sub> (625), T<sub>3</sub> (833), T<sub>2</sub> (1250) T<sub>1</sub> (417). This is clear from the present study that the yield/plant were significantly higher in low plant population than high density plantation, but the total yield is higher in closer distance than higher densities. The results of the present study are in accordance as per reported by Raja *et al.* (2013) and Mih *et al.* (2008) in drumstick, Ram and Sirohi (1991) and Singh *et al.* (2001) in mango, Bal and Dhaliwal (2003) in guava, Singh *et al.* (2011) and Singh *et al.* (2014) in aonla.

#### Economics of various treatments

The data of economics of various drumstick planting densities are presented in Table 4. The maximum cost of cultivation (₹ 105 480.30/ha) was recorded in T<sub>5</sub> followed by T<sub>4</sub> (₹ 76 250.65/ha), T<sub>2</sub> (₹ 63 345.55/ha), T<sub>3</sub> (₹ 48 625.35/ha) and minimum (₹ 38 640.25/ha) in T<sub>1</sub>. In the present study the highest cost of cultivation was recorded

Table 3 Effect of plant spacing on yield attributing parameters of drumstick cv. PKM-1

Treatment	No. of fruits/panicle at harvest	No. of fruits/plant at harvest	Fruit weight (g.)	Fruit length (cm)	Fruit girth (cm)	Yield/plant (kg)	Yield/ha (q)
T <sub>1</sub>	1.28	196.39	144.55	144.22	5.23	22.72	93.57
T <sub>2</sub>	1.24	181.77	143.48	141.25	5.15	21.43	177.87
T <sub>3</sub>	1.21	132.92	142.22	140.36	4.96	20.19	125.15
T <sub>4</sub>	1.18	92.87	140.25	136.54	4.91	18.27	226.33
T <sub>5</sub>	1.12	58.92	138.34	135.88	4.88	14.46	378.55
SEm±	0.004	0.212	0.337	0.243	0.017	0.115	0.514
CV	0.803	0.320	0.476	0.348	0.707	1.184	0.513
CD (P = 0.05)	0.014	0.654	1.041	0.750	0.054	0.354	1.585

Table 4 Economies of various plant densities of drumstick cultivation

Treatment	Gross return/ha	Cost of cultivation/ha	Net return/ha	Cost benefit ratio
T <sub>1</sub>	110809.35	38640.25	72169.10	2.87
T <sub>2</sub>	210704.85	63345.55	147359.30	3.33
T <sub>3</sub>	148302.75	48625.35	99677.40	3.05
T <sub>4</sub>	268201.05	76250.65	191950.40	3.52
T <sub>5</sub>	339561.75	92480.3	247081.45	3.67

higher in T<sub>5</sub> due to more number of plants per unit area accommodate 2 500 as compared to T<sub>1</sub> (417 plants/ha). The maximum gross returns (₹ 448 581.75/ha), net returns (₹ 343 101.45/ha) and highest B: C ratio (4.25) was recorded in the treatment T<sub>5</sub> (2m×2m distance) followed by T<sub>4</sub> (₹ 268 201.05, 191 950.40 and B: C ratio 3.52), T<sub>2</sub> (₹ 210 704.85, 147 359.30 and 3.33), T<sub>3</sub> (₹ 148 302.75, 99 677.40 and 3.05) and T<sub>1</sub> (₹ 110 809.35, 72 169.10 and 2.87), respectively. The maximum gross returns may be due to higher yield per unit area. Similar results were reported by Patel *et al.* (2009a) in acid lime and Singh *et al.* (2007) in aonla.

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