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Enhancing the Productivity of Annual Moringa (*Moringa oleifera* Lam.) var. PKM 1 through High Density Planting and Fertigation Techniques

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Experiments on high density planting and fertigation in annual moringa PKM 1 were conducted at Horticultural College and Research Institute, Periyakulam during 2008 – 2012. Among the twenty four treatment combinations evaluated, adopting high density planting system with a spacing of 1.5 × 1.0 m with two plants per hill and maintaining the plant population of 13,333 ha^{-1}along with application of 135:23:45 g of NPK pit $^{-1}$ recorded the highest yield of 114.25 tonnes ha^{-1}and BC ratio of 4.96 when compared to control which recorded the yield of 28.63 tonnes ha^{-1}and BC ratio of 1.72.

Key words: Annual Moringa, High density planting, Fertigation and Productivity.

Moringa (*Moringa oleifera* Lam.) commonly referred to as drumstick, is an indigenous plant now valued for neutraceutical properties of pods and leaves. It is a most versatile tree with rich horticultural potential in India. Fuglie (2003) has established the nutritive value of moringa and recommended moringa to address malnutrition in many of the African countries. Since last decade, efforts have been made to develop new cultivars and production technologies, which resulted in appreciable increase in the area and production of moringa in India. Moringa is cultivated in an area of 38,000 ha and the production is 2.20 million tonnes. Andhra Pradesh, Karnataka and Tamil Nadu are the leading moringa producing states in India and in Tamil Nadu, moringa is cultivated in 7,408 ha with the production of 4.20 lakh tonnes (Rajendran and Prahadeeswaran, 2014).

Any information of moringa is highly valuable since the crop is considered as incredible to mankind in terms of cultivation, nutrition, prevention of diseases and industrial application (Caceres, *et.al*., 1992). Hence, the present study has been contemplated with the objective of standardization of high density planting and fertigation to enhance yield and hence returns in annual moringa var. PKM 1.

Materials and Methods

The present study was conducted at the Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu for four years during 2008-2012. Geographically, the College is situated at 10'N latitude with an elevation of 300 m above MSL. The experiment was conducted in a split plot design replicated twice.

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The main plot treatments consisted of different high density planting systems of planting *viz.,* 2.5 × 2.5 m, 2.5 × 2.0 m, 2.5 × 1.5 m and 1.5 × 1.0 m planted with one plant and two plants per hill and the subplot treatments included graded levels of fertilizer application at three levels *viz*., recommended dose of fertilizer (RDF) - 90: 15: 30 g, 125 % of RDF - 112.5 : 19 : 38 g and 150 % of RDF - 135 : 23 : 45 g of NPK pit $^{-1}$. The trial was conducted for three crops *viz*., main crop, first ratoon and second ratoon crop.

Growth characters *viz*., plant height, number of branches, days to 50 per cent flowering, number of flowering clusters per plant and number of flowers per cluster were recorded at monthly intervals. The yield attributes *viz*., number of pods per tree, weight of pod, length and girth of pod and pod yield per tree, per plot and per hectare yield were also recorded. The BC ratio was worked out for the different treatments.

Result and Discussion

Growth parameters

Growth and development of moringa plants was highly influenced by the imposed levels of planting density and fertigation schedule. The quantitative characters *viz*., plant height and number of branches showed significant differences among the treatments. The highest plant height was recorded in the treatment M_8S_3 (1.5 × 1.0 m spacing with two plants per hill along with 135: 23:45 g of NPK per pit (150%)) in the main, first ratoon and second ratoon crops (3.48, 4.65 and 4.84 m, respectively) (Table 3). This treatment was found to be on par with M_1 S_3 (2.5 × 2.5 m with one plant per hill with 135: 23:45 g of NPK per pit) (3.23, 4.76 and 4.96 m, respectively). The higher plant height observed in the high density planting may be due to the competition among plants for getting more sunlight and hence the plants tend

Table 1. Fertigation schedule

Interval	Fertilizers	Frequency	Quantity (kg ha^{-1})		
			S_1	S_2	S_3
Stage I* - 90 to 145 DAS	Urea	11	11.00	13.50	16.50
	Murate of Potash	11	0.89	1.13	1.34
Stage II* - 146 to 190 DAS	Urea	9	7.50	9.50	11.50
	Murate of Potash	9	2.86	3.63	4.30
Stage III* - 191-235 DAS	Urea	9	4.00	5.00	6.00
	Murate of Potash	9	1.46	1.85	2.20

*once in 5 days

to grow taller. The plant height under high density planting system can either decrease as reported by Ram & Sirohi (1991), or increase, as observed by Nath *et al.* (2007) in mango. Therefore, the effect of planting density on plant height seems to be variable.

Table 2 . Treatment details

Treatment combination	Planting density		Fertigation levels (g of NPK pit^{-1})
	Spacings (m)	No. of plants hill^{-1}	
$M_1S_{1\,(Control)}$	2.5 ×2.5	1	90 : 15 :30
M_1S_2	2.5 ×2.5	1	112.5 : 19 :38
M_1S_3	2.5 ×2.5	1	135 : 23 :45
M_2S_1	2.5 ×2.5	2	90 : 15 :30
M_2S_2	2.5 ×2.5	2	112.5 : 19 :38
M_2S_3	2.5 ×2.5	2	135 : 23 :45
M_3S_1	2.5 ×2.0	1	90 : 15 :30
M_3S_2	2.5 ×2.0	1	112.5 : 19 :38
M_3S_3	2.5 ×2.0	1	135 : 23 :45
M_4S_1	2.5 ×2.0	2	90 : 15 :30
M_4S_2	2.5 ×2.5	2	112.5 : 19 :38
M_4S_3	2.5 ×2.0	2	135 : 23 :45
M_5S_1	2.5 ×1.5	1	90 : 15 :30
M_5S_2	2.5 ×1.5	1	112.5 : 19 :38
M_5S_3	2.5 ×1.5	1	135 : 23 :45
M_6S_1	2.5 ×1.5	2	90 : 15 :30
M_6S_2	2.5 ×1.5	2	112.5 : 19 :38
M_6S_3	1.5 ×1.5	2	135 : 23 :45
M_7S_1	1.5×1.0	1	90 : 15 :30
M_7S_2	1.5×1.0	1	112.5 : 19 :38
M_7S_3	1.5×1.0	1	135 : 23 :45
M_8S_1	1.5×1.0	2	90 : 15 :30
M_8S_2	1.5×1.0	2	112.5 : 19 :38
M_8S_3	1.5×1.0	2	135 : 23 :45

The number of branches was found to be more in the treatment M_1S_3(6.0, 3.30 and 5.70 respectively in all the seasons). This might be due to more nutrients available to individual plants, which would have facilitated the production of more number of branches. Whereas in higher plant density, the number of branches was found to be comparatively low. Berrill (1963) reported that in banana, increased plant girth and number of suckers per plant were observed due to the decrease in plant density and indicated that the plants had faced less competition for moisture and sunlight in wider spacing.

Flowering and yield attributes

The mean days taken for 50 per cent flowering during all the three seasons were found to be lesser in the treatment M_1 S_2(2.5 × 2.5 m with one plant per hill and 112.5: 19:38 g NPK per pit (125%)) *i.e* 143 days: followed by M_1 S_3 (145.67), whereas, it was higher in the treatment M_8 S_2 (165). Under normal planting density, with higher dose of nutrients, the days taken for flowering is lesser. This might be due to the fact that the faster growth and accumulation of more nutrients in these treatments would have resulted in easy and early conversion of vegetative to reproductive phase. De Sousa *et al*. (2012) also opined that under higher planting densities there was a reduction in number and percentage of flowering shoots in mango. Plants grown under lower planting density produced flowers in all quadrants of the canopy, while those grown under increasing planting density produced flowers only in the two quadrants of the canopy between the rows (Table 4).

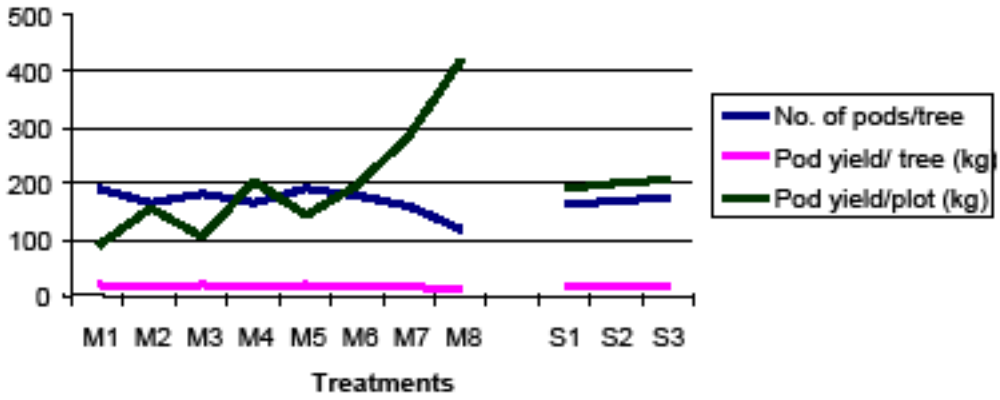
More number of pods per tree (172, 271 and 161 respectively) was recorded in the treatment M_1S_3 - 2.5 × 2.5 m with one plant per hill with 135: 23:45 g of NPK/pit (150%) during main, first ratoon and second ratoon crops respectively. In M_8 S_1 the number of pods per tree was found to be the least *i.e.* 98, 170, 75 per tree for the three crops respectively and the plant population is highest 13,333/ha. More number of pods per tree under normal planting system and less number of pods per tree under high density planting system might be due to accumulation of more food reserve in the normal planting system and competition for food under high density planting system. Similar results were obtained by Policarpo *et al.* (2006) in pear. The length of pod in the main season was found

Table 3. Effect of high density planting and fertigation on growth characters of annual moringa PKM 1

Treatments	Population	Plant height (m)				Number of branches			
		Main crop	First ratoon	Second ratoon	Mean	Main crop	First ratoon	Second ratoon	Mean
M_1S_1	1600	2.86	3.59	4.08	3.51	5.00	3.12	5.12	4.41
M_1S_2	1600	3.35	3.88	4.17	3.80	4.00	3.22	5.22	4.15
M_1S_3	1600	3.23	4.76	4.96	4.32	6.00	3.30	5.70	5.00
M_2S_1	3200	2.82	4.15	3.65	3.54	4.00	2.45	4.45	3.63
M_2S_2	3200	3.67	4.53	3.75	3.98	5.00	3.58	4.58	4.39
M_2S_3	3200	3.13	4.72	3.93	3.93	4.00	3.64	5.64	4.43
M_3S_1	2000	2.74	3.66	3.47	3.29	4.66	2.89	4.89	4.15
M_3S_2	2000	3.23	4.12	4.76	4.04	6.00	2.69	4.69	4.46
M_3S_3	2000	3.22	3.37	3.90	3.50	3.33	2.78	4.78	3.63
M_4S_1	4000	2.93	3.80	3.80	3.51	4.00	2.98	4.98	3.99
M_4S_2	4000	3.26	3.48	3.92	3.55	5.00	2.78	4.78	4.19

M_4S_3	4000	3.03	4.52	4.02	3.86	3.66	3.12	4.12	3.63
M_5S_1	2666	2.72	4.68	3.85	3.75	3.33	2.25	4.25	3.28
M_5S_2	2666	2.63	3.75	3.92	3.43	4.66	2.98	4.98	4.21
M_5S_3	2666	3.28	3.82	4.20	3.77	4.26	3.31	5.31	4.29
M_6S_1	4000	2.79	3.78	3.98	3.52	4.00	3.32	4.32	3.88
M_6S_2	4000	2.80	3.77	4.21	3.59	4.33	3.35	4.35	4.01
M_6S_3	4000	3.29	4.20	2.30	3.26	4.66	3.45	5.45	4.52
M_7S_1	6666	3.28	4.09	4.10	3.82	6.00	3.56	4.56	4.71
M_7S_2	6666	2.72	4.30	4.20	3.74	4.66	3.56	4.76	4.33
M_7S_3	6666	3.00	4.68	4.25	3.98	5.66	3.45	4.95	4.69
M_8S_1	13333	3.28	4.03	4.12	3.81	3.66	3.45	4.45	3.85
M_8S_2	13333	2.60	4.55	4.27	3.81	4.00	3.65	4.65	4.10
M_8S_3	13333	3.48	4.65	4.84	4.32	5.33	3.80	4.80	4.64
M SEd	--	0.82	0.95	1.20	1.00	8.49	0.72	0.98	3.40
CD		1.64	1.82	2.40	1.97	20.08	1.50	NS	7.20
S SEd	--	0.48	0.45	0.72	0.57	2.12	1.10	0.64	1.27
CD		1.02	0.90	1.35	1.10	4.51	2.20	NS	2.25
M at S SEd	--	0.56	1.12	0.92	0.87	9.81	1.30	0.72	5.57
CD		NS	2.22	1.79	2.00	22.60	2.60	1.44	11.14
S at M SEd	--	0.62	0.98	0.87	0.79	6.02	0.90	0.69	2.54
CD		NS	1.90	1.95	1.92	12.76	1.80	1.40	5.08

Fig. 1. Effect of high density planting and fertigation on yield attributes in moringa var. PKM 1



M_1	2.5 X 2.5 m spacing with one plant / hill
M_2	2.5 X2.5 m spacing with two plant / hill
M_3	2.5 X 2.0 m spacing with one plant / hill
M_4	2.5 X2.0 m spacing with two plant / hill
M_5	2.5 X 1.5 m spacing with one plant / hill
M_6	2.5 X1.5 m spacing with two plant / hill
M_7	1.5 X 1.0 m spacing with one plant / hill
M_8	1.5 X 1.0 m spacing with two plant / hill
S_1	Recommended dose of fertilizer(RDF) -90 : 15 :30g of NPK pit^{-1}
S_2	125 % increased dose of RDF - 112.5 : 19 :38 of NPK pit^{-1}
S_3	150 % increased dose of RDF - 135 : 23 :45 of NPK pit^{-1}

to be higher in the treatment M_3S_3 (74.20 cm), but in the first ratoon crop it was more in M_1S_1 (75.4 cm) and in the second ratoon crop the length of pod was higher in the treatment M_1S_3 (75.0 cm).

The weight of pod showed significant difference among the treatments and the highest weight of pod was recorded in the treatment M_1 S_3 (110, 129.52 and 121.52 g respectively in main, first ratoon and second ratoon crops respectively). This might be due to the availability of enhanced nutrients under normal density conditions. The weight of pod was found to be lesser in the high density planting. Similar result of higher bunch weight in banana was observed by Chundawat *et al*., (1983). This might be due to the fact that in wider spacing, the yield is compensated by closer spacing and high plant population. Under high planting density, besides the change in the quantity and quality of intercepted light, the partitioning of assimilates between vegetative and reproductive shoots may be responsible for the growth and yield.

Table 4. Effect of high density planting and fertigation on flowering, pod yield and pod characters of annual moringa PKM 1

Treatments	Days to 50 per cent flowering				No. of pods per tree				Pod length (cm)				Pod weight (g)			
	Main crop	First ratoon	Second ratoon	Mean	Main crop	First ratoon	Second ratoon	Mean	Main crop	First ratoon	Second ratoon	Mean	Main crop	First ratoon	Second ratoon	Mean
M_1S_1	149	145	147	147.00	150	255	141	182	61.0	75.4	72.4	69.60	118.00	119.19	119.00	118.73
M_1S_2	154	135	140	143.00	170	256	157	194	63.0	74.8	73.8	70.53	105.00	120.00	110.00	111.67
M_1S_3	152	148	137	145.67	172	271	161	201	56.0	75.0	75.0	68.67	110.00	129.52	121.52	120.35
M_2S_1	161	151	152	154.67	128	207	128	154	68.2	74.5	74.9	72.47	95.00	112.35	102.30	103.22
M_2S_2	162	149	148	153.00	138	216	138	164	69.0	73.8	72.8	71.87	110.00	115.13	105.13	110.09
M_2S_3	164	145	157	155.33	141	253	141	178	70.5	74.0	74.2	72.73	117.00	128.97	109.90	118.62
M_3S_1	158	158	157	157.67	140	262	140	181	72.0	70.5	72.5	71.67	109.00	122.64	110.60	114.08
M_3S_2	162	161	165	162.67	146	265	146	186	72.3	69.4	68.4	69.93	111.00	123.03	113.00	115.68
M_3S_3	163	160	163	162.00	151	264	131	182	74.2	69.5	69.7	71.07	106.00	128.57	119.05	117.87
M_4S_1	149	147	166	154.00	112	272	112	165	71.4	72.1	71.1	71.40	112.79	112.79	113.06	112.88
M_4S_2	148	148	160	152.00	121	241	121	161	72.3	72.5	74.5	73.00	101.15	101.15	101.15	101.15
M_4S_3	144	144	162	150.00	128	269	128	175	71.2	66.8	69.8	69.20	100.00	100.00	100.00	100.00
M_5S_1	152	150	160	154.00	145	270	145	187	72.0	70.0	71.0	71.00	99.00	101.19	101.00	100.40
M_5S_2	154	154	157	155.00	148	272	148	189	69.0	71.5	72.5	71.00	102.00	104.65	104.00	103.55
M_5S_3	156	158	158	157.33	152	274	152	193	68.3	72.0	73.0	71.00	101.15	101.15	98.50	100.27
M_6S_1	162	145	170	159.00	129	270	129	176	63.5	68.0	69.0	66.67	103.00	113.25	103.20	106.48
M_6S_2	164	154	168	162.00	138	265	138	180	64.0	65.7	67.7	65.80	104.00	115.48	95.40	104.96
M_6S_3	166	156	166	162.67	138	274	138	183	67.0	64.8	66.8	66.20	110.00	87.06	99.05	98.70
M_7S_1	158	158	162	159.33	111	270	98	160	67.5	64.0	65.0	65.33	98.00	75.58	80.54	84.71
M_7S_2	155	155	169	159.67	105	275	99	160	69.0	65.2	66.2	66.80	99.00	85.06	85.00	89.69
M_7S_3	154	154	166	158.00	105	278	105	163	69.5	65.0	67.0	67.00	101.00	85.71	90.40	92.37
M_8S_1	161	158	171	163.33	98	170	75	114	66.4	60.0	62.0	62.67	88.00	100.00	98.00	95.33
M_8S_2	163	158	175	165.33	102	193	80	125	66.0	72.1	73.1	70.40	89.00	101.00	99.00	96.33
M_8S_3	158	160	173	163.67	105	229	81	138	69.5	72.0	70.0	70.33	88.00	103.00	100.00	97.00
[illegible] CD	NS	1.80 3.60	2.12 4.21	2.00 3.95	7.90 16.20	0.51 1.02	6.50 13.00	5.33 10.40	0.51 1.02	0.30 0.60	2.40 4.81	1.25 2.50	2.80 6.61	2.82 6.67	2.00 4.10	2.20 4.40
[illegible] CD	NS	1.50 3.00	1.32 2.60	1.40 2.80	6.12 12.30	0.81 1.63	5.90 10.80	4.10 8.20	0.81 1.63	0.41 0.82	1.90 NS	0.75 1.50	1.25 NS	3.45 6.90	1.50 3.00	1.30 2.60
[illegible] CD	NS	2.01 4.08	1.05 2.10	1.50 3.00	8.80 19.00	0.60 1.20	8.80 17.60	5.67 11.30	0.60 1.20	0.50 1.00	1.70 NS	0.90 1.80	1.98 NS	6.10 12.20	2.53 5.08	3.40 6.80
[illegible] CD	NS	0.98 1.76	2.35 4.70	1.56 3.12	5.02 10.76	0.43 0.86	5.00 10.00	4.50 9.00	0.43 0.86	0.41 0.82	2.16 NS	0.60 1.20	1.45 NS	4.50 9.01	3.20 6.40	3.00 6.00

Table 5. Effect of high density planting and fertigation on yield characters of annual moringa PKM 1

Treatments	Pod yield kg plant $^{-1}$				Pod yield kg plot^{-1}				Estimated yield t. ha^{-1}				BC ratio			
	Main crop	First ratoon	Second ratoon	Mean	Main crop	First ratoon	Second ratoon	Mean	Main crop	First ratoon	Second ratoon	Mean	Main crop	First ratoon	Second Ratoon	Mean
M_1S_1	17.70	19.20	16.78	17.89	84.96	92.16	80.54	85.89	28.32	30.72	26.85	28.63	0.92	1.72	1.65	1.43
M_1S_2	17.85	20.40	17.27	18.51	85.68	97.92	82.90	88.83	28.56	32.64	27.63	29.61	0.93	1.86	1.70	1.50
M_1S_3	18.92	20.50	19.56	19.66	90.84	98.40	93.91	94.38	30.27	32.80	31.30	31.46	1.00	1.90	1.80	1.57
M_2S_1	12.16	18.20	13.09	14.48	116.78	174.72	125.71	139.07	36.40	50.69	41.90	43.00	1.59	3.46	3.40	2.82
M_2S_2	15.18	17.50	14.51	15.73	145.71	168.00	139.28	151.00	46.34	50.84	46.43	47.87	1.64	3.19	3.22	2.68
M_2S_3	16.50	18.70	15.50	16.90	158.36	179.52	148.76	162.21	49.70	52.83	49.59	50.71	1.79	3.27	3.25	2.77
M_3S_1	15.26	18.00	15.48	16.25	91.58	108.00	92.90	97.49	30.52	36.00	30.97	32.50	1.15	2.05	1.85	1.68
M_3S_2	16.21	18.70	16.50	17.14	97.25	112.20	98.99	102.81	31.78	35.92	33.00	33.57	1.14	2.09	2.00	1.74
M_3S_3	16.01	19.50	15.60	17.04	96.03	117.00	93.57	102.20	31.21	37.04	31.19	33.15	1.17	2.22	2.05	1.81
M_4S_1	12.63	19.40	12.66	14.90	151.59	232.80	151.95	178.78	41.71	50.53	50.65	47.63	2.49	4.42	4.40	3.77
M_4S_2	12.24	17.60	12.24	14.03	146.87	211.20	146.87	168.31	41.50	48.96	48.96	46.47	2.24	3.93	3.93	3.37
M_4S_3	12.80	17.50	12.80	14.37	153.60	210.00	153.60	172.40	44.32	51.20	51.20	48.91	2.73	3.99	4.00	3.57
M_5S_1	14.36	17.00	14.65	15.34	114.81	135.97	117.13	122.64	35.66	39.12	39.04	37.94	1.72	2.52	2.50	2.25
M_5S_2	15.10	18.00	15.39	16.16	120.79	143.96	123.11	129.29	37.45	41.29	41.04	39.93	1.63	2.60	2.62	2.28
M_5S_3	15.37	17.60	14.97	15.98	122.95	140.76	119.75	127.82	38.39	40.99	39.92	39.77	1.79	2.49	2.52	2.27
M_6S_1	13.29	18.80	13.31	15.13	159.51	225.60	159.75	181.62	47.24	58.44	53.25	52.98	2.17	4.18	4.15	3.50
M_6S_2	14.35	19.40	13.17	15.64	172.13	232.80	157.98	187.64	52.26	63.74	52.66	56.22	2.22	4.20	4.17	3.53
M_6S_3	15.18	14.80	13.67	14.55	182.15	177.60	164.03	174.59	55.01	48.06	54.68	52.58	2.26	3.14	3.20	2.87
M_7S_1	10.88	13.00	7.89	10.59	217.66	259.97	157.84	211.82	56.93	49.37	52.61	52.97	3.62	4.20	4.30	4.04
M_7S_2	10.40	14.80	8.42	11.21	207.85	295.97	168.28	224.03	54.36	56.13	56.09	55.53	3.53	4.53	4.50	4.19
M_7S_3	10.61	15.00	9.49	11.70	212.22	299.97	189.82	234.00	56.58	59.99	63.27	59.95	3.73	4.38	4.45	4.19
M_8S_1	8.62	7.50	7.35	7.82	344.79	299.99	293.99	312.92	114.93	100.00	98.00	104.31	4.62	4.85	4.80	4.76
M_8S_2	9.08	8.10	7.92	8.37	363.19	323.99	316.79	334.66	120.92	107.73	105.60	111.42	4.71	4.90	4.85	4.82
M_8S_3	9.24	8.30	8.10	8.55	369.59	331.99	323.98	341.86	123.52	111.24	108.00	114.25	4.85	4.96	4.95	4.92
M SEd	0.84	0.80	0.45	0.70	28.30	24.00	18.00	23.00	8.30	7.10	6.90	7.00	--	---	---	---
CD	1.99	1.71	0.92	1.40	56.60	48.10	36.10	46.00	16.60	14.20	13.80	14.00				
S SEd	0.49	0.50	0.52	0.50	20.32	20.30	19..30	20.00	7.88	6.80	6.50	6.89	---	--	--	--
CD	1.05	1.00	1.04	1.00	40.64	40.60	39.00	40.00	15.76	13.00	13.00	14.00				
M at S SEd	1.45	1.40	1.30	1.20	31.15	27.00	22.00	25.00	9.20	7.10	5.90	7.50	---	--	--	--
CD	3.15	2.80	2.60	2.40	62.30	54.15	44.15	50.00	18.40	14.20	11.80	15.00				
S at M SEd	0.72	0.70	0.75	0.75	25.10	25.00	20.00	21.00	8.00	7.50	6.20	7.20	---	--	--	--
CD	1.44	1.40	1.50	1.40	50.20	50.00	40.05	42.00	16.05	15.09	13.40	14.00				

The pod yield per plant was more in the treatment M_1S_3 (18.92, 20.50 and 19.56 kg/tree in main, first ratoon and second ratoon crops respectively). The yield per plant was found to be the least in the treatment M_8S_1 (8.62, 7.50 and 7.35 kg tree^{-1}, respectively). The treatment M_8S_3 recorded the highest yield per plot (369.59, 331.99 and 323.98 kg plot^{-1} respectively in three seasons) and estimated yield per hectare (123.52, 111.24 and 108.00 tonnes ha^{-1}, respectively) while it was found to be the least in M_1 S_1. In the same treatment M_8S_3, BC ratio was also found to be the highest (4.85, 4.96 and 4.95, respectively), while it was found to be the least in M_1S_1 (0.92, 1.72 and 1.65 respectively).

Even though yield per plant was the highest in the normal planting system, the yield per plot and estimated yield per ha was found to be the highest in high density planting system (Table 5). Singh *et.al.* (2007) reported that in guava, the total yield was the highest (79.5 kg tree^{-1}) when the trees were planted at 3.0 × 6.0 m spacing, while it was only 32.60 kg tree^{-1} when the spacing was 1.5 × 3.0 m. However, the yield per unit area was more at closer planting because of more number of trees (2222 ha^{-1}) (Fig 1). Ahmed and Mannan (1970) also reported that in banana, yield per hectare was significantly higher in high density planted with closer spacing mainly due to increase in plant population per unit area.

Conclusion

Based on the studies, it is concluded that by adopting the high density planting with the spacing of 1.5 × 1.0 m, by planting two plants per hill and maintaining a plant population of 13,333 plants ha^{-1} along with application of 135: 23:45 g of NPK pit^{-1} through drip irrigation, the highest yield of 8.55 kg plant $^{-1}$, yield of 341.86 kg plot^{-1} and the estimated yield of 114 tonnes ha^{-1}could be obtained. Hence, high density planting system may be adopted for getting higher yield in annual moringa var. PKM 1.

References

Ahmed, K. and Mannan, A., 1970. Effect of size of pit and spacing on the performance of Amritsagar banana. *Punjab Fruit J.* **32**: 7-13.

Berrill, F. W., 1963, Bunch covers in bananas. Queensland Agric*. J.*, **82**: 435-440.

Caceres A, Saravia A, Rizzo S, Zabala L, LeonED, Nave.F. 1992. Pharmacologic properties of *Moringa oleifera*. Screening for antispasmodic, anti-inflammatory and diuretic activity, *J. Ethnopharmacol*. **36**: 233–237.

Chundawat, B. S., Dave, S. K. and Patel, N. I.1983. Effect of close planting on the yield and quality of Lacatan banana. *Indian J. Agric. Sci*., **53** : 470-472

De Sousa.C.A.F., M. I.L. Gondim Cavalcanti, L.F.Lopes Vasconcelos, H. U. De Sousa , V.Q. Ribeiro and J. A.L. da Silva . 2012 . Mangueiras 'Tommy Atkins' submetidas à alta densidade de plantio em condições de clima tropical subúmido no Nordeste do Brasil. Pesq. agropec. bras. Brasília, v.**47**, n.1, p. 36 – 43.

Fuglie, L. 2003. The Miracle Tree. Church World Service. **p:114**.

Nath, V., B. Das and M. Rai. 2007. Standardization of high density planting in mango (*Mangifera indica*) under sub-humid Alfisols of Eastern India*. Indian J. Agricultural Sciences*, v.**77**, p.3-7.

Policarpo. M., G. Talluto and R.L. Bianco. 2006. Vegetative and productive responses of 'Conference' and 'Williams' pear trees planted at different in - row spacings. *Scientia Horticulturae*, v.**109**, p.322 - 331.

Ram, S. and S. C. Sirohi. 1991. Feasibility of high density orcharding in Dashehari mango. *Acta Horticulturae*, In.**291**, p.207- 212.

Rajendran . T. and M. Prahadeeswaran . 2014. Marketing strategies for promotion of annual moringa in Tamil Nadu: An economic analysis. *J. Marketing Research*. V 2. Issue 1. 289 -295.

Singh, G., Singh, A.K. and D. Mishra. 2007. High density planting in guava. *Acta Hortic.* **735**, 235-241.

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