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Fertigation Studies in Moringa (*Moringa oleifera* Lam) under High Density Planting System for Leaf Biomass

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Horticultural College and Research Institute, TNAU, Periyakulam to determine the effect of drip fertigation on the plant growth and leaf yield of moringa variety PKM -1 under high density planting system. The treatment consisted of 75,100, 125, 150 percent of recommended dose of fertilizers under fertigation system along with soil application of 100 percent of recommended dose of fertilizers and without any fertilizers application as control. The experiment was laid out in randomized block design with six treatments and four replications. Five individual plants were randomly selected from each plot and observations were recorded on growth, physiology and yield characters. Observations were recorded initially at 70 days after planting and subsequently at 35 days interval and totally three harvests were made during the study period.The result of the study indicated that among all the treatments application of 150

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percent of recommended dose of fertilizers through drip fertigation produced significantly higher estimated fresh leaf yield of 2.93, 3.79 and 4.04 tonnes per hacter in first, second and thire harvests respectively when compare to other treatments.

Keywords: Moringa; fertigation; RDF; leaf yield.

1. INTRODUCTION

Drumstick (*Moringa oleifera* Lam.) commonly referred as "moringa" is the most widely cultivated species of the family Moringaceae. It is a South East Asian (northwest region of India) and African originated fast-growing multipurpose tree extensively grown in tropics and subtropics of India and Africa [1]. The genus Moringa contains thirteen species and two commercial species viz., M*. oleifera* and *M. concanensis* originated in India and other eleven from the African continent. Moringa is widely used as vegetable and grown commercially for its edible pods and leaves. The value of moringa is highly recognised since the ancient times in many regions of India and Africa because of its nutritional as well as therapeutic properties. Moringa leaf possess umpteen number of nutrient complex and all this complex having full of essential disease-preventing nutrients mainly β- carotene which acts as a shield against eye disease, skin disease and heart ailments, Vitamin C fighting a host of illnesses including colds and flu. Calcium-build up strong bones and teeth, helps prevent osteoporosis, Potassium is essential for the brain and nerves proteins the basic building blocks of all body cells. It is a rich source of phosphorus, zinc and good source of natural antioxidants such as ascorbic acid, flavonoids, phenolics and carotenoids [2]. Not only leaves and pods, all the parts of this plant have nutritional, therapeutical and industrial importance [3,4]. Moringa is used many ways in cropping systems includes inter cropping, alley cropping, animal forage, agro forestry. Besides it is also used in biogas, fencing, fertilizer, foliar nutrient, green manure, gum, sugarcane juice clarifier, medicine, ornamental plantings, bio pesticide, pulp, rope, tannin and water purification, It is a multipurpose tree, where the leaves, flowers and fruits are used for culinary and medicinal purposes. The roots are a good substitute for horse radish [5]. The wood has suitable characteristics for pulp, paper cellophane and textile production [6]. The stem gum exudates are used in calico printing. In the West, one of the best known uses for moringa is the use of powdered seeds to flocculate contaminants and purify drinking water [7]. Moringa seed oil also known as ben oil is used as edible oil for fine machine lubrication and in the manufacture of cosmetics [8]. Its demand in domestic as well as in export market gets increasing every year [9]. To cater for the need of the growing market of moringa leaf products many research activities have been initiated globally for the production quality raw materials with international regulation and standards. High density planting system of crops is being popularly followed in many crops to harvest more productivity per unit area and fertigation technique helps to supply the nutrients precisely and timely which ultimately fetches better yield in crops [10]. With this view a study was focused onto determine optimum fertilizer requirement with high density planting system to get maximum leaf biomass yield.

2. MATERIALS AND METHODS

The present investigation was undertaken in the field which is situated at 77 º E longitude, 10ºN latitude and at an altitude of 300 m above mean sea level (MSL) at Horticultural College & Research Institute, Periyakulam. Soil type in the experimental plot was Sandy loam with pH 7.0, EC 0.36 dSm^{-1}, Available nitrogen was 275.55 kg $ha^{-1,}$ available phosphorus12.30 kg ha^{-1} and available potassium, 275.60 kg ha^{-1}. The experimental field was ploughed repeatedly to bring the soil to fine tilth. Raised beds were made with 160 cm width,10 M length, and 20 cm height [11]. The design of experiment is randomized block design with six treatments and four replications. A dosage of 90:15:30 g of NPK / $5m^2$ was taken as 100% dose as per the recommendation of the crop production manual (TNAU Crop production Guide, 2013). The fertilizer doses for soil application and for fertigation were worked out by taking account of the N, P_2O_5 and K_2O contents present in the fertilizers used. Nitrogen was supplied in the form of urea, phosphorus in the form of orthophosphoric acid and potassium in the form of muriate of potash. Orthophosphoric acid liquid fertilizer is converted on weight basis as per the formula Mass = Volume / Specific density (Kg). For each treatment, RDF was applied in four stages *viz,*10 per cent at 18 DAS, 30 per cent of

RDF at 40 DAS, 30 per cent of RDF at 80 DAS and remaining 30 per cent RDF at 120 DAS. In the treatment T_1, T_2, T_3, and T_4 the fertilizer was applied as fertigation and for the treatment T_5 through soil application and no fertilizer was applied to T_6 (Control).

Table 1. Design of drip system employed for the research

Materials	Specifications
Motor	5 HP
Ventury pipe	50 mm
Filter size (Screen filter)	75 mm
Main and sub main type	PVC (Poly Vinyl Chloride)
Main line diameter	63 mm
Sub main diameter	40 mm
Control valve	63 mm
Flush value	40 mm
Lateral type	LDPE(Low Density Poly Ethylene)
Lateral diameter	12 mm
Emitter model	Online
Emitter discharge rate	8 lph

Treatment Details:

T_1: 75% of NPK (135: 23: 45 kg ha^{-1}) through fertigation
T_2: 100% of NPK (180: 30: 60 kg ha^{-1}) through fertigation
T_3: 125% of NPK (225: 38: 75 kg ha^{-1}) through fertigation
T_4: 150% of NPK (270: 45:90 kg ha^{-1}) through fertigation
T_5: 100% of NPK (180: 30: 60 kg ha^{-1}) as soil application
T_6: Control (without any fertilizer application)

Required quantity of Annual Moringa seeds Variety PKM -1 were obtained from the Department of Vegetable Science, Horticultural College & Research Institute, Periyakulam. The seeds were sown in raised bed with spacing of 40 X 20 cm. The plants were allowed a minimum of 70 days to develop strong roots that in order to absorb the shocks of initial cutting. Harvesting was done 75 days after sowing at the height of 45 cm above the ground level. Subsequent harvests were done at every 40 days intervals. Five individual plants. were randomly selected from each treatment plot and observation recorded on growth, physiological characters and leaf yield such as Plant height (cm), Number of branches $plant^{-1}$, Leaf area (cm^2), Specific leaf weight g cm^{-2}, Leaf area index, Chlorophyll content (mg g^{-1}), Green leaf yield (kg $plot^{-1}$) and Green leaf yield (t ha^{-1}). The data recorded were subjected to statistical analysis as per the method [12]. The significance of the mean difference between different treatments was determined by computing the standard error and critical difference.

3. RESULTS AND DISCUSSION

3.1 Growth Character

Influence of fertigation on plant height was found to be significant (P=0.05) among the various treatments at all the three harvests. In the first harvest (70 DAS) highest plant height of 127.16 cm was recorded in T_4 which was on par with T_3 and T_2 *i.e*., 121.24 cm and 114.68 cm, respectively. In the second and third harvest the same T_4 recorded the plant height of 109.54 cm and 107.12 cm respectively *i.e*., 102.55 cm and 104.45 cm. Increased uptake of nutrients particularly nitrogen in drip fertigation system could be attributed to the increased plant height and stem girth. Similar findings [13] reported that the height of tomato plants increased significantly with the increased levels of nitrogen. Significant (P=0.05) increase in plant height observed in the present investigation might be due to the better utilization of resources like water and nutrients through drip fertigation system [14]. The number of branches and leaflets $plant^{-1}$ was significantly increased by the application of fertilizers through fertigation. The traits, number of branches $plant^{-1}$ and leaflets $plant^{-1}$ directly influenced the yield of moringa, since more number of branches contributed more yield. In the present investigation, application of 150% RDF through fertigation resulted in higher number of branches $plant^{-1}$ and leaflets $plant^{-1}$. Better sink developed by axillary branches because of the précised and timely availability of large amount of available nutrients [15]. Besides, elevated level and readily available nutrients through fertigation helped in building up of a strong vegetative frame work through the production of enhanced levels of growth hormones *viz.,* auxin and gibberellins. Auxins, in turn increased the cell division process and greater cell division resulted in better growth of plants [16].

3.2 Physiological Characters

The leaf area $plant^{-1}$ was the highest with the higher levels of nutrients. In the present study 150% RDF (T_4) applied through the fertigation registered better leaf area, leaf area index [17], Specific leaf weight [18], chlorophyll content of leaves than other treatments. Fertigation gives flexibility of fertilizer availability, which enables the specific nutritional requirements of the crop to be met at different stages of its growth. The effect of nutrients in enhancing the leaf area is well established and increased levels usually had positive relationship with growth [19]. This could also be attributed due to the production of greater number of photo-synthetically active leaves because of adequate nutrients uptake by plants which might have led to higher metabolic activity resulting in higher production of carbohydrates and phytohormones.

The increase in LAI might be due to continuous and uninterrupted supply of water, nutrients and also due to easy availability of nutrients from water soluble fertilizers as well as better mobilization of nutrients in the plants as they were supplied through several splits at critical growth stages [16]. The increased chlorophyll content observed with drip fertigation treatment might be due to increased uptake of nutrients, particularly N. The phenomenon of increased chlorophyll content with higher nutrients as observed in the present study was also reported [19] in bitter gourd. Presence study ensured balanced nutrition through drip fertigation made the applied nutrients into easily available might have resulted in well developed leaves with greater chlorophyll content. It might be due to more accumulation of assimilates. More over potassium is an integral part for the development of chlorophyll. It plays an important role in photosynthesis, which is converting carbon dioxide and hydrogen into sugars, for translocation of sugars, and for starch formation, and also metabolic activities of plants [20]. Dry matter production was favourably influenced by different levels of fertigation. The water soluble fertilizers might be responsible for enhancing the photosynthetic ability while better availability and absorption of N, P and K could have helped in the translocation of metabolites to the sink and thereby increased the growth and dry matter content. This is in agreement with the earlier works [21] in tomato.

3.3 Yield Characters

In any production system, the primary goal is to achieve maximum yield per unit area without affecting the quality negatively. In the present study application of NPK fertilizer through fertigation significantly (P=0.05) increased the vegetative growth and leaf yield of moringa plant and this finding is in accordance with the earlier findings in moringa [22,23]. Among the different fertigation treatments, 150 percent of RDF recorded maximum fresh and dry leaf yield. Fertigation with 125 per cent water soluble fertilizers had registered increased fresh leaf weight, dry leaf weight and nutritive content in all the stages of the crop growth in coriander as reported earlier [18]. Acceleration of growth parameters might be due to influence of nitrogen, which is the chief constituent of proteins, essential for the formation of protoplasm which might have led to cell division and cell enlargement and thereby the increased biomass yield. Besides, availability of nitrogen in higher quantities was reported to accelerate the synthesis of amino acids [24]. Potassium is one of the important macronutrient elements in plants that plays significant roles in the activation of several metabolic processes, including photosynthesis, protein synthesis, and enzymes, as well as in resistance to diseases and insects pests [25-27]. In plant physiology it is the crucial cation in regard to its content in plant tissues and with respect to its biochemical and physiological functions [17].

Table 2. Effect of fertigation on growth parameters of moringa cv. PKM -1

Treatments	**Plant height**			**Number of branches**		**Leaf lets/ plant**		
	I Harvest	**II Harvest**	**III Harvest**	**II Harvest**	**III Harvest**	**I Harvest**	**II Harvest**	**III Harvest**
T_1	106.49	97.80	100.30	3.23	4.40	172.98	192.43	195.45
T_2	114.68	101.06	102.29	4.25	4.80	174.50	195.28	204.43
T_3	121.24	102.55	104.45	5.25	5.35	177.03	198.33	214.55
T_4	127.16	109.54	107.12	6.28	5.85	182.33	204.48	229.75
T_5	97.57	91.19	91.45	2.78	3.93	161.43	187.38	189.20
T_6	87.53	89.79	87.28	2.50	3.38	155.53	175.20	179.43
SE (d)	**3.64**	**4.43**	**2.32**	**0.35**	**0.60**	**3.88**	**2.60**	**3.52**
P=.05	**7.75**	**9.44**	**4.95**	**0.74**	**1.29**	**8.28**	**5.53**	**7.50**

Table 3. Effect of fertigation on physiological parameters of moringa cv. PKM -1

Treatments	Leaf Area (cm^2)			Leaf Area Index			Chlorophyll (mg g^{-1})			Dry Matter Production (g $plant^{-1}$)		
	I Harvest	II Harvest	III Harvest	I Harvest	II Harvest	III Harvest	I Harvest	II Harvest	III Harvest	I Harvest	II Harvest	III Harvest
T_1	0.63	0.65	0.71	4.79	5.57	5.65	2.70	2.68	2.79	101.55	111.40	113.13
T_2	0.87	0.90	0.77	4.90	5.61	5.68	2.96	3.09	3.20	111.80	116.50	117.80
T_3	0.96	1.06	1.00	5.52	5.65	5.67	3.39	3.12	3.33	117.23	122.08	123.20
T_4	1.07	1.11	1.22	6.09	6.20	6.11	3.20	3.18	3.71	124.20	125.83	126.25
T_5	0.58	0.56	0.61	4.52	4.92	5.07	2.40	2.54	2.32	102.43	104.78	105.23
T_6	0.42	0.48	0.56	4.08	4.18	4.22	1.36	2.06	2.36	88.91	94.93	102.85
SE (d)	**0.05**	**0.04**	**0.05**	**0.33**	**0.51**	**0.48**	**0.16**	**0.25**	**0.21**	**3.17**	**3.81**	**3.46**
P=.05	**0.10**	**0.10**	**0.10**	**0.70**	**1.10**	**1.03**	**0.35**	**0.52**	**0.45**	**6.76**	**8.13**	**7.38**

Table 4. Effect of fertigation on leaf yield of moringa cv.PKM-1

Treatments	Fresh Leaf Yield (kg plot^{-1})			Estimated Fresh Leaf Yield (t ha^{-1})		
	I Harvest	II Harvest	III Harvest	I Harvest	II Harvest	III Harvest
T_1	2.58	3.68	4.08	2.03	2.93	3.17
T_2	3.19	3.84	4.16	2.55	3.04	3.28
T_3	3.38	4.16	4.48	2.66	3.28	3.61
T_4	3.70	4.80	5.18	2.93	3.79	4.04
T_5	1.77	3.36	3.77	1.43	2.68	2.92
T_6	1.30	2.88	3.18	1.03	2.31	2.42
SE (d)	**0.18**	**0.24**	**0.24**	**0.26**	**0.48**	**0.59**
P=.05	**0.38**	**0.51**	**0.52**	**0.56**	**1.03**	**1.26**

4. CONCLUSION

The present investigation was effectively carried out to get many valuable findings with regards to plant growth, physiological character and yield in response to different fertigation treatments. In this study it is clearly indicated that when the nutrients application through drip fertigation ultimately lead to better vegetative growth of plant thus it helped to get maximum fresh leaf yields. Hence it is concluded that application of elevated doses of recommended dose of fertilizer through fertigation will yield better biomass in moringa.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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