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RESEARCH ARTICLE

Interventions of Plant Geometry and Harvesting Heights on Growth and Leaf Yield Parameters in Moringa (*Moringa oleifera* Lam.)

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ABSTRACT

The present study aimed to understand the interventions of plant geometry and harvesting heights on growth and leaf yield parameters in Moringa. The crop geometry of moringa highly influenced the leaf yield. An experiment has been conducted in 2021 at Western block farm, Horticultural College and Research Institute, Periyakulam under irrigated conditions to study the effect of crop geometries and harvesting heights on leaf yield of moringa var. PKM 1. Treatments combination consists of four crop geometries viz., 1.50m x 0.25m (S_1), 1.50m x 0.50m (S2), 1.50m x 0.25m x 0.25m (S3), 1.50m x 0.50m x 0.50m (S4) and three harvesting heights of 30 cm (T_1), 45 cm (T_2) and 60 cm (T_3). The study laid out in a Split plot design with three replications. The growth parameters such as plant height and a number of compound leaves were significantly higher in the closer spacing of 1.50m x 0.25m x 0.25m whereas a number of primary branches and stem girth were significantly higher in the wider spacing of 1.50 m x 0.50 m. Harvesting heights have no influence on the growth parameters. Moringa raised under spacing 1.50 m x 0.25 m x 0.25 m in conjunction with harvesting height of 30 cm (S_3T_1) significantly influenced the yield parameters such as compound leaf yield, fresh leaflets weight, dry leaf weight, and found maximum.

Keywords: Moringa; Plant Geometry; Harvesting Heights; Leaf Yield

INTRODUCTION

Moringa (*Moringa oleifera*) is a deciduous perennial tree that comes under the monogeneric family Moringaceae. Moringa is a fast-growing, medium-sized drought tolerant perennial tree widely spread over the Himalayan tracts of North India (Pandey *et al*., 2010). Moringa is locally called Murungai in Tamil Nadu. The optimum temperature for moringa cultivation is 25-35 °C, but can tolerate up to 48°C in summer and also survive in cold winters. Annual and perennial types of moringa have been cultivated in India where perennial types are propagated through cuttings and annual types are propagated through seeds. All parts of moringa had more functional and nutraceutical properties; making it ideal for food and allied uses. From the ancient period, Indians were well known for using Moringa oleifera for edible pods, seed oil, fodder, and some medicinal purpose. Ben oil extracted from moringa seeds is edible and used as a salad oil, illuminant, lubricant, biofuel, and in the cosmetic industry. (Rashid *et al*., 2008). Moringa is a good source of calcium, phosphorous, and iron. Leaves are rich in protein (27%), vitamins, potassium, calcium, iron, phosphorous, beta carotene, and natural antioxidants. (El Sohaimy *et al*., 2015). Moringa controls malnutrition in India and other developing nations. Moringa leaves are gaining popularity among growers nowadays due to the huge nutritional properties in the leaves. Leaves

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are dried and made into powder; which is used in various forms likecapsule, and tablet. Moringa leaf powder is processed into various food products like moringa biscuits and used in the various food products as adjuncts which adds more nutrients to the food. Thus, the demand for moringa leaves has been increased, and accordingly, the yield should be maximized. Since the land area is diversified and limited in India, increasing the moringa leaf productivity is needed. A denser population system will be the only solution to increase the productivity of leaves and so to eradicate malnutrition. Harvesting height plays a major role in the mechanisation of harvest. Therefore, optimum harvesting height should be standardized. The present study was done to find the optimum plant geometry with suitable harvesting heights to pave the way for yield intensification and mechanization.

MATERIAL AND METHODS

The experiment was conducted on Western block farm of Horticultural College and Research Institute, Periyakulam, Theni, Tamil Nadu (Latitude 10.1283o N and longitude 77.5998o E) during the year 2021 with a total area of 1.2 acres. Annual moringa variety PKM 1 was used for the study and sown during the month of February. All the standardized cultivation practices were followed. Treatments comprised of four different spacing 1.50 m x 0.25 m (S_1), 1.50 m x 0.50 m (S_2), 1.50 m x 0.25 m x 0.25 m (S_3), 1.50 m x 0.50 m x 0.50 m (S_4) with three harvesting heights 30 cm (T_1), 45 cm (T_2), 60 cm (T3). Field laid out in split-plot design with three replications. The planting geometries were allotted randomly in the main plot while the harvesting heights were fixed to sub-plots.

Fifteen plants were randomly tagged in each plot and observations such as the plant height, number of primary branches, number of compound leaves, stem girth. The average value of 15 plants in each plot was taken for each observation. Harvesting was carried out 90 days after sowing with the harvesting heights 30 cm, 45 cm and 60cm from the ground level. Leaves are harvested from each treatment combination and the fresh leaf weight is recorded for all treatment combinations. Fresh leaves were dried using a solar drier and dry leaf yield was recorded.

RESULTS AND DISCUSSION

Plant height (cm)

Among the various spacing; S_3 (1.50 m x 0.25 m x 0.25 m) recorded significantly higher plant height. S_2 (1.50 m x 0.50 m) recorded a minimum number of compound leaves (Table 1). Increased plant height might be due to the competition for light in the closest spacing and etiolation character of plants. This was in concordance with Bagri *et al*., (2018). No significant difference was seen in various harvesting heights and there is no significant interaction between the spacing and harvesting heights.

Number of Compound leaves

The spacing 1.50 m x 0.25 m x 0.25 m exhibits a significantly more number of compound leaves due to a dense population followed by 1.50 m x 0.50 m x 0.50 m while the least number was observed in the spacing 1.5 m x 0.5 m. More number of compound leaves might be due to increased plant height. Harvesting heights have no significance both alone and in interaction with the plant spacing.

Number of Primary branches

The spacing S_2 showed maximum primary branches (4.09) significantly followed by S_4. Wider spacing results in a greater number of primary branches. S_3 has the least number of primary branches. Ramkumar and Anuja (2017) reported that more primary branches were observed in the wider spacing of 120 cm x 120 cm over 45 cm x 45 cm, 60 cm x 60 cm, 75 cm x 75 cm, and 90 cm x 90 cm. The same was also interfered with by Ponnuswami and Rani (2019). There is no significance in the harvesting heights and no significant interaction between heights and spacing.

Stem Girth

Stem girth is significantly higher in the wider spacing 1.50 m x 0.50 m while the closest spacing has the lower stem girth. The spacing S1 and S4 are more or less on par with each other. Denser population reduced the stem diameters while increased in the low dense population, as reported by Goss 2012. As the plants grow without any competition, it results in good growth of stem with enlarged stem thickness. Interaction of plant geometry and cutting heights are not significant with each other in stem girth.

Weight of Compound leaves

The yield of compound leaves per hectare was significantly higher (7.45 tonnes/ha) in the closer spacing (1.50 m x 0.25 m x 0.25 m) followed by spacing 1.5 m x 0.50 m x 0.50 m (S_4). Compound leaves yield in spacing S_4 is on par with spacing S_1.

The least yield was seen in the wider spacing of 1.50 m x 0.50 m. This was in accordance with Basra *et al.*, 2015. An increase in plant density leads to increased biomass production (Mabapa *et al.*, 2017). Cutting height of 30cm above the ground level has the greatest yield level significantly, followed by 45 cm and 60 cm (Table 2). The harvesting heights also influenced the yield. More side branches can be harvested when harvested at the height of 30 cm, which results in more number of compound leaves than at other heights. The interaction effect of spacing and harvesting heights is significant to each other. Significant interaction exists between the harvesting heights and spacing.

Weight of fresh leaflets

Individual leaflets were alone taken from the compound leaves and weighed. Leaflets' weight is significantly greater in S_3 while least in S_4. Closer spacing (1.50 m x 0.25 m x 0.25 m) accommodates more plant population and results in increased yield per hectare (4.71 tonnes/ha) (Figure 1). Adegun and Ayodele (2015) stated that the yield was greater in the closest spacing of 30 cm x 40 cm than in wider spacing of 40 cm x 60 cm, 60 cm x 80 cm, and 100 cm x 100 cm. The same was revealed by Maheswari *et al.*, 2019. Harvesting at 30cm above the ground level is significantly higher than other heights. Interaction between geometry and spacing is significant to each other in the treatment combinations. The lowest cutting level (30cm) has more yield than cutting at the top as reported by El-Morsy (2009).

Weight of Dry leaves

Fresh leaflets were dried and weighed to get the dry leaf yield. Spacing S_3 (0.86 tonnes/ha) has the maximum dry leaf yield followed by S_4 which is on par with S_1. Wider spacing (1.50 m x 0.50 m) accommodates fewer plants and gives low yield, resulting in minimum dry leaf yield. Among the subplot treatments, harvesting height at 30cm is significant and there arises a significant effect of interaction among the various plant geometry in the main plot and harvesting heights in a subplot. (Table 3)

Table 1. Effect of plant geometry and harvesting heights on Plant height (cm), Number of Compound leaves, Number of Primary branches and Stem Girth

Growth parameters				
Treatment	Plant height (cm)	Compound leaves	Number of primary branches	Stem girth (cm)
Spacing				
S1	150.02	25.92	2.97	6.55
S2	143.14	24.41	4.09	7.39
S3	151.59	29.19	2.63	5.96
S4	145.05	27.48	3.81	6.85
SEd	2.12	1.06	0.32	0.29
CD (P=0.05)	5.20	2.61	0.79	0.70
Harvesting heights				
T1	147.95	27.26	3.48	6.59
T2	146.96	26.69	3.40	6.85
T3	147.45	26.30	3.25	6.63
SEd	1.68	0.96	0.13	0.21
CD (P=0.05)	NS	NS	NS	NS

Main plot	Sub plot (harvesting heights)
S1 – 1.50 m X 0.25 m	T1- 30 cm
S2 – 1.50 m X 0.50 m	T2- 45 cm
S3 – 1.50 m X 0.25 m X 0.25 m	T3- 60 cm
S4 – 1.50 m X 0.50 m X 0.50 m	

Table 2. Effect of plant geometry and harvesting heights in leaf yield of PKM 1 annual moringa in a plot (36 m X 3 m)

Plot Yield (36 m x 3 m)			
Treatment	Compound leaves weight (Kgs)	Leaflets weight (Kgs)	Dry leaf weight (Kgs)
Spacing			
S1	61.58	38.49	7.00
S2	49.83	32.03	5.85
S3	80.49	50.81	9.33

S4	64.05	40.59	7.42
SEd	5.75	0.82	0.17
CD (P=0.05)	14.09	2.02	0.42
Harvesting heights			
T1	67.71	42.78	7.82
T2	64.52	39.82	7.31
T3	59.74	38.84	7.07
SEd	1.88	1.19	0.22
CD (P=0.05)	3.99	2.52	0.47

Main plot	Sub plot (harvesting heights)
S1 – 1.50 m X 0.25 m	T1- 30 cm
S2 – 1.50 m X 0.50 m	T2- 45 cm
S3 – 1.50 m X 0.25 m X 0.25 m	T3- 60 cm
S4 – 1.50 m X 0.50 m X 0.50 m	

Table 3. Effect of plant geometry and harvesting heights on PKM 1 moringa leaf yield (tonnes) for one hectare

Treatments	Compound leaf yield (tonnes/ hectare)					Fresh Leaflets yield (tonnes/ hectare)					Dry Leaf Yield (tonnes/hectare)				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
T1	5.82	4.91	8.36	5.98	6.27	3.64	3.04	5.36	3.80	3.96	0.66	0.55	0.98	0.70	0.72
T2	5.66	4.87	7.44	5.92	5.97	3.53	2.98	4.47	3.76	3.69	0.65	0.54	0.83	0.69	0.68
T3	5.63	4.05	6.56	5.88	5.53	3.52	2.87	4.29	3.71	3.60	0.64	0.53	0.77	0.68	0.65
Mean	5.70	4.61	7.45	5.93	5.92	3.56	2.97	4.71	3.76	3.75	0.65	0.54	0.86	0.69	0.69
	S	T	SxT	T x S		S	T	SxT	TxS		S	T	Sx T	Tx S	
SEd	0.53	0.17	0.35	0.99		0.08	0.11	0.22	0.26		0.01	0.02	0.04	0.05	
CD															
(P = 0.05)	14.09	3.99	7.99	25.65		0.19	0.23	0.47	0.57		0.04	0.04	0.09	0.11	

Main plot	Sub plot (harvesting heights)
S1 – 1.50 m X 0.25 m	T1- 30 cm
S2 – 1.50 m X 0.50 m	T2- 45 cm
S3 – 1.50 m X 0.25 m X 0.25 m	T3- 60 cm
S4 – 1.50 m X 0.50 m X 0.50 m	

CONCLUSION

The harvesting heights influenced the plant yield and the harvesting at minimum height of 30 cm gave maximum yield in all the four spacing. But the harvesting heights did not influence on the growth parameters such as plant height, number of compound leaves, number of primary branches and stem girth. From the results it can be concluded that the spacing 1.50 m x 0.25 m x 0.25 m provides increased yield when harvested at the height of 30 cm above the ground level.

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Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Originality and plagiarism

The work done is a original research and references are appropriately cited. Consent for publication All the authors agreed to publish the content.

Competing interests

There were no conflict of interest in the publication of this content

Data availability

All the data of this manuscript are included in the MS. No separate external data source is required.

Author contributions

Nil

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