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OPTIMIZING GROWTH: IMPACT OF VARIETY, PLANTING TIME AND SPACING ON FODDER MORINGA

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SUMMARY

A field study entitled "Effect of variety, planting time, and spacing management on growth parameters of fodder Moringa," was carried out at Agronomy Research Farm of CCSHAU, Hisar, Haryana, India using the crop that was sown in the summer season of 2023. Sandy loam soil with a somewhat alkaline composition, 0.43% organic carbon, low available nitrogen, medium available phosphorus, and medium available potash was found at the experimental site. In factorial RBD with three replications, two varieties *viz*. PKM-1 and Moringa desi were assessed on two sowing dates (10 March and 25 March) and three spacings (30 cm × 15 cm, 30 cm × 30 cm, and 45 cm × 15 cm). According to the results, the PKM-1 variety performed noticeably better than Moringa Desi in terms of growth characteristics. Better growth, nutrient uptake, and financial gains were obtained from sowing on March 10th as compared to March 25th sowing. Wider spacing improved the performance of individual plants, whereas, 30 cm × 15 cm spacing produced the highest gross and net returns. The results reveal that the PKM-1 variety, which was displayed on March 10 at a spacing of 30 cm × 15 cm, has the potential to maximize yield and financial returns in Moringa farming.

Key words: Moringa, variety, sowing time, spacing, management, growth, productivity, quality, profitability and fodder

In recent years, underutilized crops have drawn the interest of industrialists, researchers, farmers, and nutritionists. One plant that has long been disregarded but is now being researched for its potential as a feed crop, high nutritional value, and quick growth is Moringa oleifera. Native to North-West India, *Moringa oleifera* L. is a member of the Moringaceae family and does well in tropical and subtropical environments. There are 13 species in the genus, including two that are native to India: *Moringa oleifera* Lam. and *Moringa concanensis* (Pradheep *et al.*, 2011). From an area of 38,000 hectares, India produces 1.1 to 1.3 million tonnes of tender fruits annually. India is home to the biggest moringa growers in the world, claim Bharathi *et al.* (2018). In terms of area and output, Andhra Pradesh is in first place, followed by Tamil Nadu and Karnataka. Due to its wide genetic diversity (annual and perennial Moringa) from various geographic locations, it is easier to set up and more versatile. Sekhar *et al.* (2018) describe *M. oleifera* as the "natural nutrition of the tropics," making it a noteworthy food item that has garnered a lot of attention. According to El-Hack *et al.* (2018), the valuable features in each component of plant makes it versatile by virtue of its usage as forage, herbal medicine, fertilizer, spices, food, natural coagulant, nectar for bees and its ability to check soil erosion. It also possesses antioxidant, anti-diabetic, anti-bacterial and anti-fungal properties. Furthermore, Moringa is a good source of â-carotene, ascorbic acid, alpha-tocopherol, nicotinic acid, riboflavin, pyridoxine, folic acid, and essential amino acids (El-Hack *et al.*, 2018). The most used portion is its leaves, which possess pharmacological qualities due to their abundance in vitamins, carotenoides, polyphenols, phenolic acids, glucosinolates, flavonoides, alkanoides, isothiocyanates, tannins, and saponins (Leone *et al.*, 2015).

Farmers found that it was remunerative to produce Moringa crops in the summer. Because of its rich nutrient profile and immune-modulatory characteristics, moringa leaves are also utilized as animal feed, which boosts animal productivity (Fahey, 2005). As a result, moringa acquire foothold as summertime vegetable and fodder crop. Even though there is enormous area under cultivation and common grazing pasture, India observes a lack of green fodder (net deficit 35.6%). In these settings, fodder plants species perform crucial function to supply the needs for green fodder, especially during lean periods. According to a study, in India fodder need is 583.66 Mt of dry fodder and 883.95 Mt of green fodder. While the approximate production of dry fodder is 355.93 Mt, and green fodder is 664.73 Mt. To solve the current deficiency of 218.22 Mt of green fodder and 227.73 Mt of dry fodder (Yadav *et al.,* 2017), it is vital to develop effective policies and research programs to boost existing fodder resources. Green fodder is the least accessible following the harvest of wheat, brassica, and maize. As a result, cattle rearing becomes particularly problematic in places with water scarcity due to the low quality and insufficient quantity of forage. Fodder tree leaves serve as an alternate feeding source for livestock and can address feed shortages and nutritional deficits in small ruminants. Therefore, we need high-quality fodder tree crops that can preserve natural resources while increasing milk and meat production at a reasonable cost.

Because moringa is so drought tolerant, it can thrive in saline soils, where the seeds dormant for a long time but the seedlings grow quickly. Moringa can withstand repeated harvests because of its strong potential for regeneration. Furthermore, there is now more interest in using it as a source of protein for cattle due to its low toxicity to animals (Furo and Ambali, 2011) (Asaolu *et al.,* 2012). Since Moringa leaves have a favorable nutritional profile that includes components like neutral detergent fiber (NDF), acid detergent fiber (ADF), crude protein (CP), gross energy (GE), ether extract (EE), and amino acids, Rubanza *et al.* (2005) found that animals eating Moringa leaves had improved feed digestibility. The nutritional value of moringa species is very high; they provide a big amount of crude protein, as well as substantial energy and organic matter digestibility. Moringa may be produced successfully in marginal terrain with high temperatures and little water availability, while other crops find it difficult to flourish (Pradhan *et al.,* 2023, Nouman *et al.,* 2014). Plant density, genotype, and planting date are the primary determinants of Moringa fodder yield. Plant density has a direct impact on Moringa leaf yield and quality in addition to growth. Varieties, cultivation methods, soil characteristics, and climate all affect plant density. Furthermore, the amounts of active ingredients in aromatic and medicinal crops are strongly influenced by the planting date (Ghani *et al.,* 2011). Depending on the soil and climate, commercially available Moringa varieties include PKM 1, PKM 2, GKVK 1, GKVK 2, and Rohit. Many ecotypes of M. oleifera can be found in India, and some new kinds have just been created. Two new kinds, Periyakulum-1 (PKM-1) and Periyakulum-2 (PKM-2), have been introduced by Tamil Nadu Agricultural University (TNAU). The KDM-1 cultivar was also created at the University of Horticultural Sciences in Bagalkot. Due to its great output, which was attained through pure breeding, the hybrid drumstick (PKM-1 or Periyakulam-1) stands out among these (Tripathi *et al.,* 2018). The absence of elite varieties that are appropriate for regional conditions frequently limits productivity, despite the significant morphological variability and room for development (Leone *et al.,* 2015).

MATERIALS AND METHODS

The experiment entitled was conducted with crop sown during summer at Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana. Hisar is located in the Indo-Gangetic plains at coordinates 29° 10' N latitude and 75° 46' E longitude, with an altitude of 215.2 meters above sea level in the western part of Haryana, in factorial randomized plot design, thrice replication having varieties (2) - PKM-1, Moringa Desi first factor, planting time (2)- 1st fortnight of March 2nd , fortnight of March second factor and spacing (3) 30 cm × 15 cm, 30 cm × 30 cm, 45 cm × 15 cm third factor. Total land was divided into thirty-six plots. The size of each plot was 5.0 m × 3.0 m. The region has a subtropical semi-arid climate. The site was characterized by uniform topography, well-textured soil, and good fertility, complemented by effective irrigation facilities. The analysis made use of the replicated observations’ means. A statistical program called OPSTAT (http://hau.ernet.in/sheoranop/) was utilized to analyses all the data collected in the research field. As nitrogen, phosphorus and potassium source, the fertilizer urea, DAP and muriate of potash was used in the experiment. The data indicate that the surface soil (0-15 cm) of the experimental field is classified as sandy loam, with a composition of 61.1% sand, 17.7% silt, and 20.1% clay. The soil has organic carbon content (0.43%), low available nitrogen (149.89 kg/ha), medium available phosphorus (12.37 kg/ha), and medium available potash (235.5 kg/ha). Additionally, the soil was found to be slightly saline having a pH of 7.7.

RESULTS AND DISCUSSION

Plant height (cm)

The data pertaining to plant height of Moringa at different stages are presented in Table 1. The plant height of Moringa was significantly influenced by variety, sowing date and spacing at different harvesting stages. Variety PKM-1 recorded significantly higher plant height at all harvest stages compared to the Moringa desi (local variety). At 60 DAS, PKM-1 attained a height of 93.21 cm, while Moringa desi reached 82.70 cm. The data in Table 1. further showed that plants sown on 10th March exhibited statistically greater height at all stages compared to the sowing time of 25th March. For instance, at 60 DAS, plants sown on 10th March reached 88.97 cm compared to 86.94 cm for the 25th March sowing. The 30 cm × 15 cm spacing recorded significantly taller plant (*i.e.*, 91.89 cm at 60 DAS) over to 45 cm × 15 cm spacing (88.32 cm at 60 DAS) and 30 cm × 30 cm spacing (83.65 cm at 60 DAS) due to increased competition for light and vertical growth. At 60 DAS the difference in 30 cm × 30 cm and 45 cm × 15 cm was also significant in respect of plant height and the spacing 30 cm × 30 cm pertain significantly smaller plant over other spacing. The higher performance of PKM-1 can be growth parameters to its superior genetic potential and improved physiology for vegetative growth. The results revealed that variety PKM-1 consistently outperformed Moringa desi in terms of plant height and number of branches production. Research supports the observed trends in plant height and number of branch production under different treatments. These findings align with studies by Patel *et al*. (2020), who reported improved growth characteristics for hybrid varieties under similar agro-climatic conditions.

No. of branches per m^2

The analysis of the data presented in table 1.1 revealed that the number of branches per square meter was significantly influenced by variety, sowing time, and spacing. The results revealed that Moringa variety PKM-1 recorded significantly more branches m^{-2} compared to Moringa desi. At 60 DAS, PKM-1 recorded 143.07 branches/m^{-2}, significantly higher than Moringa desi with 127.00 branches m^{-2}. Sowing time had significant effect on number of branches m^{-2}. Data further showed that plants sown on 10th March exhibited a slightly higher number of branches compared to those sown on 25th March. At 60 DAS, the number of branches were 136.41/m^{-2} for the 10th March sowing, compared to 133.66/m^{-2} for the 25th March. The data in Table 1.1 further showed that the plant spacing had a profound effect on the number of branches/m^{-2}. Spacing 30 cm × 15 cm resulted in the highest branch count, over to 30 cm × 30 cm and 45 cm × 15 cm with values such as 164.16

TABLE 1

Effect of variety, sowing time and spacing management on growth parameters and yield of Moringa

Treatments	At 60 DAS				Total Green fodder yield from 4 cuts (t/ha)
	Plant height (cm)	No. of branches/ m^2	Stem girth (cm)	Leaf: stem	
Variety					
V_1: PKM-1	93.21	143.07	2.54	1.566	76.74
V_2: Moringa desi	82.70	127.00	2.39	1.522	58.55
SEm±	0.53	0.80	0.04	0.003	0.37
CD (p=0.05)	1.54	2.33	0.11	0.010	1.08
Sowing time					
P_1: 10th March	88.97	136.41	2.48	1.546	70.60
P_2: 25th March	86.94	133.66	2.45	1.542	64.69
SEm±	0.53	0.80	0.04	0.003	0.37
CD (p=0.05)	1.54	2.33	NS	NS	1.08
Spacing					
S_1: 30 cm × 15 cm	91.89	164.16	2.37	1.568	81.73
S_2: 30 cm × 30 cm	83.65	106.30	2.57	1.514	56.49
S_3: 45 cm × 15 cm	88.32	134.64	2.46	1.549	64.72
SEm±	0.37	0.56	0.03	0.002	0.26
CD (p=0.05)	1.09	1.65	0.08	0.007	0.77

branches m^{-2} at 60 DAS and 204.57 branches/m^{-2} at the second harvest. Spacing 30 cm × 30 cm recorded the lowest branch numbers, with only 106.30 branches m^{-2} at 60 DAS. These results are consistent with Sharma *et al*. (2021) and Prasad *et al*. (2018), who noted that narrower spacing increased overall branching due to higher plant density, while wider spacing promoted branching per plant but reduces overall canopy density. Patel *et al*. (2020) highlighted the superior performance of hybrid varieties like PKM-1 in branching.

Stem girth (cm)

The stem girth reflects the robustness and structural strength of the plant, contributing to its overall biomass and productivity. Data indicated that variety PKM-1 showed significantly higher stem girth compared to Moringa desi (Table 1). At 60 DAS, the girth of PKM-1 was 2.54 cm, while Moringa desi recorded 2.39 cm. No significant difference in stem girth was observed at 60 DAS. The 10th March sowing date resulted in slightly higher stem girth compared to 25th March. Data illustrated in Table 1.1 further displays that the spacing 30 cm × 30 cm resulted in statistically higher stem girth (2.57 cm) over to 45 cm × 15 cm (2.46 cm) and 30 cm × 15 cm (2.37 cm) at 60 DAS.

Leaf: stem ratio

The data presents on leaf: stem in Table 1, which is a critical indicator of vegetative biomass distribution in Moringa, influencing the quality of fodder and biomass productivity. PKM-1 exhibited a higher leaf: stem compared to Moringa desi. The effect of variety on leaf: stem was significant. At 60 DAS, the ratio for PKM-1 was 1.566 compared to 1.522 for Moringa desi. Sowing time had no significant effect on leaf: stem. The 30 cm × 15 cm spacing yielded the highest leaf: stem of 1.514 at the 60 DAS. Spacing 30 cm × 30 cm consistently showed the lowest ratios. This is likely because 30 cm × 15 cm which is a narrower spacing, promotes vertical growth and leaf production per unit area, whereas, wider spacing allows more stem growth per plant.

Fodder yield

The effect of varieties on fodder yield was significant. PKM-1 significantly higher was green fodder (76.74 t/ha) to Moringa desi (58.55 t/ha). fodder yield was significantly affected due to sowing time. Table 1 predicted that sowing early, March first fortnight produced significantly higher total green fodder yield (70.60 t/ha) than sowing during second fortnight of March (64.69 t/ha). Spacing significantly

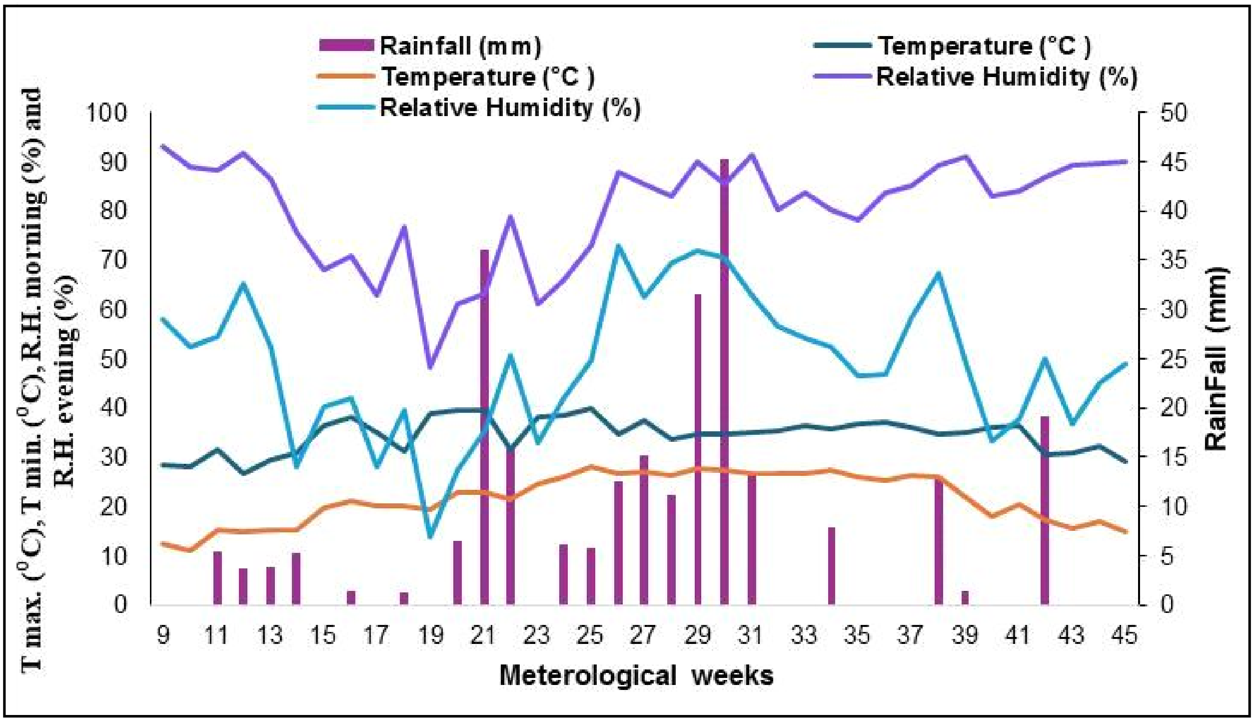
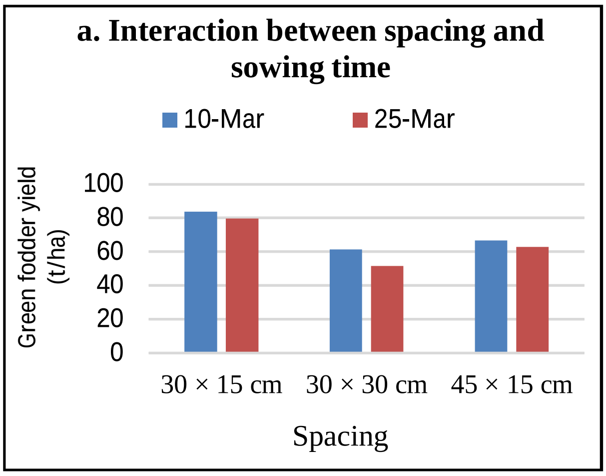


Fig. 1. Weekly meteorological data of crop season.



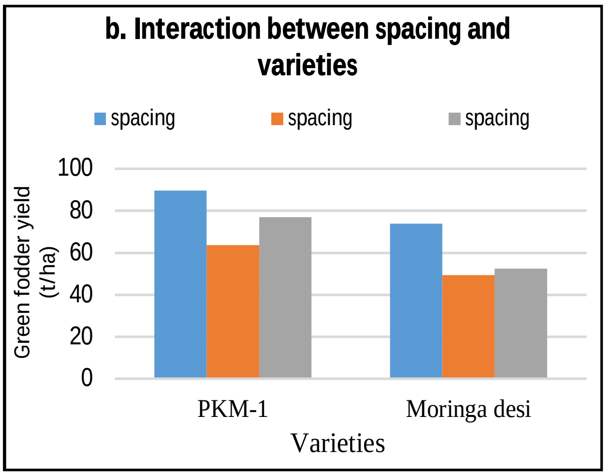


Fig. 2. Interaction effect of sowing time and spacing (a) and spacing and varieties (b) on green fodder yield of moringa.

differs from the fodder yield. Crop geometry 30 cm x 15 cm (81.73 t/ha) produced significantly higher total green fodder in comparison to 30 cm x 30 cm (56.49 t/ha) and 45 cm x 15 cm (64.72 t/ha).

Interaction between spacing and sowing time, and varieties with spacing shown in Fig 2. Data presented in Fig 2(a) indicate that spacing 30 cm x 15 cm gave higher yield in both the varieties and followed by 45 cm x 15 cm. In 30 cm x 30 cm crop geometry, sowing at second fortnight reduced yield more (16.1 %) comparison to 45 cm x 15 cm (5.62%) and 30 cm x 15 cm (4.92 %). Interaction effect between varieties and spacing shows the effect on fodder yield and PKM-1 reduced fodder yield 29.03 & 14.10% and Moringa desi reduced 33.13 & 28.96 %, when sowing was done at 30 cm x 30 cm and 45 cm x 15 cm spacing, respectively, over to 30 cm x 15 cm (Fig 2b).

CONCLUSION

Variety PKM-1 consistently obtained taller plants and a higher number of branches per square meter at 60 DAS as compared to Moringa desi. PKM-1 also had a higher leaf: stem as compared to Moringa desi. Moringa sowing at 10th March resulted in taller plants and greater number of branches per square meter than 25th March. However, the differences were not large, and both sowing dates exhibited significant effects at 60 DAS. The earlier sowing date (10th March) generally resulted in thicker stems. Growth parameters were significantly higher under the crop geometry 30 cm × 15 cm. Moringa plant grown with 30 cm × 15 cm density resulted in better yield and highest leaf-stem ratio.

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