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Effect of planting methods and fertilizer levels on growth of mint (*Mentha spicata* L.)

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Abstract
A field experiment entitled, "Effect of planting methods and fertilizer levels on growth and yield of mint (*Mentha spicata* L.)" was conducted at College of Horticulture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during the year 2023-24. The experiment was laid out in Split plot design with 18 treatment combinations replicated thrice. The first factor consists of three planting methods i.e. 1) M_1- Ridges and furrow method 2) M_2- Raised bed method and 3) M_3- Flat bed method and second factor consists of six fertilizer levels 1) F_1- 100:50:40 NPK kg/ha 2) F_2- 100:50:50 NPK kg/ha (control) 3) F_3- 80:50:40 NPK kg/ha 4) F_4- 80:50:50 NPK kg/ha 5) F_5- 120:50:40 NPK kg/ha 6) F_6- 120:50:50 NPK kg/ha. The results revealed that raised bed method of planting (M_2) recorded significantly highest plant height (30.09 and 15.60 cm) Number of leaves (606.21 and 909.87) Number of branches (94.68 and 97.54) Plant spread E-W (39.81 and 37.25 cm) Plant spread N-S (39.41 and 42.28 cm). In fertilizer levels, application of 80:50:40 NPK kg/ha (F_3) recorded maximum Plant height (34.88 and 16.97 cm) number of leaves (729.80 and 941.80) number of branches (100.84 and 97.71) plant spread E-W (41.63 and 38.33 cm) Plant spread N-S (41.47 and 40.80 cm). In interaction effect the treatment combination M_2F_3 recorded the highest plant height (39.30 and 17.69 cm), Number of leaves (792.27 and 1115.40), Plant spread E-W (47.41 and 40.54 cm) and Plant spread N-S (42.87 and 45.73 cm) at 60 DAP and at 30 days after harvesting. Number of branches recorded highest in M_2F_2 (113.40) treatment combination at 60 DAP and M_2F_3 treatment combination recorded highest number of branches (111.80) at 30 DAH.

Keywords: Mint, planting method, fertilizer level, growth parameters

Introduction
Mint is a stimulant herb that can enhance the taste of variety of foods. About 25 species of the genus *mentha* which are members of the lamiaceae family. Spearmint is considered an industrial crop among mint species Because it contains essential oils rich in particular monoterpenes like carvol, dihydrocarveole, dihydrocarveylacetate, menthol, menthone, caryophyllene, terpineol, and cubebene-all of which are widely used in the food (Edris *et al*., 2003) [3], flavor, cosmetics, and pharmaceutical industries (Foda *et al*., 2010) [4].
India started producing and exporting mint to other nations on a business basis in the 1980s. With an average productivity of almost 120 kg/ha, it is currently the largest producer of this crop in the world, taking approximately 0.30 million hectares of land and yielding 38,000 metric tonnes of essential oil annually. This supplies around 80% of the world's supply of mint oil, meeting 75% of global demand; China and Japan come in second and third, respectively, with roughly 10% of the total (Misra *et al*., 2000) [11]. Uttar Pradesh is the state that produces the most mentha in India, accounting for 80-90% of the overall production. Next in line are Himachal Pradesh, Punjab, Haryana, and Bihar. Karvy (2011) [8]. According to Pearson *et al*. (2010), the herb spearmint has stimulant, diuretic, restorative, carminative, anti-inflammatory, and anti-spasmodic qualities. Recently, spearmint has become well-known as a powerful antioxidant source for nutraceuticals. It has strong antioxidant properties and is high in polyphenols. It is widely cultivated all over the world for the production of its highly valuable essential oil. The spear-shaped blossoms that distinguish it from other varieties give it its name, and it is believed to be the oldest mint. *Mentha rotundifolia* and *Mentha longifolia* are its parents. With notes of sweetness and lemon, spearmint's fresh, woodsy, and minty aroma has a cooling effect (Lawrence, 2007) [13].

For mint to develop and yield as best it can, the right planting technique and fertilizer level must be determined. Using the three planting techniques and different fertilizer levels, the goal is to increase the output per unit of land area. Nitrogen is vitally required for plant growth because it is key component of protein, nucleic acid, some hormones and chlorophyll which are critical for plant growth. Phosphorus and nitrogen are both essential and primarily found as phosphate esters, which are crucial for photosynthesis. Also, it is a major ingredient of phospholipids and nucleic acid. Potassium including its involvement in osmoregulation and the activation of several enzymes involved in respiration and photosynthesis. Therefore, the most crucial elements influencing nutrient absorption, development, yield, and plant quality are planting techniques and nutrient management. Different planting techniques increase crop quality and productivity. It aids with aeration, waterlogging prevention, and water use efficiency. Additionally, it improves crop stand and boosts the effectiveness of fertilizer utilization. This experiment was conducted to ascertain the optimal planting technique and fertilizer dosage to optimize mint yield.

2. Materials and Methods

The field experiment was conducted during the year 2023-24 at Nursery No. 4, College of Horticulture, Dapoli, Dist. Ratnagiri to study the effect of planting methods and fertilizer levels on growth and yield of mint (*Mentha spicata* L.). The treatment combinations comprised with three planting methods *viz*., M_1- Ridge and furrow method, M_2- Raised bed method and M_3- Flat bed method and six fertilizer levels (F_1- 100:50:40 NPK kg/ha, F_2- 100:50:50 NPK kg/ha (control), F_3- 80:50:40 NPK kg/ha, F_4- 80:50:50 NPK kg/ha, F_5- 120:50:40 NPK kg/ha and F_6- 120:50:50 NPK kg/ha) were conducted with split plot design where planting methods were allocated to main plots and fertilizer levels were assigned to sub plots and replicated thrice.

The field selected for the experiment was well levelled. The whole experimental plot was brought to a fine tilth by repeated ploughings followed by harrowing by tractor drawn cultivator. In ridge and furrow method, ridges were prepared at 60 cm apart and with a length of 3 m. Raised beds of 15 cm height and 3 X 1m size were prepared with 1 m gap between two beds and mint cuttings were planted at 45 X 30 cm distance. Flat beds of size 3 X 1m were prepared with 1m gap between two beds and mint cuttings were planted at 45 X 30 cm distance. Fifteen to twenty days old terminal rooted cuttings of 12-15 cm height were used for planting.

Vermicompost @ 5 t/ha was applied at the time of planting while full dose of phosphorous in the form of single super phosphate was applied at the time of planting as per treatment as a basal dose. Nitrogen and potassium in the form of urea and muriate of potash were applied in three equal split doses @ 1/3rd N and K at planting, 1/3rd at N and K at one month after planting and remaining 1/3rd N and K at two month after planting.

Ten plants were randomly selected from each treatment for recording observations on growth and yield parameters. Observations regarding growth parameters were recorded at 15 days interval whereas yield parameters were recorded at first harvest *i.e*. 70 DAP and at second harvest *i.e*. 110 DAP. Gap filling and weeding were done wherever necessary.

3. Results and Discussion

3.1 Effect of planting methods

Planting methods significantly influenced the growth characters. The results revealed that raised bed planting method for mint recorded significantly the maximum plant height (30.09 and 15.60 cm), number of leaves (606.21 and 909.87), number of branches (94.68 and 97.54), plant spread E-W (39.81 and 37.25 cm) and plant spread N-S (39.41 and 42.28 cm) at 60 DAP and at 30 days after harvesting. The ridge and furrow method recorded the minimum plant height (27.06 and 14.18 cm), number of leaves (509.60 and 637.86), number of branches (73.73 and 59.26), plant spread E-W (33.75 and 32.11 cm) and plant spread N-S (33.73 and 32.77 cm) at 60 DAP and at 30 days after harvesting. The significant improvement noticed in growth and yield parameters observed with the raised bed method of planting might be due to improved drainage and aeration which promotes the development of deep root systems and better nutrient utilization consequently, it improved the physical condition of the soil in the raised bed method resulting in a good soil plant water relationship. With increased in nutrient and water use efficiency, improved aeration from elevated beds speeds up the pace of mineralization and significantly improves the growth characteristics. Moreover, these findings of plant growth with planting methods are in agreement with the works of Gurjar *et al*. (2022) [5] in chrysanthemum Nithin *et al*. (2018) [12] in menthol mint, Tomar *et al*. (2016) [17] in black gram, Varsha Rani *et al*. (2023) [18] in round red radish.

3.2 Effect of fertilizer levels

The results revealed that application of fertilizer level F_3- 80:50:40 NPK kg/ha fertilizer level recorded significantly the highest plant height (34.88 and 16.97 cm), number of leaves (729.80 and 941.80), number of branches (100.84 and 97.71), plant spread E-W (41.63 and 38.33 cm) and plant spread N-S (41.47 and 40.80 cm) at 60 DAP and at 30 days after harvesting. The fertilizer levels F_6- 120:50:50 NPK kg/ha recorded the lowest plant height (24.37 and 13.88 cm), number of leaves (419.00 and 620.67), number of branches (68.22 and 70.62), plant spread E-W (31.44 and 31.42 cm) and plant spread N-S (31.92 and 31.88 cm) at 60 DAP and at 30 days after harvesting. The fertilizer level showed significant effect on growth and yield parameters because of the adequate and well-balanced supply of necessary nutrients (NPK) at the ideal fertilizer levels, which are crucial for cell division, elongation, and the general development of vegetative growth. Potassium increased the efficiency of nutrient and water intake, phosphorous promoted root establishment and energy transmission, and nitrogen probably contributed to improved leaf development. The results were similar to the findings of Shelke *et al*. (2024) [16] in Kalmegh, Izhar *et al*. (2015) [7] in mint (*Mentha arvensis*), Kalita *et al*. (2018) [9] in tulsi, Patel *et al*. (2021) [14] in spinach, Alhassan *et al*. (2022) [1] in spearmint (*Mentha spicata* L.), Gupt *et al*. (2025) [6] in Japanese mint (*Mentha arvensis* L.), Pujankhanal *et al*. (2022) [15] in radish

Table 1: Effect of planting methods, fertilizer levels and their interaction on plant height of mint (*Mentha spicata* L.)

Treatment	Plant height (cm) at 60 DAP				Plant height (cm) at 30 DAH			
Fertilizer levels	Planting methods				Planting methods			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
F_1	26.86	28.09	28.91	27.95	13.71	14.87	13.85	14.14
F_2	25.56	30.59	27.28	27.81	14.05	14.36	13.83	14.08
F_3	31.92	39.30	33.43	34.88	16.61	17.69	16.33	16.97
F_4	29.49	31.69	32.77	31.31	13.59	16.53	16.06	15.39
F_5	24.19	26.40	25.16	25.25	13.89	15.70	14.27	14.62
F_6	23.90	24.47	24.75	24.37	13.23	14.48	13.93	13.88
Mean	27.06	30.09	28.72	28.62	14.18	15.60	14.71	14.83
	S.Em±	CD at 5%		RESULT	S.Em±	CD at 5%		RESULT
M	0.57	2.25		SIG	0.22	0.87		SIG
F	0.61	1.77		SIG	0.22	0.63		SIG
M X F	1.06	3.07		SIG	0.38	1.09		SIG

Table 2: Effect of planting methods, fertilizer levels and their interaction on number of leaves of mint (*Mentha spicata* L.)

Treatment	Number of leaves at 60 DAP				Number of leaves at 30 DAH			
Fertilizer levels	Planting methods				Planting methods			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
F_1	416.87	759.33	543.33	573.18	588.87	907.40	646.73	714.33
F_2	569.07	412.13	377.00	452.73	547.80	824.27	734.93	702.33
F_3	630.47	792.27	766.67	729.80	826.80	1115.40	883.20	941.80
F_4	516.33	739.47	562.47	606.09	738.73	996.60	803.20	846.18
F_5	465.00	508.13	577.67	516.93	544.87	937.93	744.53	742.44
F_6	459.87	425.93	371.20	419.00	580.07	677.60	604.33	620.67
Mean	509.60	606.21	533.06	549.62	637.86	909.87	736.16	761.29
	S.Em±	CD at 5%		RESULT	S.Em±	CD at 5%		RESULT
M	9.59	37.63		SIG	31.58	123.96		SIG
F	37.02	106.92		SIG	19.95	57.62		SIG
M X F	64.13	185.18		SIG	34.56	99.81		SIG

Table 3: Effect of planting methods, fertilizer levels and their interaction on number of branches of mint (*Mentha spicata* L.)

Treatment	Number of branches at 60 DAP				Number of branches at 30 DAH			
Fertilizer levels	Planting methods				Planting methods			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
F_1	71.60	91.80	84.53	82.64	54.47	86.40	89.87	76.91
F_2	68.33	113.40	53.47	78.40	51.60	93.93	73.20	72.91
F_3	105.00	100.60	96.93	100.84	76.40	111.80	104.93	97.71
F_4	74.13	90.93	95.33	86.80	71.20	101.87	94.80	89.29
F_5	60.20	99.33	83.47	81.00	49.33	95.67	87.13	77.38
F_6	63.13	72.00	69.53	68.22	52.53	95.60	63.73	70.62
Mean	73.73	94.68	80.54	82.99	59.26	97.54	85.61	80.80
	S.Em±	CD at 5%		RESULT	S.Em±	CD at 5%		RESULT
M	2.59	10.18		SIG	4.59	18.04		SIG
F	4.59	13.26		SIG	2.32	6.70		SIG
M X F	7.95	22.97		SIG	4.02	11.61		SIG

Table 4: Effect of planting methods, fertilizer levels and their interaction on plant spread E-W of mint (*Mentha spicata* L.)

Treatment	Plant spread E-W (cm) at 60 DAP				Plant spread E-W (cm) at 30 DAH			
Fertilizer levels	Planting methods				Planting methods			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
F_1	34.40	39.15	33.34	35.63	30.81	38.16	36.99	35.32
F_2	27.45	41.28	34.92	34.55	30.89	37.10	33.74	33.91
F_3	39.71	47.41	37.78	41.63	36.47	40.54	37.99	38.33
F_4	37.90	39.93	36.41	38.08	35.17	36.64	37.75	36.52
F_5	31.25	39.72	35.43	35.47	31.15	36.50	31.05	32.90
F_6	31.80	31.34	31.17	31.44	28.19	34.56	31.50	31.42
Mean	33.75	39.81	34.84	36.13	32.11	37.25	34.84	34.73
	S.Em±	CD at 5%		RESULT	S.Em±	CD at 5%		RESULT
M	0.90	3.54		SIG	0.92	3.61		SIG
F	1.09	3.14		SIG	0.58	1.68		SIG
MxF	1.88	5.44		SIG	1.01	2.91		SIG

Table 5: Effect of planting methods, fertilizer levels and their interaction on plant spread N-S of mint (*Mentha spicata* L.)

Treatment	Plant spread N-S (cm) at 60 DAP				Plant spread N-S (cm) at 30 DAH			
Fertilizer levels	Planting methods				Planting methods			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
F_1	38.50	40.14	35.29	37.98	31.96	44.07	35.46	37.16
F_2	26.04	38.78	34.15	32.99	33.50	39.59	32.63	35.24
F_3	40.93	42.87	40.61	41.47	36.94	45.73	39.73	40.80
F_4	36.13	38.87	33.37	36.12	35.20	44.05	37.12	38.79
F_5	31.78	40.51	34.55	35.61	31.45	40.93	32.40	34.93
F_6	29.01	35.30	31.45	31.92	27.57	39.31	28.75	31.88
Mean	33.73	39.41	34.90	36.02	32.77	42.28	34.35	36.46
	S.Em±	CD at 5%		RESULT	S.Em±	CD at 5%		RESULT
M	0.85	3.35		SIG	0.65	2.56		SIG
F	0.97	2.80		SIG	0.50	1.45		SIG
M X F	1.68	4.85		SIG	0.87	2.50		SIG

3.3 Interaction effect of planting method and fertilizer levels

From the data presented in (Table 1, 2, 3, 4 and 5) the treatment combination M_2F_3 (raised bed method with 80:50:40 NPK kg/ha) recorded significantly the highest plant height (39.30 cm) at 60 DAP and (17.69 cm) at 30 DAH. M_1F_3 (16.61 cm) treatment combination was found at par at 30 DAH, number of leaves highest in M_2F_3 treatment combination (792.27) at 60 DAP which was found at par with treatment combination M_2F_3 (766.67), M_2F_1 (759.33), M_2F_4 (739.47) and M_1F_3 (630.47) and at 30 DAH, treatment combination M_2F_3 (1115.40) significantly superior over rest of the treatments combinations, number of branches (113.40) were recorded in treatment combination M_2F_2 which was found at par with treatment combination M_1F_3 (105.00), M_2F_3 (100.60), M_2F_5 (99.33), M_3F_3 (96.93), M_3F_4 (95.33), M_2F_1 (91.80) and M_2F_4 (90.93) at 60 DAP and at 30 DAH, M_2F_3 (111.80) treatment combination recorded the highest number of branches which was found at par M_3F_3 (104.93) and M_2F_4 (101.87), plant spread E-W (47.41cm) at 60 DAP found significantly superior in M_2F_3 over other treatment combination and at 30 DAH, the treatment combination M_2F_3 (40.54 cm) recorded the highest plant spread which was found at par with treatment combination M_2F_1 (38.16 cm), M_3F_3 (37.99 cm) and M_3F_4 (37.75 cm) and the highest plant spread N-S (42.87 cm) was recorded in M_2F_3 treatment combination which was found at par with M_1F_3 (40.93 cm), M_3F_3 (40.61 cm), M_2F_5 (40.51 cm), M_2F_1 (40.14 cm), M_2F_4 (38.87 cm) and M_2F_2 (38.78 cm) at 60 DAP and at 30 DAH the treatment combination M_2F_3 (45.73 cm) recorded the highest plant spread which was found at par with treatment combinations M_2F_1 (44.07 cm) and M_2F_4 (44.05 cm). The treatment combination M_1F_6 recorded lowest plant height (23.90 cm) and (13.23 cm) at 60 DAP and at 30 DAH, number of leaves recorded lowest (371.20) in M_3F_6 treatment combination at 60 DAP and at 30 DAH, M_1F_5 recorded lowest number of leaves (544.87), the lowest number of branches (53.47) recorded at 60 DAP in M_3F_2 treatment combination and at 30 DAH, the lowest number of branches (49.33) were recorded in M_1F_5 treatment combination. At 60 DAP, plant spread E-W was recorded lowest (27.45 cm) in M_1F_2 treatment combination and M_1F_6 recorded lowest (28.19 cm) plant spread E-W at 30 DAH. The lowest plant spread N-S (26.04 cm) was recorded in M_1F_2 treatment combination at 60 DAP and at 30 DAH, M_1F_6 recorded lowest plant spread N-S (27.57 cm). The results might be due to combination of improved soil conditions and deep root system brought about by raised bed methods and continuous soil nutrient availability over the growing season, better fertilizer use efficiency and improved nutrient uptake from nutrient application. Similar findings were also reported by Kumar and Singh (2014) [10] in French bean, Chawla *et al.* (2018) [2] in tuberose and Gurjar *et al.* (2022) [5] in chrysanthemum.

4. Conclusion

From present investigation, it can be concluded that different planting methods, fertilizer levels and their interaction showed significant effect on growth and yield of mint. It was observed that in planting method raised bed method (M_2) and fertilizer levels, 80:50:40 (F_3) had significant effect on growth parameters like plant height, number of leaves, number of branches, plant spread (N-S) and (E-W) followed by flat bed method (M_3) and ridge and furrow method (M_1). So, it can be concluded that growing of mint on raised bed method along with the application of 80:50:40 NPK Kg/ha recorded highest growth attributes.

5. Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT etc.) and text-to-image generators have been used during writing or editing this manuscript.

6. Competing Interests

Authors have declared that no competing interests exist.

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