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Research Article

EFFECT OF ROW SPACING AND NITROGEN LEVELS ON GROWTH AND YIELD OF JAPANESE MINT (*Mentha arvensis* L)

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Abstract- A field study was conducted during 2015 to investigate the effect of row spacing (30 cm, 45 cm and 60 cm) and nitrogen levels (50,100,150 and 200 kg/ha) on growth and yield of Japanese mint (*Mentha arvensis* L.). The result revealed maximum plant height, plant spread, branches, leaves per plant and higher fresh herbage yield per plant was recorded at 60 cm. Whereas, the highest fresh herbage yield per plot, yield per hectare was noticed at closer row spacing of 30 cm. Among different nitrogen levels application of 150 Kg N/ha recorded maximum plant spread, number of branches, leaves per plant, fresh herbage yield per plant, yield per plot and yield per hectare. Whereas, the maximum plant height was recorded with the application of 200 kg nitrogen per hectare.

Keywords- Growth, Yield, Nitrogen levels, Spacing, Days after planting

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Introduction

Mentha is a genus of aromatic perennial herbs belonging to the family Lamiaceae. India dominates in mint production and it supplies 80 per cent of mints globally, followed by China and Japan. In India, Uttar Pradesh accounts for around 90 per cent of Indian mint production, with the remaining 10 per cent coming from smaller areas in Punjab, Rajasthan etc.

Spacing is an important factor which can limit crop growth, production and yield. The factors, *viz*., dry matter accumulation, nutrient uptake, flower number and herb yield are dependent on optimum spacing level. Hence, there is a need to determine specific spacing for crop production.

Nitrogen is an important component of enzymes and nucleic acids. It is an integral constituent of chlorophyll, which promotes photosynthesis and formation of photosynthates from which the vegetative parts are developed. These vegetative structures have a direct bearing on yield [1].

It is possible to produce higher yields by judicious practices in the supply of nutrients and adoption of proper spacing. Being a herbaceous crop, great potential exists for increasing the plant growth and yield through the application of inorganic nitrogenous fertilizers. In general, mint being a leafy crop responds well to nitrogen fertilization and proper spacing is of prime importance to improve the productivity. The effect of spacing on growth and development is largely due to change in interception of radiant energy [2]. Hence, the study is planned to evaluate the performance of Japanese mint under different levels of nitrogen and spacing and identify optimum dose of nitrogen and spacing for maximizing the herbage and oil yield.

Material and Methods

An investigation was carried out to study the effect of row spacing and nitrogen levels on growth and yield of Japanese mint variety Kosi at the Department of Plantation, Spices, Medicinal and Aromatic Crops, Kittur Rani Channamma College of Horticulture, Arabhavi, University of Horticultural Sciences, Bagalkot during 2015. The experiment was laid out in split plot design with twelve treatments and three replications, considering spacing as main plot and nitrogen levels as sub plot.

Japanese mint is propagated through stolons of uniform thickness and standard sizes of 3.0 to 4.0 cm in length were separated from the underground part of the plant. Phosphorous and potassium fertilizers at the rate of 50 and 40 kg per ha in the form of single super phosphate and muriate of potash respectively were uniformly applied to all the plots as basal dose. The crop was harvested 100 days after planting.

Observations on growth parameters were recorded on five randomly selected plants in each replication of different treatments at 30, 60, 90 and 100 days after planting (DAP).

Plant height was measured from the ground level to the growing tip of the main stem and expressed in centimeter. The number of branches per plant was counted from five randomly selected plants and mean was expressed as number of branches per plant. The number of leaves per plant was counted and mean was expressed as number of leaves per plant. The plant spread was taken in N-S and E-W direction from five tagged plants. The mean value of five selected plants was considered as plant spread and expressed in cm.

The fresh herbage yield was recorded in each plot at the time of harvest. Then fresh yield per hectare was calculated on the basis of fresh herbage yield per plot. The fresh herbage yield per hectare was expressed in tonnes.

Result and Discussion

The plant height was significantly influenced by row spacing. At harvest, plants planted at wider row spacing of 60 cm (S_3) were tallest (68.21 cm) compared to the closer spacing (60.17 cm). The increased plant height in wider row spacing might be due to lesser competition between plants at lower plant densities for

nutrients, water, light [3,4]. The plant height increased significantly with increase in the nitrogen level. At 100 DAP, the maximum (68.15 cm) plant height was recorded with the application of 200 kg per ha (N_4) and the least (59.79 cm) was noticed in the plants supplied with lower nitrogen level of 50 kg per ha. The positive influence of nitrogen on plant height might be due to the fact that nitrogen is required for cell division and cell elongation which triggers the growth of meristamatic tissue and the efficient utilization of this by the plants manifested in production of taller plants. [5,6].[Table-1]

Table-1 *Effect of row spacing and nitrogen levels on plant height in Japanese mint (Mentha arvensis L.).*

Plant height (cm)																				
Treatments	30DAP					60 DAP					90 DAP					100 DAP				
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean
S_1	19.22	20.00	20.00	21.54	**20.19**	39.50	42.09	45.73	48.12	**43.86**	55.80	57.64	58.88	62.30	**58.65**	57.07	59.15	60.49	63.98	**60.17**
S_2	20.35	20.87	21.80	22.60	**21.40**	38.13	45.23	48.59	49.11	**45.26**	57.93	59.26	63.65	65.38	**61.55**	59.50	61.24	64.75	67.43	**63.23**
S_3	20.23	22.70	23.15	23.80	**22.47**	45.51	47.49	51.39	52.82	**49.30**	61.70	65.37	68.29	70.95	**66.57**	62.82	65.54	71.43	73.05	**68.21**
Mean	**19.93**	**21.19**	**21.65**	**22.64**		**41.04**	**44.93**	**48.57**	**50.01**		**58.47**	**60.75**	**63.60**	**66.21**		**59.79**	**61.97**	**65.55**	**68.15**	
For comparison of mean																				
	S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %		
Row spacing(S)	0.463		NS			0.864		3.391			1.238		4.860			1.208		4.744		
Nitrogen (N)	0.920		NS			1.582		4.701			1.642		4.879			1.712		5.087		
S at same level of N	1.455		NS			2.525		NS			2.756		NS			2.837		NS		
N at same or different level of S	1.593		NS			2.740		NS			2.844		NS			2.965		NS		

Main plot treatments (S)
S_1: 30 cm
S_2: 45 cm
S_3: 60 cm

Sub plot treatments (N)DAP: Days after planting
N_1: 50 kg/ha
N_2:100 kg/ha
N_3: 150 kg/ha
N_4: 200 kg/ha

Table-2 *Effect of row spacing and nitrogen levels on number of branches per plant in Japanese mint (Mentha arvensis L.).*

Number of branches																				
Treatments	30DAP					60 DAP					90 DAP					100 DAP				
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean
S_1	2.67	2.93	3.37	3.20	**3.04**	8.20	9.37	12.23	9.60	**9.85**	14.83	16.33	20.00	17.40	**17.14**	15.69	18.33	21.20	18.39	**18.40**
S_2	2.80	3.27	3.42	3.20	**3.17**	8.17	12.00	13.23	12.13	**11.38**	16.93	19.53	22.40	20.60	**19.86**	18.80	20.27	25.10	20.93	**21.27**
S_3	3.00	3.07	3.53	3.47	**3.26**	12.00	13.93	14.57	14.10	**13.65**	19.87	20.73	25.37	23.60	**22.39**	21.97	21.50	26.10	24.07	**23.41**
Mean	**2.82**	**3.09**	**3.44**	**3.29**		**9.45**	**11.76**	**13.34**	**11.94**		**17.21**	**18.86**	**22.59**	**20.53**		**18.82**	**20.03**	**24.13**	**21.13**	
For comparison of mean																				
	S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %		
Row spacing(S)	0.092		NS			0.384		1.508			0.499		1.957			0.479		1.882		
Nitrogen (N)	0.171		NS			0.491		1.458			0.623		1.851			0.833		2.474		
S at same level of N	0.272		NS			0.830		NS			1.059		NS			1.337		NS		
N at same or different level of S	0.296		NS			0.850		NS			1.079		NS			1.442		NS		

Main plot treatments (S)
S_1: 30 cm
S_2: 45 cm
S_3: 60 cm

Sub plot treatments (N)DAP: Days after planting
N_1: 50 kg/ha
N_2:100 kg/ha
N_3: 150 kg/ha
N_4: 200 kg/ha

Table-3 *Effect of row spacing and nitrogen levels on number of leaves per plant in Japanese mint (Mentha arvensis L.).*

Number of leaves																				
Treatments	30DAP					60 DAP					90 DAP					100 DAP				
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean
S_1	22.87	22.83	24.79	25.00	**23.87**	257.00	294.80	376.33	325.60	**313.43**	620.00	630.07	716.83	668.60	**658.87**	633.43	642.00	732.17	686.73	**673.58**
S_2	24.17	24.97	24.83	25.00	**24.74**	281.57	356.20	406.20	372.67	**354.16**	686.93	773.33	880.00	800.00	**785.06**	692.77	779.50	896.73	820.03	**797.25**
S_3	23.67	24.80	25.71	24.87	**24.76**	362.07	408.40	493.17	439.83	**425.86**	796.67	890.00	1033.33	846.97	**891.74**	808.07	907.00	1053.41	856.75	**906.30**
Mean	**23.57**	**24.20**	**25.11**	**24.95**		**300.21**	**353.13**	**425.23**	**379.36**		**701.20**	**764.46**	**876.72**	**771.85**		**711.42**	**776.16**	**894.10**	**787.83**	
For comparison of mean																				
	S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %		
Row spacing(S)	0.983		NS			7.885		30.960			14.132		55.487			14.876		58.410		
Nitrogen (N)	0.549		NS			7.640		22.698			17.278		51.335			16.443		48.855		
S at same level of N	1.282		NS			13.910		NS			29.518		NS			28.803		NS		
N at same or different level of S	0.951		NS			13.232		NS			29.925		NS			28.480		NS		

Main plot treatments (S)
S_1: 30 cm
S_2: 45 cm
S_3: 60 cm

Sub plot treatments (N)DAP: Days after planting
N_1: 50 kg/ha
N_2:100 kg/ha
N_3: 150 kg/ha
N_4: 200

Table-4 *Effect of row spacing and nitrogen levels on canopy spread (E-W) in Japanese mint (Mentha arvensis L.)*

Canopy spread (cm)																				
Treatments	30DAP					60 DAP					90 DAP					100 DAP				
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean
S_1	19.07	23.66	24.02	23.52	**22.56**	26.50	28.07	32.68	29.40	**29.16**	33.25	34.66	40.46	40.30	**37.16**	35.27	37.68	44.06	41.04	**39.51**
S_2	20.00	21.43	24.22	23.91	**22.39**	31.37	31.52	35.65	34.51	**33.26**	39.72	41.95	43.96	42.84	**42.11**	41.32	41.95	46.07	44.87	**43.55**
S_3	22.05	23.79	25.40	21.90	**23.28**	36.23	38.95	40.61	39.87	**38.91**	43.07	45.43	49.63	46.81	**46.23**	45.18	48.25	51.48	50.50	**48.85**
Mean	**20.37**	**22.96**	**24.54**	**23.11**		**31.36**	**32.84**	**36.31**	**34.59**		**38.68**	**40.68**	**44.68**	**43.31**		**40.59**	**42.62**	**47.20**	**45.47**	
For comparison of mean																				
	S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %		
Row spacing(S)	0.988		NS			1.091		4.285			0.939		3.688			1.079		4.237		
Nitrogen (N)	1.298		NS			1.102		3.274			1.033		3.070			1.242		3.689		
N at same level of S	2.183		NS			1.980		NS			1.812		NS			2.152		NS		
N at same or different level of S	2.248		NS			1.908		NS			1.789		NS			2.150		NS		

Main plot treatments (S)
S_1: 30 cm
S_2: 45 cm
S_3: 60 cm

Sub plot treatments (N)DAP: Days after planting
N_1: 50 kg/ha
N_2:100 kg/ha
N_3: 150 kg/ha
N_4: 200 kg/ha

Table-5 *Effect of row spacing and nitrogen levels on canopy spread (N-S) in Japanese mint (Mentha arvensis L.).*

Canopy spread (cm)																				
Treatments	30DAP					60 DAP					90 DAP					100 DAP				
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean
S_1	21.63	23.69	24.45	24.30	**23.51**	32.96	34.65	38.62	36.45	**35.67**	40.60	41.68	45.16	42.72	**42.54**	41.27	43.47	46.70	43.23	**43.66**
S_2	22.04	23.72	25.58	24.56	**23.97**	33.30	36.84	42.44	38.38	**37.74**	40.77	43.27	47.39	46.89	**44.58**	42.58	45.81	49.41	48.93	**46.68**
S_3	23.60	24.17	25.68	26.08	**24.88**	40.19	43.37	47.46	45.54	**44.14**	46.79	49.94	55.69	51.20	**50.90**	47.74	51.26	57.40	53.01	**52.35**
Mean	**22.42**	**23.86**	**25.23**	**24.98**		**35.48**	**38.28**	**42.84**	**40.12**		**42.72**	**44.96**	**49.41**	**46.93**		**43.86**	**46.84**	**51.17**	**48.39**	
For comparison of mean																				
	S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %			S.Em ±		S.Em ±		
Row spacing(S)	0.941		NS			1.001		3.930			0.820		3.219			1.023		4.016		
Nitrogen (N)	1.270		NS			1.282		3.809			1.337		3.973			1.226		3.642		
S at same level of N	2.124		NS			2.167		NS			2.166		NS			2.104		NS		
N at same or different level of S	2.198		NS			2.220		NS			2.315		NS			2.123		NS		

Main plot treatments (S)
S_1: 30 cm
S_2: 45 cm
S_3: 60 cm

Sub plot treatments (N)DAP: Days after planting
N_1: 50 kg/ha
N_2:100 kg/ha
N_3: 150 kg/ha
N_4: 200 kg/ha

Table-6 *Effect of row spacing and nitrogen levels on fresh herbage yield in Japanese mint (Mentha arvensis L.).*

Fresh herbage yield															
Treatments	g/plant					Kg/plot					t/ha				
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean
S_1	277.50	319.59	367.33	329.03	**323.36**	16.65	19.18	22.04	19.74	**19.40**	20.56	23.67	27.21	24.37	**23.95**
S_2	305.50	331.87	382.80	349.00	**342.29**	12.22	13.27	15.31	13.96	**13.69**	15.09	16.39	18.90	17.23	**16.90**
S_3	347.90	366.20	471.00	377.20	**390.57**	10.44	10.99	14.13	11.32	**11.72**	12.89	13.56	17.44	13.97	**14.46**
Mean	**310.30**	**339.22**	**407.04**	**351.74**		**13.10**	**14.48**	**17.16**	**15.00**		**16.18**	**17.87**	**21.18**	**18.52**	
For comparison of mean															
	S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %			S.Em ±		CD @ 5 %		
Row spacing(S)	9.265		36.380			0.493		1.935			0.609		2.389		
Nitrogen (N)	12.969		38.532			0.674		2.004			0.833		2.474		
S at same level of N	21.546		NS			1.125		NS			1.389		NS		
N at same or different level of S	22.462		NS			1.168		NS			1.442		NS		

Main plot treatments (S)
S_1: 30 cm
S_2: 45 cm
S_3: 60 cm

Sub plot treatments (N)
N_1: 50 kg/ha
N_2:100 kg/ha
N_3: 150 kg/ha
N_4: 200kg/ha

The number of branches per plant was significantly influenced by row spacing. At 100 DAP, more (23.41) number of branches per plant was noticed in wider row spacing S_3 (60 cm), while less (18.40) number of branches per plant was recorded in closer spacing S_1 (30 cm). The increase in branching at wider row spacing could be attributed to the availability of more spatial area for spreading which helped in more interception of light due to higher surface area [7]. The production of number of branches per plant increased significantly with the increase in nitrogen dose. Among different levels of nitrogen, N_3 (150 kg N/ha) had the highest (24.13) number of branches per plant and the minimum (18.82) was noticed in treatment N_1 (50 kg N/ha) at harvest. The production of more number of branches might be due to the fact that in the initial stages of growth the number of branches produced per plant was minimum and as the growth proceeds, production of more branches occurs. This could be ascribed to the availability of optimum quantity of nitrogen during vegetative growth and split application, which influenced the availability of N [5]. [Table-2]

Row spacing had significant influence on production of leaves per plant at 60, 90

and 100 DAP. At harvest (100 DAP), maximum (906.30) number of leaves was produced in plants planted at a row spacing of 60 cm (S_3), while, minimum (673.58) was observed in 30 cm (S_1) spacing. The increase in leaf production may be attributed to more number of branches put forth by the plants at this spacing [7] and [8]. The influence of nutrients on the number of leaves per plant was found significant at 60, 90 and 100 DAP. At harvest, the treatment N_3 (150 kg N/ha) resulted in production of maximum (894.10) number of leaves, while the minimum (711.42) was found in N_1 (50 kg N/ha). The possible reason for this increase in number of leaves with increase in nitrogen might be due to the nitrogen which contributes to the chief constituent of protein, essential for the formation of protoplasm which leads to cell division and cell enlargement. More over nitrogen is an important component of amino acids and co enzymes which are of considerable biological importance [9]. [Table-3]

Plant spacing had significant effect on plant spread in east-west and north-south directions at 60, 90 and 100 DAP. At harvest, maximum plant spread was recorded in wider row spacing (60 cm) and the least was noticed in closer spacing (30 cm). The higher plant spread could be attributed to the higher availability of spreading area which resulted in plageotrophic growth [10]. At harvest, the plants which were supplied with 150 kg N per ha (N_3) recorded the maximum plant spread, while the plants supplied with 50 kg N per ha (N_1) recorded the minimum plant spread. The higher plant spread at this nitrogen level might be due to the robust nature of plant growth as evident by production of more number of branches [11]. [Table-4 and 5.]

The influence of row spacing was significant on fresh herbage yield per plant. The widest row spacing of 60 cm (S_3) recorded the highest (390.57 g) fresh herbage yield per plant and the minimum (323.36 g) was noticed in 30 cm row spacing (S_1). The higher fresh herbage yield at wider spacing might be due to the fact that widely spaced plants put up better vegetative growth resulting in higher fresh herbage yield per plant. Fresh herbage yield per plot was also significantly influenced by row spacing. The closer spacing of 30 cm (S_1) produced significantly highest (19.40 Kg) fresh herbage yield per plot and the lowest (11.72 Kg) was observed in wider row spacing of 60 cm (S_3). This might be due to presence of more number of plants per unit area at closer spacing resulting in higher fresh herbage yield [12]. The results revealed significant difference in fresh herbage yield per hectare due to row spacing. Row spacing of 30 cm (S_1) maintained its superiority in the production of fresh herbage yield per hectare also by recording maximum (23.95 t) fresh herbage yield per hectare, while the least (14.46 t) was noticed in 60 cm (S_3). This is on account of higher plant population per unit area [6]. Fresh herbage yield differed significantly due to nitrogen levels. Application of 150 kg N/ha (N_3) resulted in production of maximum fresh herbage yield per plant (407.04 g), per plot (17.16 kg) and per ha (21.18 t), while the minimum fresh herbage yield per plant (310.30 g), per plot (13.10 kg) and per ha (16.18 t) was observed in plants supplied with 50 kg N per ha (N_1).The increase in yield may be attributed to the fact that under increasing nitrogen levels, there would be improved growth of the plant, which leads to production of more number of leaves, branches and ultimately resulting in highest fresh herbage yield [13]. [Table-6]

Conclusion

The result led to a conclusion that, planting of Japanese mint at 30 cm row spacing and supplemented the crop with 150 kg nitrogen per hectare is favourable for getting higher fresh herbage yield under northern dry zone of Karnataka.

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Author contributions

1. Mahantesh P. S. – Carried out the entire research programme
2. Gangadharappa P. M.- Chairman.
3. Hiremath J. S.- Member of my Advisory Committee.
4. Sharatbabu A.G, Pooja M. R Nishchitha M- Co- authors helped in getting observations and laboratory works.

Abbreviations

cm: Centimetre
kg/ha: Kilogram per hectare
t/ha: tonnes per hectare
/: per
g: Gram
N: Nitrogen
S: Spacing
DAP: Days after planting
N-S: North - South
E-W: East -West
SE.m: Standard error mean
CD: Critical difference

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest: None declared

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