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A comparative study on direct planted and transplanted menthol mint (*Mentha arvensis* L.) under integrated nutrient management

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Abstract

An experiment was conducted at Lucknow (Uttar Pradesh) to assess crop productivity and economics of direct planted and transplanted menthol mint (*Mentha arvensis*) in sandy loam soil, under integrated nutrient management. The treatments consisted of five different combinations of farmyard manure (FYM) and inorganic fertilizers (NPK). Herb and essential oil yield was maximum with application of 133:40:40 kg NPK $ha^{-1}$and 6.7 t FYM ha^{-1} in both the methods of planting. However, the crop established with direct planting of suckers was more profitable than the transplanted crop. Net returns were 269% and 213% higher over control, with combined application of 133:40:40 kg NPK ha^{-1} and 6.7 t FYM ha^{-1} in direct and transplanted crop, respectively, during the first year of experimentation and 305% and 232%, respectively, during the second year. Dry matter production and NPK uptake were also maximum in the same treatment in both the methods of planting. Maximum N and P uptake was recorded in sole application of inorganic fertilizers (200:60:60 kg NPK ha^{-1}) and maximum K uptake was observed under application of 100:30:30 kg NPK ha^{-1} and 10 t FYM ha^{-1} in direct planted crop during the first year. Post-harvest soil characteristics like organic carbon, available NPK, Fe and Zn were higher during the second year, while a reverse trend was observed for soil pH.

Key words: integrated nutrient management, *Mentha arvensis*, menthol mint, net return, soil sustainability.

Introduction

Menthol mint (*Mentha arvensis* L.) is a highly remunerative crop, in Uttar Pradesh, North Indian plains and *tarai* region of Uttaranchal in India. This crop is well suited in various traditional cropping systems in the Indo-Gangetic plain owing to its adaptability to all seasons (Kumar & Patra 2000). Generally, suckers are planted directly during the last week of January. The crop is also established from transplanted suckers which are planted at the end of March or first week of April. The practice of transplanting of suckers after raising in nurseries allows the cultivation of mint after the harvest of winter season crops such as mustard, wheat, etc. (Singh *et al.* 1998). Cost of planting material, time of planting and method of propagation play a key role in determining the cost of menthol mint production. Transplanting of menthol mint is becoming a successful strategy as it can be grown after main *rabi* crops. In this study efforts were made to compare the performance of

direct planted and transplanted suckers of menthol mint in terms of yield, relative economics and post harvest soil nutrient status.

Materials and methods

Field experiments were conducted for two years (1996-97 and 1997-98) at Central Institute of Medicinal and Aromatic Plants, Research Farm, Lucknow (Uttar Pradesh) (26.5° N, 80.5° E,120 m MSL). The experiments were laid out in a randomized block design with five treatment combinations replicated four times. The test crop was established by two methods of planting, namely, through direct planting of suckers and transplanting 45 days old rooted suckers raised in the nursery during the first week of January and April, respectively. The treatments consisted of individual or combined application of farmyard manure (FYM) and inorganic fertilizers (NPK) namely, T_1-control, T_2-20 t FYM ha^{-1}, T_3-100:30:30 kg NPK ha^{-1} and 10 t FYM ha^{-1}, T_4-133:40:40 kg NPK ha^{-1} and 6.7 t FYM ha^{-1} and T_5-200:60:60 kg NPK ha^{-1}. N, P and K were applied through urea, single superphosphate and muriate of potash, respectively. Half of N and full dose of P and K were applied at the time of planting of suckers. Second split of N was applied after 45 days of planting of suckers. In the case of transplanted crop, full dose of P and K were applied at the time of planting, while N was applied in two splits (50% each) 20 and 50 days after transplanting. Menthol mint was harvested during the last week of June for recording herb yield and essential oil content. Mustard (cv. Pusa bold) was grown after menthol mint crop as residual crop during October–March, with application of N, P and K @ 50, 50 and 40 kg ha^{-1}, respectively. The soils of the experimental field had pH 7.81, EC 0.80 dSm^{-1}, organic carbon 0.29% and available N, P and K 167.0, 32.1 and 86.4 kg ha^{-1}, respectively. DTPA extractable Fe and Zn varied between 6.40 to 6.92 ppm and 0.52 to 0.57 ppm, respectively.

Menthol mint nursery was raised during the second week of February by preparing uniformly levelled land of 5 m x 6 m into which FYM (5 t ha^{-1}) and NPK (100:50:50 kg ha^{-1}) were thoroughly mixed. Menthol mint suckers (cv. Kosi) were dug out from stock field and chopped in to 2-4 cm length so that each piece contained at least one node. The chopped suckers were uniformly broadcasted in the nursery bed and covered by loose sandy soil and ground FYM mixture. About 100 kg suckers were required for raising the nursery to transplant in 1 ha of land. The bed was irrigated with light flooding followed by covering with paddy straw/lemongrass distillation waste to avoid surface incrustation and to promote easy emergence of seedlings. Forty five day old seedlings were transplanted in well prepared field at a spacing of 50 cm x 10 cm in 6 m x 4 m plot. Other management practices were followed as per recommended package of practices. The crop was harvested during the last week of June. The suckers were obtained from the previous year's plantation and planted in furrows of 8 cm opened 50 cm apart. After planting, the furrows were covered with soil by light planking and the field was immediately irrigated. Soil samples were collected from the experimental field (0-15cm) prior to and after planting and harvesting of both (mint and mustard) the crops. Samples were processed by drying under shade, crushing and passing through 2 mm sieve. Processed samples were analysed for pH, EC, organic carbon, available N, P and K (Page *et al.* 1992).

Results and discussion

Herb and oil yield

All the treatment combinations significantly influenced herb and essential oil yield over control during both the years under both the systems of production of menthol mint crop. In 1996-97, herb yield increased by 35%-131% over control with the application of different combinations of inorganic fertilizers and FYM in direct planted crop (Table 1). Oil yield increased by 42%-132% over control with different combinations of FYM and inorganic fertilizers. Both herb and oil yield were maximum under application of 133:40:40 kg NPK ha^{-1} + 6.7 t FYM ha^{-1} during 1996-97. The trend with respect to herb and oil yield

was the same in the transplanted crop as that of direct planted crop in 1996-97. However, there was slight reduction in herb and oil yield of transplanted crop compared to direct planted one. The highest herb and oil yield during 1997-98 was also recorded with 133:40:40 kg NPK ha^{-1} + 6.7 t FYM ha^{-1} (Table 1). The extent of increase in herb and oil yield in different treatments over control ranged between 17%-89% and 50%-142%, respectively in direct planted crop. The transplanted crop followed the same trend with marginal reduction in herb and oil yield during 1997-98.

Dry matter

Dry matter content was also significantly influenced by the treatment combinations (Table 1). Maximum dry matter was recorded in the treatment 133:40:40 kg NPK ha^{-1} + 6.7 t FYM ha^{-1}, in both the methods of planting during both the years. The extent of increase in dry matter production over control was 48% to 125% and 40% to 118 % with direct and transplanted crops, respectively, in 1996-97.

Nutrient uptake

Maximum N and P uptake was recorded with application of 200:60:60 kg NPK ha^{-1} in direct planted crop, whereas K uptake was maximum under combined application of 100:30:30 kg NPK ha^{-1} + 10 t FYM ha^{-1} (Table 2). The transplanted crop also followed the same trend for N, P and K uptake as that of direct planted crop. The results on major nutrient uptake indicated the beneficial effect of integrated supply of nutrients which was ultimately reflected on productivity (herb and oil yield). Similar observations on higher accumulation of nutrients in menthol mint-mustard cropping system was reported by Patra *et al.* (1997).

Net return

The prices of fertilizers and other inputs increased considerably during the last decade affecting the cost of production of mint oil to a great extent. Maximum oil production was recorded under application of 133:40:40

Table 1. Oil and herb yield and dry matter production in direct and transplanted menthol mint

Treatment	Direct planted crop									Transplanted crop								
	Oil yield (l ha^{-1})			Herb yield (t ha^{-1})			Dry matter (t ha^{-1})			Oil yield (l ha^{-1})			Herb yield (t ha^{-1})			Dry matter (t ha^{-1})		
	1996-97	1997-98	Mean	1996-97	1997-98	Mean	1996-97	1997-98	Mean	1996-97	1997-98	Mean	1996-97	1997-98	Mean	1996-97	1997-98	Mean
T_1	95	92	93.5	12.67	13.14	12.91	4.11	4.37	4.24	93	91	92.0	12.40	13.00	12.70	4.01	4.32	4.17
T_2	135	138	136.5	17.09	15.33	16.21	6.07	5.94	6.01	125	131	128.0	15.82	14.56	15.19	5.62	5.65	5.62
T_3	205	210	207.5	28.08	23.33	25.71	8.56	8.64	8.60	198	198	198.0	27.13	22.00	24.57	8.27	8.15	8.21
T_4	220	223	221.5	29.33	24.77	27.05	9.23	8.55	8.89	208	211	209.5	27.73	23.44	25.59	8.73	8.09	8.39
T_5	195	192	193.5	26.00	24.30	25.15	7.16	8.50	7.83	190	184	187.0	25.33	23.29	24.31	6.98	8.14	7.56
CD (P=0.05)	15	13	-	1.25	1.22	-	0.62	0.11	-	10	9	-	1.22	1.20	-	1.11	1.11	-

T_1=Control; T_2=FYM 20 t ha^{-1}; T_3=N:P:K 100:30:30 kg ha^{-1} + FYM 10 t ha^{-1}; T_4=N:P:K 133:40:40 kg ha^{-1} + FYM 6.7 t ha^{-1}; T_5=N:P:K 200:60:60 kg ha^{-1}

Table 2. Uptake of major nutrients in direct and transplanted menthol mint (1997-98)

Treatment	Direct planted crop			Transplanted crop		
	Uptake (kg ha^{-1})			Uptake (kg ha^{-1})		
	N	P	K	N	P	K
T_1	86.96	20.98	97.89	85.97	20.74	96.77
T_2	118.21	30.29	140.18	112.44	28.82	133.34
T_3	171.07	34.56	237.60	161.37	32.60	224.13
T_4	177.84	37.62	209.48	168.77	35.60	198.21
T_5	212.50	49.30	191.25	203.50	47.21	183.15
CD (P=0.05)	12.00	2.80	15.50	4.89	2.10	16.00

T_1=Control; T_2=FYM 20 t ha^{-1}; T_3=N:P:K 100:30:30 kg ha^{-1} + FYM 10 t ha^{-1}; T_4=N:P:K 133:40:40 kg ha^{-1} + FYM 6.7 t ha^{-1}; T_5=N:P:K 200:60:60 kg ha^{-1}

kg NPK ha^{-1} + 6.7 t FYM ha^{-1} in direct planted and transplanted mint crop in both the years and the net return was Rs. 42,307 ha^{-1} and Rs. 41,367 ha^{-1} which was 269% and 213 % higher, over control in both the production methods, respectively, in 1996-97 (Table 3). The net return was Rs. 42,307 ha^{-1} and Rs. 41,367 ha^{-1} in direct planted and transplanted mint crop which was 305% and 232% higher over control, respectively, in 1997-98 (Table 4). Net return per rupee invested was also maximum under supply of 133:40:40 kg NPK ha^{-1} + 6.7 t FYM ha^{-1} in both the methods of planting during both the years. Maximum oil production and net return obtained under combined application of 133:40:40 kg NPK ha^{-1} and 6.7 t FYM ha^{-1} may be attributed to balanced supply of macro and micro-elements for longer period of crop growth through integrated supply of nutrients. Sustained production, optimum availability and crop growth following integrated approach was observed by Patra *et al.* (2000) in mint-mustard cropping sequence. Kothari & Singh (1994) observed that use of improved variety, planting at optimum time, application of optimum quantity of fertilizers and organic manures, irrigation, weed management, harvesting at optimum time and proper distillation are main prerequisites for determining the cost of cultivation of mint under specific crop rotation and climatic conditions.

Soil physico-chemical properties

Major soil physico-chemical characteristics and available nutrients fluctuated under different stages of sampling during the two year cropping period.

After harvest of menthol mint (1996-97)

Soil samples were analysed for their different characteristics after harvest of menthol mint (1996-97). Soil pH was maximum in plots that received only inorganic fertilizers as compared to plots applied with organic manure along with inorganic fertilizers (Table 5). However, the differences among treatments were not statistically significant. Electrical conductivity of the soil did not vary significantly. Organic carbon was, however, higher in soil receiving organic manure alone or in combination with inorganic fertilizers, as compared to control and with inorganic fertilizer only. Total N content in soil increased by 24%-54% over control with different combinations of organic manure and fertilizers and the maximum value was observed with combined application of 100:30:30 kg NPK ha^{-1} + 10 t FYM ha^{-1}. Available N was highest with combined application of 100:30:30 kg NPK ha^{-1} + 10 t FYM ha^{-1} registering an increase of 29% over control. Available P was highest with combined application of 133:40:40 kg NPK ha^{-1} + 6.7 t FYM ha^{-1}. Available K was significantly affected by different treatments and was highest with application of 133:40:40 kg NPK ha^{-1} + 6.7 t FYM ha^{-1}. The data indicated an improvement in the soil physico-chemical characteristics and available N, P and K status. Similar observations were also made by Tamhane *et al.* (1970) and Singh & Dhar (1986). Increased nutrient availability by application of FYM with inor-

Table 3. Economics of menthol mint cultivation under menthol mint-mustard cropping system (1996-97)

Cost of cultivation ha^{-1}	Direct planted crop					Transplanted crop				
	T_1	T_2	T_3	T_4	T_5	T_1	T_2	T_3	T_4	T_5
A. Expenditure										
Land preparation	800	800	800	800	800	800	800	800	800	800
Planting material	4500	4500	4500	4500	4500	1000	1000	1000	1000	1000
Planting charges	650	650	650	650	650	750	750	750	750	750
Raising nursery	-	-	-	-	-	1100	1100	1100	1100	1100
Fertilizers	-	1500	2545	2893	3590	-	1500	2545	2893	3590
Irrigation	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
Weeding (manual)	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Plant protection and miscellaneous expenses	500	500	500	500	500	500	500	500	500	500
Distillation charges @ Rs 30 kg^{-1}	2850	4050	6150	6600	5850	2790	3750	5940	6240	5700
Total expenditure	17,050	19,750	22,895	23,693	23,640	14,690	17,160	20,385	21,033	21,190
B. Gross return (Rs ha^{-1})	28,500	40,500	61,500	66,000	58,500	27,900	37,500	59,400	62,400	57,000
Oil yield (kg ha^{-1})	95	135	205	220	195	93	125	198	208	190
Net return (Rs)										
(i) Per hectare	11,450	20,750	38,605	42,307	34,860	13,210	20,340	39,015	41,367	35,810
(ii) Per rupee investment	0.68	1.05	1.69	1.79	1.47	0.90	1.98	1.91	1.97	1.69

T_1=Control; T_2=FYM 20 t ha^{-1}; T_3=N:P:K 100:30:30 kg ha^{-1} + FYM 10 t ha^{-1}; T_4=N:P:K 133:40:40 kg ha^{-1} + FYM 6.7 t ha^{-1}; T_5=N:P:K 200:60:60 kg ha^{-1}
Labour wages @ Rs 60 man^{-1} day^{-1}; oil price @ Rs. 300 kg^{-1}
Cost of nitrogen=Rs 10.65 kg^{-1}; phosphorus=Rs 17.50 kg^{-1}; potassium=Rs 7.33 kg^{-1}

Table 4. Economics of menthol mint cultivation under menthol mint-mustard cropping system (1997–98)

Cost of cultivation ha^{-1}	Direct planted crop					Transplanted crop				
	T_1	T_2	T_3	T_4	T_5	T_1	T_2	T_3	T_4	T_5
A. Expenditure										
Land preparation	800	800	800	800	800	800	800	800	800	800
Planting material	4500	4500	4500	4500	4500	1000	1000	1000	1000	1000
Planting charges	650	650	650	650	650	750	750	750	750	750
Raising nursery	-	-	-	-	-	1100	1100	1100	1100	1100
Fertilizers	-	1500	2545	2893	3590	-	1500	2545	2893	3590
Irrigation	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
Weeding (manual)	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Plant protection and miscellaneous expenses	500	500	500	500	500	500	500	500	500	500
Distillation charges @ Rs 30 kg^{-1}	2760	4140	6300	6690	5760	2730	3930	5940	6330	5520
Total expenditure	16,960	19,840	23,045	23,783	23,550	14,630	17,330	20,385	21,123	21,010
B. Gross return (Rs ha^{-1})	27,600	41,400	63,000	66,900	57,600	27,300	39,300	54,400	63,300	55,200
Oil yield (kg ha^{-1})	92	138	210	223	192	91	131	198	211	184
C. Net return (Rs)										
(i) Per hectare	10,640	21,560	39,955	43,117	34,050	12,670	21,970	39,015	42,177	34,190
(ii) Per rupee investment	0.68	1.08	1.73	1.81	1.45	0.86	1.27	1.91	2.00	1.63

T_1=Control; T_2=FYM 20 t ha^{-1}; T_3=N:P:K 100:30:30 kg ha^{-1} + FYM 10 t ha^{-1}; T_4=N:P:K 133:40:40 kg ha^{-1} + FYM 6.7 t ha^{-1}; T_5=N:P:K 200:60:60 kg ha^{-1}
Labour wages @ Rs 60 man^{-1} day^{-1}; oil price @ Rs. 300 kg^{-1}
Cost of nitrogen=Rs 10.65 kg^{-1}; phosphorus=Rs 17.50 kg^{-1}; potassium=Rs 7.33 kg^{-1}

Table 5. Influence of combined application of FYM and NPK fertilizers on soil characteristics after harvesting of menthol mint (1996–97) and prior to planting of menthol mint (1997–98)

Treatment	pH		EC (dSm^{-1})		OC (%)		Total N (%)		Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})		Fe (ppm)		Zn (ppm)	
	AHM	PMP	AHM	PMP	AHM	PMP	AHM	PMP	AHM	PMP	AHM	PMP	AHM	PMP	AHM	PMP	AHM	PMP
T_1	8.16	7.36	0.15	0.55	0.30	0.33	0.099	0.054	162.30	194.58	72.06	30.80	165.60	127.05	0.80	9.55	5.98	0.73
T_2	8.18	7.26	0.18	0.70	0.33	0.43	0.140	0.163	183.76	209.82	81.13	40.80	240.35	137.33	1.18	10.40	5.75	0.88
T_3	8.16	7.34	0.16	0.68	0.35	0.46	0.152	0.171	209.40	263.86	83.58	41.90	240.65	151.00	0.97	11.68	7.18	0.70
T_4	8.13	7.19	0.19	0.75	0.39	0.44	0.150	0.172	188.03	298.00	84.69	44.10	254.75	169.70	1.07	19.35	6.15	0.75
T_5	8.24	7.28	0.22	0.65	0.32	0.33	0.123	0.098	176.58	220.18	74.13	41.10	192.50	144.50	0.93	8.35	6.00	0.73
CD (P=0.05)	0.07	NS	NS	NS	0.03	0.09	0.012	0.080	15.20	22.50	8.50	14.50	12.10	15.20	NS	3.45	NS	NS

AHM=after harvest of menthol mint (1996–97); PMP=prior to menthol mint planting (1997–98)
T_1=Control; T_2=FYM 20 t ha^{-1}; T_3=N:P:K 100:30:30 kg ha^{-1} + FYM 10 t ha^{-1}; T_4=N:P:K 133:40:40 kg ha^{-1} + FYM 6.7 t ha^{-1}; T_5=N:P:K 200:60:60 kg ha^{-1}

ganic N, P and K was also reported earlier (Chattopadhyay *et al.* 1993 and Chattopadhyay 1997). The treatments did not significantly influence Fe and Zn contents in the post-menthol mint soil.

Prior to menthol mint planting (1997-98)

Soil samples were also analysed prior to planting of menthol mint during 1997–98 (Table 5). Soil characteristics such as electrical conductivity, organic carbon, total and available N and Fe increased during the second year as compared to first year, whereas, soil pH, available P, K and Zn decreased during the second year.

After harvest of menthol mint (1997-98)

Data on major soil characteristics after harvest of menthol mint during 1997–98 indicated significant effects of the treatments imposed (Table 6). Soil pH in all the treatments significantly decreased over control and the highest decrease was recorded under 133:40:40 kg NPK ha^{-1} + 6.7 t FYM ha^{-1}. This could be attributed to organic acids formed in soil due to organic matter addition and left over biomass remaining in soil due to cropping. As a result of higher microbial activity on organic matter substrates (Patra *et al.* 2000), acids are constantly being formed, which are responsible for lowering the pH (Tamhane *et al.* 1970). No significant change was recorded in electrical conductivity of soil but there was significant build up of organic carbon due to imposition of different treatments over control and maximum organic carbon was recorded under 20 t FYM ha^{-1} and combined application of 133:40:40 kg NPK ha^{-1} + 6.7 t FYM ha^{-1} control. Total N was significantly increased over control due to different treatment combinations and highest N build up was observed in combined application of 100:30:30 kg NPK ha^{-1} + 10 t FYM ha^{-1}. This could be attributed to manure and fertilizers applied prior to planting of menthol mint and subsequently addition of N due to leaf residue and sloughed off tissues and debris of mint. Similar observations were made by Patra *et al.* (2002). Varying influence of treatments was observed on available N, P and K in post-har-

Table 6. Influence of combined application of FYM and NPK on soil characteristics after harvesting of menthol mint (1997-98)

Treatment	pH	EC (dSm^{-1})	OC (%)	Total N (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Fe (ppm)	Zn (ppm)
T_1	8.06	0.15	0.30	0.049	174.02	51.15	135.30	11.10	0.40
T_2	7.03	0.13	0.48	0.159	214.02	67.10	180.95	16.45	0.82
T_3	7.01	0.12	0.45	0.164	242.72	62.70	217.65	14.70	0.93
T_4	6.98	0.15	0.48	0.159	221.42	59.95	244.50	16.60	0.85
T_5	7.06	0.16	0.35	0.065	187.07	92.95	167.20	17.35	0.59
CD (P=0.05)	0.06	NS	0.09	0.050	12.10	NS	25.20	2.85	0.38

T_1=Control; T_2=FYM 20 t ha^{-1}; T_3=N:P:K 100:30:30 kg ha^{-1} + FYM 10 t ha^{-1}; T_4=N:P:K 133:40:40 kg ha^{-1} + FYM 6.7 t ha^{-1}; T_5=N:P:K 200:60:60 kg ha^{-1}

vest soil. Treatment differences with respect to P was not significant; available N and K increased significantly due to treatment imposition. N increased by 39% with 100:30:30 kg NPK ha^{-1} + 10 t FYM ha^{-1} over control and the increase in K was 80% with 133:40:40 kg NPK ha^{-1} + 6.7 t FYM ha^{-1}over control. DTPA extractable Fe and Zn were significantly increased due to combined application of organic and inorganic fertilizers over application of inorganic NPK alone and control.

The study indicated that integrated supply of nutrients is a better proposition for sustaining productivity and soil fertility. Although yields were marginally lower in transplanted (nursery raised) menthol mint compared to suckers planted directly in field, it permits cultivation of winter season crop following a rice-wheat/mustard-menthol mint crop rotation.

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