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Research Article

Integrated Nutrient Management in Mentha (*Mentha arvensis*)

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ABSTRACT

Field experiment was conducted to evaluate the inorganic and inorganic fertilizers with *Trichoderma viride* on growth and yield of mentha (*Mentha arvensis*). Trials were conducted at Rampur Maniharan Saharanpur in Randomized Block Design with nine treatments and replicated three times for two consecutive years. Different doses of NPK (inorganic) and Farm Yard Manure (FYM, organic) were combined with *T. viride*. Results revealed that the green foliage yield was maximum when 25 t FYM ha^{-1} and *T. viride* were applied together. Dry matter yield was significantly higher in FYM treated plots (alone and in combination with *T. viride*) as compared to inorganic fertilizers and control. The oil content due to various treatments ranged from 0.95 to 1.10% in first year. The corresponding range during second year was from 0.97 to 1.12%. The oil content in mentha plants increased with FYM levels. The oil yield was highest in T_8 (N_{100} + P_{50} + K_{50} + *T. viride*) treatment in both the years. Oil yield increased with increasing levels of NPK fertilizers over control. This may be attributed to the higher herb yield of mentha. Menthone content of the second year (14.0 to 14.6%) was more than that of first year (13.7 to 14.2%). Menthyl acetate ranged from 6.8 to 7.5% and was more or less similar in both the years.

Key words: *Mentha arvensis*, Integrated Nutrient Management, *T. viride*

Introduction

The basic concept of integrated plant nutrient system is maintenance and improvement of soil fertility for sustaining crop productivity on long-term basis. This may be achieved through combined use of all natural resources and nutrients in scientific manner for optimum growth of crops. This practice not only ensures reduced burden on chemical fertilizers but also balanced use of natural resources coupled with chemical fertilizers to supply micronutrients and quality assurance besides maintaining soil fertility.

The application of FYM in the soil helps in increasing the fertility of the soil as well as the physical condition including its water holding capacity. According to Singh *et al*. (1998), the combined application of Zn and BGA was more effective than single application in enhancing crop yield, Zn-uptake, zinc use efficiency and DTPA extractable Zn in post harvest soil.

Trichoderma viride is fungus that is present in nearly all soils and other diverse habitats. In soil, it is the frequently among the most prevalent culturable fungi. They are favoured by the presence of high levels of plant roots, which they colonize readily. Kumar *et al*. (1999) studied the integrated nitrogen management in sugarcane through urea, FYM and *Azotobacter* during 1996-97. Applications of urea or *Azotobacter* alone were not effective in improving the yield, quality of sugarcane and nitrogen efficiency. However, *Azotobacter* when applied in conjunction with urea and FYM was found to be an efficient

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nitrogen carrier. Highest cane and commercial cane sugar yield and total N uptake were obtained with 90 kg N as urea + 30 kg N as FYM +*Azotobacter.*

Mints are popularly cultivated in India for over a period of thirty years since inception by some Research and Development institutions including Central Institute of Medicinal And Aromatic Plants (CIMAP). Out of the four commercially cultivated mint species in India, viz. *Mentha arvensis, M. piperita, M. spicata and M. citrate*, the former occupies a predominant position registering huge amount of mint oil contributing to more than 53 percent of global production (Khanjua *et al*., 1997). It is common observation during the last decade that in most of the mentha growing areas, the productivity of mint is decreasing when it is grown in the same field for several years. This is presumably due to improper fertilizer management. No attention is being given to replenishment of the major as well as micronutrients removal by the crop. Supplying nutrients through manures and fertilizers is expected to play a major role in sustaining the mentha productivity. There is need to improve the nutrient-supply system in terms of integrated nutrient management, involving the use of chemical fertilizers in conjunction with organic manures. Singh *et al*. (1994) reported that the application of farmyard manure increased the crop growth as judged from dry matter. The N and P contents increased significantly with increasing levels of farmyard manure compared with the control. The application of farmyard manure increased the uptake of N, P, S and Mo. Anwar *et al*. (2007) revealed from the experiment that among the six treatments compared, the combination of Vermicompost at 5 t ha^{-1} + fertilizer NPK 50:25:25 kg ha^{-1} performed the best with respect to growth, herb, dry matter, oil content, and oil yield of French Basil. Bajeli *et al*. *(*2016) investigated that highest yield attributes and oil yield of Japanese mint were recorded in combined application of FYM, vermicompost and poultry manure as compared with other treatments. The increase in yield with addition of FYM alone or in combination of inorganic fertilizers may be attributed to the fact that FYM being the store house of nutrients also made release of applied nutrients at its optimum at the same time improved the soil physical conditions Kumar *et al*. (2002). FYM application also enhanced population of stimulated nitrogen fixing and phosphate solubilizing microorganisms and thus increased availability of plant nutrients in steady manner (Gaur, 1998). Currently, no information is available about INM in mentha crop. Therefore, the present study was carried out to assess different levels of inorganic and organic fertilizers combined with T. viride on growth and yield of mentha.

Material and Methods

Field experiments were conducted at farmers' field at Rampur Maniharan, Saharanpur (U.P.) for two consecutive years to ascertain the effect of integrated nutrient management on yield and oil yield of *Mentha arvensis* in mentha-maize rotation. Saharanpur is an agriculturally important district situated below foot hills of North Himalaya. Experimental soil is a member of Sandy loam. Soil had pH 7.2, EC 0.11 dS m^{-1}, organic carbon 4.5 g kg^{-1}, calcium carbonate 5.0 g kg^{-1}, $KMnO_4$-N 190.0 kg ha^{-1}, Olsen's-P 9.5 kg ha^{-1}, ammonium acetate extractable-K 215.0 kg ha^{-1} and DTPA Extractable Zn and Fe were 0.60 mg kg^{-1} and 5.0 mg kg^{-1}, respectively (Table 1). The treatments were: T_1 - Control ,T_2 - 25 t FYM ha^{-1}, T_3 - 12.5 t FYM ha^{-1} + *T. viride*, T_4 - 25 t FYM ha^{-1} + *T. viride*, T_5 - N_{50} + P_{25} + K_{25} + 12.5 t FYM ha^{-1}, T_6 - N_{50} + P_{25} + K_{25} + *T. viride*, T_7 - N_{50} + P_{25} + K_{25} + 12.5 t FYM ha^{-1} + *T. viride*, T_8 - N_{100} + P_{50} + K_{50} + *T. viride* and T_9 - N_{100} + P_{50} + K_{50} . The treatments were imposed in first year with mentha crop as first test crop in the sequence with maize and replicated three times in a Randomized Block Design. The Urea, Single superphosphate, muriate of potash and zinc sulphate were used as a sources of N, P, K and Zn, respectively. Nitrogen (as per treatments) was applied in two equal splits, the first applied at planting and the remaining after one and half month of planting. Full dose of well-decomposed FYM was applied as per treatments at the time of planting. The seedlings of mentha were treated with *T. viride* culture. The seedlings of Japanese

Table 1. Physico-chemical characteristics of the soil

Characteristics	Value		Mean	Methods of determination
	I Year	II year		
pH (1:2.5) soil water suspension	7.2	7.2	7.2	Method No. 21, USDA Handbook No. 60 (Richards, 1954)
EC (dSm^{-1})	0.11	0.12	0.11	Method No. 4, USDA Hand book No. 60 (Richards, 1954)
Organic carbon ($g\ kg^{-1}$)	4.5	4.7	4.6	Walkley and Black method (Jackson, 1973)
$CaCO_3$ ($g\ kg^{-1}$)	5.0	5.0	5.0	Rapid titration method (Piper, 1966)
Available N ($kg\ ha^{-1}$)	190.0	195.0	192.0	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P ($kg\ ha^{-1}$)	9.5	9.7	9.6	Olsen's method (Olsen *et al.*, 1954)
Available K ($kg\ ha^{-1}$)	215.0	214.0	214.0	Ammonium acetate method (Hanway and Heidal, 1952)
Available Zn ($mg\ kg^{-1}$)	0.60	0.58	0.59	Lindsay and Norvell (1978)
Available Fe ($mg\ kg^{-1}$)	5.0	5.2	5.1	Lindsay and Norvell (1978)

mint (*Mentha arvensis* L.) crop cv, Hy-77 were transplanted at a row to row distance of 50 cm and plant to plant distance of 10 cm. The field was flooded prior to transplanting. The second irrigation was given within a week of transplanting to avoid dry up of the field and easy to establishment of seedlings. Plant samples of mentha crop were taken in both the years. At harvest of maize crop straw and grain samples were also collected. The straw yield was computed by subtracting the grain yield from the biomass of the crop. For distillation of essential oils, representative plant samples were collected preferably in the morning and were distilled through hydro-distillation procedure using Clevenger's apparatus (1928) at CIPMAP, Lucknow, under regulated temperature condition for 2-3 hours. Distilled oil was stored in clean and dry vials for its GLC analysis. The volume of oil was recorded and multiplied by 0.9 (specific gravity of mint oil) to express it on weight basis. The oil yield on fresh weight basis was calculated.

Results and Discussion

Herb yield

The herb yield of *Mentha arvensis* influenced significantly with the Intregrated use of fertlilizer application in both the years. (Table 2). The herb yield increased by 17.8-87.0% over control with the application of different treatments. The mean increase in herb yield with 25 t FYM ha^{-1} was 35.3%. The green foliage yield was further increased when 25 t FYM ha^{-1} and *T. viride* were

Table 2. Effect of various treatments on herb yield of mentha crop

Treatments	Herb yield ($t\ ha^{-1}$)			% Response
	I Year	II year	Mean	
T_1 control	12.91	11.85	12.38	-
T_2 25 t FYM ha^{-1}	17.31	16.22	16.76	35.3
T_3 12.5 t ha^{-1} + *Trichoderma*	15.18	14.00	14.59	17.8
T_4 25 t ha^{-1} + *Trichoderma*	18.87	17.17	18.02	45.5
T_5 $N_{50} + P_{25} + K_{25}$ + 12.5 t FYM ha^{-1}	15.90	14.32	15.11	22.0
T_6 $N_{50} + P_{25} + K_{25}$ + *Trichoderma*	16.75	15.82	16.28	31.5
T_7 $N_{50} + P_{25} + K_{25}$ + 12.5 t FYM + *Trichoderma*	21.88	20.95	21.41	72.9
T_8 $N_{100} + P_{50} + K_{50}$ + *Trichoderma*	23.76	22.55	23.15	87.0
T_9 $N_{100} + P_{50} + K_{50}$	23.67	22.44	23.05	86.1
SEm±	1.22	1.18	1.24	-
CD (P=0.05)	3.58	3.44	3.62	-

Table 3. Effect of various treatments on dry matter yield of mentha crop

Treatments	Dry matter yield (t ha^{-1})			% Response
	I Year	II year	Mean	
T_1 control	4.16	3.82	3.99	-
T_2 25 t FYM ha^{-1}	5.77	5.40	5.58	39.8
T_3 12.5 t ha^{-1} + *Trichoderma*	4.74	4.37	4.55	14.0
T_4 25 t ha^{-1} + *Trichoderma*	5.91	5.38	5.64	41.3
T_5 N_{50} + P_{25} + K_{25} + 12.5 t FYM ha^{-1}	5.00	4.50	4.75	19.0
T_6 N_{50} + P_{25}+ K_{25} + *Trichoderma*	5.28	4.99	5.13	28.5
T_7 N_{50} + P_{25}+ K_{25} + 12.5 t FYM + *Trichoderma*	6.85	6.56	6.70	67.9
T_8 N_{100} + P_{50}+ K_{50} + *Trichoderma*	7.47	7.09	7.28	82.4
T_9 N_{100} + P_{50} + K_{50}	7.39	7.01	7.20	80.4
SEm±	0.39	0.35	0.40	-
CD (P=0.05)	1.14	1.02	1.17	-

applied together. The herb yield was highest at T_8 (100% NPK + *T. viride*) treatment followed by T_9, T_7 and T_4 during both the years. However, T_8 and T_9 treatments were at par with respect to herb yield in both crop seasons. The increase in yield due to FYM application may be ascribed to increase availability of nutrients in soil. The herb yield of mentha also increased with the application of 50% NPK dose over control. The herb yield was further improved when 100% NPK fertilizer were applied. This increase in herb yield is due to more availability of nutrients (NPK) to plants. These results are in agreement with the finding of Gangwar and Singh (1992). T. *viride*. inoculation with NPK fertilizer levels (50 and 100%) also improved the herb yield of mentha crop. The order of increase in herb yield was T_8 > T_9 > T_7 > T_4 > T_2 > T_6 > T_5 > T_3 > T_1. Similar synergistic effect of FYM and NPK fertilizers on crop yield was reported by Verma (1996) and Singh *et al*. (1996).

Dry matter yield

Perusal of data on dry matter yield in Table 3 revealed that the minimum dry matter yield of mentha was recorded in both the years under control treatment. Both the levels of FYM alone improved the dry matter yield of mentha crop significantly over control in both crop seasons. The increase in dry matter yield is due to more availability of essential nutrients to plants and improvement in physico-chemical properties of soils. Similar results were reported by Dahiya *et al*. (1987). Inoculation with *T. viride* along with 25 t FYM ha^{-1} produced more dry matter yield than control and 25 t FYM ha^{-1} alone in both crop seasons which may be due to beneficial effects of activity of *T. viride*. Application of NPK at the rate of 50 and 100% recommended dose also increased dry matter yield over control in both crop seasons.

Oil content and oil yield

Data on oil content in Table 4 reveals that the oil content was markedly affected by various treatments in both the years. The oil content due to various treatments ranged from 0.95 to 1.10% in first year. The corresponding range during second year was from 0.97 to 1.12%. The oil content in mentha plants increased with FYM levels. A further study reveals that the oil yield was highest in T_8 treatment in both the years. Oil yield increased with increasing levels of NPK fertilizers over control. This may be attributed to the higher herb yield of mentha. The crop produced minimum oil (122.6 and 115.0 kg ha^{-1}) under control in both the years. Saxena and Singh (1996) also reported an increase in oil yield due to application of nitrogen. Application of FYM alone or in combination with *T. viride* and NPK fertilizer also improved the oil yield significantly over control. The treatments T-$_8$ and T_9 were at

Table 4. Effect of various treatments on content and yield of oil in mentha crop

Treatments	Oil content (%)		Oil yield (kg ha^{-1})	
	I Year	II year	I Year	II year
T_1 control	0.95	0.97	122.6	115.0
T_2 25 t FYM ha^{-1}	1.10	1.11	190.4	180.0
T_3 12.5 t ha^{-1} + *Trichoderma*	0.99	1.00	150.2	140.0
T_4 25 t ha^{-1} + *Trichoderma*	1.10	1.11	207.5	190.6
T_5 N_{50} + P_{25} + K_{25} + 12.5 t FYM ha^{-1}	1.00	1.02	159.0	146.1
T_6 N_{50} + P_{25} + K_{25} + *Trichoderma*	1.00	1.02	167.5	161.4
T_7 N_{50} + P_{25} + K_{25} + 12.5 t FYM + *Trichoderma*	1.05	1.06	229.7	222.1
T_8 N_{100} + P_{50} + K_{50} + *Trichoderma*	1.11	1.12	263.7	252.6
T_9 N_{100} + P_{50} + K_{50}	1.11	1.12	262.7	251.3
SEm±	0.07	0.06	11.5	10.1
CD (P=0.05)	NS	NS	33.8	29.5

Table 5. Effect of various treatments on menthol, menthone and methyl acetate in mentha crop

Treatments	Year I			year II		
	Menthol	Menthone	Methyl acetate	Menthol	Menthone	Methyl acetate
T_1 control	78.8	13.7	6.9	76.5	14.0	6.9
T_2 25 t FYM ha^{-1}	79.5	13.9	7.0	77.4	14.3	6.8
T_3 12.5 t ha^{-1} + *Trichoderma*	79.0	13.7	7.2	77.0	14.0	7.2
T_4 25 t ha^{-1} + *Trichoderma*	79.6	14.0	7.3	77.2	14.4	7.4
T_5 N_{50} + P_{25} + K_{25} + 12.5 t FYM ha^{-1}	79.8	14.1	7.3	77.4	14.5	7.3
T_6 N_{50} + P_{25} + K_{25} + *Trichoderma*	80.4	14.1	7.4	78.4	14.5	7.4
T_7 N_{50} + P_{25} + K_{25} + 12.5 t FYM + *Trichoderma*	80.0	13.9	7.2	78.0	14.2	7.0
T_8 N_{100} + P_{50} + K_{50} + *Trichoderma*	81.2	14.2	7.4	79.0	14.6	7.4
T_9 N_{100} + P_{50} + K_{50}	81.3	14.2	7.4	79.0	14.6	7.4
SEm±	0.86	0.18	0.19	0.91	0.21	0.22
CD (P=0.05)	NS	NS	NS	NS	NS	NS

par with each other in respect of oil production in both crop seasons.

Oil composition

The data on oil composition (menthol, menthone and menthyl acetate) of mentha as affected by various treatments are presented in Table 5. Results revealed that Menthol content ranged from 78.8 to 81.3 percent in first year this was higher in all treatments over the control, but statistically at par in both the years. Menthone content of the second year (14.0 to 14.6%) was more than that of first year (13.7 to 14.2%). Menthyl acetate ranged from 6.8 to 7.5% and was more or less similar in both the years. Izhar *et al*. (2015) demonstrated that plant height was maximum with T_7 (T_7 : N, P, K 225:60:60 kg/ha and No FYM) while no.of leaves, leaf area, herb yield and oil yield with T_5 (T-$_5$:N, P, K 150:45:45 kg/ha and FYM 8 t/ha) and menthol contents was maximum with T_6 (T_6 : N, P, K 175:50:50 kg/ha and FYM 6 t/ha).

Conclusions

Farm yard manure (@ 12.5 t ha^{-1}) and *T. viride* when combined with half doses of recommended NPK produced at par herb and dry matter yield and the main produce to which crop

is grown *i.e.* oil content. The composition of oil was also the same its components like menthol, menthone and methyl acetate were at par in all treatments. This combination of organic and inorganic fertilizers combined with *T. viride* reduces the use of inorganic fertilizers without compromising quality and yield of Mentha.

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