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Effect of Zinc and Sulphur on herb, oil yield and quality of Menthol mint (*Mentha arvensis* L.) var. Kosi

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ABSTRACT

The field experiment was conducted during the years 1999 and 2000 on mollisols of Crop Research Center Pantnagar (Uttarakhand) to study the effect of zinc and sulphur with three different NPK levels. Addition of Sulphur increased the herb, oil and menthol yield as compared to zinc but combined application of zinc +sulphur with all three NPK levels resulted in higher herb, oil and menthol yield. Total oil yield and total menthol yield was highest due to the application of recommended NPK (150:60:40) +Zn + S. While plant height, LAI, L: S ratio and herb yield was more due to application of 130% of recommended NPK +Zn +S.

Key words: Zinc, sulphur, menthol yield, LAI, L:S ratio, herb and oil yield.

INTRODUCTION

Menthol mint (*Mentha arvensisL.*) is menthol rich essential oil bearing crop. The oil and menthol is widely used in pharmaceuticals, cosmetics, flavour and confectionary industries. In recent years India has become a major producer of *Mentha arvensisL.* oil and menthol in the world, and now its share is around 85% in mint oil and menthol (16). Kosi is a new released, early variety of menthol mint (90-100 days) and produces higher oil content (0.8-1.0%) containing 81-83% menthol (2). Zn has been found to increase the menthol content (5) whereas sulfur deficiency caused reduction in dry matter production (14). Though this genotype has been reported to contain high oil content, but farmers are not able to get high yields mainly due to imbalanced use of nutrients. In view the present investigation was undertaken to study the effect of S and Zn along with different NPK levels.

MATERIALS AND METHODS

The field experiment was conducted at the Crop Research Center, G.B.P.U.A&T Pantnagar during the years Feb-Aug in 1999 and 2000 respectively. The experimental field was silty clay loam in texture having the pH of 7.2, medium in available nutrients viz. N (262 kg/ha), P (18.23 kg/ha), K (165.2 kg/ha), S (16.90 kg/ha) and Zn (1.88 kg/ha). The C.E.C of the soil was 26.5 centimole/kg and Organic carbon content was 0.55%. The experiment was laid out in Randomized Block Design having three levels of N.P.K viz. 70%of the recommended N.P.K, recommended N.P.K (150:60:40) and 130 % of recommended N.P.K. along with sulphur (20kg/ha), zinc (5.625 kg/ha applied through $ZnSO_4.7H_2O$ @ 25 kg/ha) and zinc plus sulphur (@ 25 kg $ZnSO_4.7H_2O$ / ha and 20 kg S/ha) including one control (13 treatments). Nitrogen was applied in 4 equal split doses at planting, 50 days after planting, just after first harvest, and 35 day after first harvest. The whole amount of P, K, S, and Zn was applied as basal before the planting. The amount of sulphur supplied by Zn SO_4 was corrected by applying uniform dose of gypsum to all the plots including control. The suckers of menthol mint were planted on Febth 5 and 10th during 1999 and 2000 in end to end fashion 4 cm deep in furrows opened at 45 cm apart. The harvesting was done twice at 112 days and 172 days after planting during both the years. The oil in the fresh herbage was extracted through hydro stem distillation using Clevenger's apparatus. The chemical composition of oil samples was estimated by using Nucon 5700 (GC) with capillary injector, Capillary column and thermal conductivity detector.

RESULTS AND DISCUSSION

Growth and Yield

Application of sulphur, zinc and zinc + sulphur increased plant height, leaf area index (LAI) and leaf to stem ratio with all three NPK levels during both harvest in the years 1999 and 2000. The highest plant height, LAI and leaf to stem ratio were observed in treatment S+Zn with 130 % of recommended NPK level which was significantly higher as compared to 70 % of recommended NPK levels with S, Zn, and Zn+S (Table-1).

Zinc has been found to involve in photosynthesis and saccharide metabolism, and protein synthesis. It has been reported (9), that zinc deficiency retards the activity of photosynthetic enzymes such as carbonic anhydrase, ribulose1-5bisphosphate carboxylase/oxygenase, and fructose 1-6 bisphosphate. Whereas sulfur, deficiency causes a strong shift in the balance between the soluble and insoluble nitrogen towards the soluble fraction (mainly glutamine and asparagine). Sulfur deficiency is characterized by arginine and amide accumulation, as protein synthesis is arrested (4). Thus due to better availability of zinc and sulfur, the activities of various enzyme were enhanced causing more protein synthesis, this led to increase in various growth parameters such as plant height, leaf area index, and leaf to stem ratio, ultimately resulting in higher herbage yield.

The herbage and essential oil yield were significantly influenced by NPK levels alone or with zinc, sulfur, or zinc + sulfur (Table-2). The higher crop growth with application of 130% of NPK +Zn+S resulted in higher herbage yield at first harvest (265.2 and 248.7 q/ha) and at second harvest (379.4 and 376.7 q/ha) over the other NPK levels, alone or with zinc, sulfur or zinc+sulfur in the year 1999 and 2000 respectively. This increase in herbage yield was due to increase in various growth parameters during both the years. The increased supply of nutrients in this treatment enhanced leaf area for sufficient photosynthetic surface which in turn facilitated the crop for more vegetative growth and secondary metabolites accumulation. Similar increase in herbage yield of *Mentha arvensis* L. due to application of 80-140 kg N, 40-60 kg P_2O_5 and 20-40

kg K_2O/ha (5); 150 kg N, 35.2 kg P and 50.4 kg K/ha (3), and 200 kg N, 24 kg P and 50 kg K/ha (12) in different menthol mint genotypes has been reported from different parts of the country.

The total herbage yield in both the years was found to be highest due to application of 130% of NPK +Zn + S followed by 130% of NPK + S treatment. This may be because of combined affect of nutrients as sulfur has synergism with nitrogen availability. Thus better utilization of nitrogen under sulfur treatments may have led to more yield. Similarly the sulfur treatment of 9 ppm in *Mentha arvesnsis* L. var. MAS –1 (13), and 20 kg/ha in *Coriandrum sativum* L.(11) has been reported to increase growth parameters, and herbage yield.

Enhancement in total herbage yield due to zinc application along with various NPK levels was also observed to be significant. In the year 1999 the treatment 130% of NPK+Zn, recorded significantly higher herbage yield over the treatments 70% of NPK alone or along with Zn, S or Zn+S and recommended NPK level alone or with Zn. While in the year 2000 the treatment 130 % of NPK+Zn, recorded significantly higher herbage yield over the treatments 70% of NPK alone or along with Zn, S or Zn+S and recommended NPK level. This may be due to the involvement of zinc in enhancing photosynthetic enzyme activity thereby more photosynthate production leading to increased growth and yield of mint plant. Similar results were also obtained by (1,6,8) from different parts of the country.

The phenomenon of response of mint to fertility levels with zinc sulfur, or zinc+sulfur is understandable as balanced fertility levels along with important secondary and micronutrient application promoted proper growth and development of crop resulting in higher growth parameters which contributed for enhancement in yield.No application of nutrients (control) resulted in drastic reduction in total herbage yield which was 104.7 and 132.7 percentage less compared to highest NPK levels in the year 1999 and 2000 respectively.

Oil and Menthol Yield

The highest total oil yield 439.1 and 446.9 l/ha was obtained due to the application of recommended NPK levels+Zn+S during both the years (Table-3). Since nitrogen and sulfur play an important role in enhancing the carbohydrate and protein synthesis, potassium to enhance the translocation and proper utilization of amino acids in to protein synthesis (15) and zinc by way of its action as activator of various enzymes involved in essential oil synthesis, the combined effect of the sufficient availability of these input factor might have led to higher essential oil content in plants resulting in higher essential oil yield in both the years. The increase in oil yield has been reported with increase in NPK level alone or with S or Zn in the past (for NPK :7 ;for sulfur :15; for zinc : 14,16).

In the present investigation the total menthol yield was found to be more during 1999 compared to 2000 (Table-3).In both the years highest menthol yield was recorded in the treatment, recommended NPK+Zn+S followed by the treatment recommended NPK+Zn. The treatment recommended NPK+Zn+S resulted in significant increase in menthol yield over 70% of recommended NPK alone or with Zn, S or Zn + S, recommended NPK+Zn+S,130% of recommended NPK and control treatments during both the years. Control treatment resulted in 176.2%to 214.3% reduction in menthol yield over highest value obtained with recommended NPK+Zn+S treatment. It was mainly because of significantly less essential oil content and yield in control treatment. In the present investigation higher menthol percentage in essential oil due to NPK + Zn or Zn + S can be seen in light of the effect of nitrogen and sulfur on increased protein and carbohydrate synthesis in leaves, which served as respiratory substances and maintain reducing condition in the oil producing cells where enzymes responsible for the conversion of

Table-1 Growth parameters of *M arvensis* var. Kosi as influenced by zinc and sulphur treatments

Treatments	Plant Height (cm)				Leaf Area Index				Leaf : Stem Ratio			
	1999		2000		1999		2000		1999		2000	
	H-I	H-II	H-I	H-II	H-I	H-II	H-I	H-II	H-I	H-II	H-I	H-II
70% of Recommended N.P.K.	48.9	68.2	50.9	63.3	3.20	4.38	3.61	4.14	1.05	0.63	1.06	0.57
70% of Recommended N.P.K. +Zn	54.3	69.6	51.5	64.7	3.69	4.69	3.69	4.18	1.07	0.65	1.07	0.57
70% of Recommended N.P.K. +S	62.5	71.6	54.9	67.0	3.89	4.96	3.83	4.29	1.09	0.69	1.11	0.63
70% of Recommended N.P.K. +Zn +S	64.4	74.2	58.9	68.3	4.26	5.10	4.51	4.43	1.12	0.72	1.15	0.65
Recommended N.P.K.(150:60:40 kg/ha)	66.2	75.1	63.5	68.7	4.27	5.24	4.62	5.03	1.14	0.75	1.18	0.74
Recommended N.P.K. + Zn	72.1	75.6	67.0	69.0	5.15	5.64	4.66	5.07	1.19	0.76	1.19	0.76
Recommended N.P.K. +S	72.6	76.8	69.4	70.0	5.17	5.69	5.09	5.16	1.20	0.79	1.23	0.78
Recommended N.P.K. +Zn +S	76.3	79.5	69.8	73.9	5.27	5.80	5.44	5.43	1.26	0.84	1.30	0.79
130% of Recommended N.P.K.	78.4	82.6	69.1	73.8	5.49	6.10	6.04	5.97	1.24	0.83	1.36	0.89
130% of Recommended N.P.K. + Zn	79.3	79.5	74.9	78.9	5.69	6.34	6.03	6.04	1.26	0.84	1.42	0.89
130% of Recommended N.P.K. +S	80.4	83.7	75.1	81.5	6.05	6.35	6.20	6.19	1.29	0.85	1.45	0.93
130%of Recommended N.P.K. +Zn +S	81.9	87.5	78.5	85.8	6.58	7.00	6.47	6.40	1.32	0.95	1.46	0.98
Control	24.5	53.5	46.8	54.7	2.11	3.11	3.70	3.24	0.86	0.52	0.93	0.51
S.Em	4.8	3.9	3.1	3.3	0.06	0.28	0.07	0.06	0.07	0.05	0.05	0.03
CD(5%)	13.9	11.5	9.0	9.5	0.17	0.81	0.21	0.18	0.21	0.15	0.11	0.08

H-I is first harvest and H-II is second harvest

Table 2: Herbage and essential oil yield of *M arvensis* var. Kosi as influenced by zinc and sulphur treatments

Treatments	Herbage yield (q/ha)						Oil yield (l/ha)					
	1999			2000			1999			2000		
	H-I	H-II	Total	H-I	H-II	Total	H-I	H-II	Total	H-I	H-II	Total
70% of Recom. N.P.K	192.6	245.2	422.7	150.0	200.0	350.0	144.5	144.8	289.3	112.1	124.0	236.1
T-1 +Zn	208.7	270.7	479.4	162.5	220.0	382.5	177.3	177.7	355.1	136.5	154.0	290.5
T-1 +S	208.2	287.5	495.7	164.6	241.7	406.2	167.2	187.4	354.7	131.6	162.6	294.3
T-1 +Zn +S	224.2	295.4	518.6	166.7	275.0	441.7	183.6	194.1	377.6	137.8	187.8	325.7
Recommended N.P.K	227.1	291.5	518.6	195.0	265.8	460.8	186.8	188.3	375.5	163.8	180.8	344.6
T-5 + Zn	236.1	312.6	548.3	213.7	283.3	497.1	203.4	216.9	420.4	206.7	213.3	420.0
T-5 +S	230.8	334.3	561.8	228.3	298.3	526.6	189.1	218.9	408.0	200.9	217.8	418.7
T-5 +Zn +S	260.5	338.3	598.8	239.2	310.8	550.0	216.2	223.4	439.1	216.9	230.0	446.9
130% of Recom. N.P.K	234.2	336.1	570.2	216.7	315.0	531.7	180.0	192.1	372.1	166.2	180.5	346.7
T-9 + Zn	249.7	342.5	592.2	234.2	335.8	570.0	198.1	207.4	405.6	189	214.9	403.9
T-9 +S	256.2	375.4	631.7	240.4	356.7	597.1	201.9	226.1	428.1	189.2	218.6	407.8
T-9+Zn +S	265.2	379.4	644.5	248.7	376.7	625.4	209.2	227.4	436.6	196.0	237.3	433.3
Control	144.8	170.0	314.8	102.1	166.7	268.7	87.9	79.8	167.7	68.7	80.0	148.7
S.Em	9.0	11.7	14.2	18.5	30.1	28.1	11.1	8.3	11.8	16.1	19.9	24.3
CD 5%	26.3	34.3	41.2	54.0	88.0	81.8	32.3	24.2	34.5	46.8	58.1	71.0

H-I is first harvest and H-II is second harvest

Tables 3 : Oil content, menthol content, total menthol yield and net return of *M arvensis* var. Kosi as influenced by zinc and sulphur treatments

Treatments	Oil Content (%)				Menthol Content (%)				Total Menthol Yield (H-I+H-II) kg/ha		Net Return§ (Rs/ha)	
	1999		2000		1999		2000				1999	2000
	H-I	H-II	H-I	H-II	H-I	H-II	H-I	H-II	1999	2000		
70% of Recom. N.P.K	0.75	0.59	0.75	0.62	80.16	81.08	79.18	79.28	236.7	177.5	45573	29613
T-1 +Zn	0.85	0.66	0.84	0.70	82.05	83.61	82.54	81.12	293.5	223.5	59878	40498
T-1 +S	0.80	0.65	0.80	0.67	80.50	83.47	79.68	79.04	290.4	208.9	59838	41718
T-1 +Zn +S	0.82	0.66	0.83	0.68	82.24	83.55	81.96	79.32	312.4	222.3	64490	48920
Recommended N.P.K	0.82	0.65	0.84	0.68	80.21	82.95	80.40	79.0	302.7	261.1	64638	55368
T-5 + Zn	0.86	0.69	0.97	0.75	81.06	85.00	83.27	81.21	347.3	319.8	74270	74120
T-5 +S	0.82	0.65	0.88	0.73	80.25	81.30	80.61	78.50	330.4	309.7	71500	74710
T-5 +Zn +S	0.83	0.66	0.91	0.74	79.98	83.67	80.85	78.67	357.3	326.0	77998	80338
130% of Recom. N.P.K	0.77	0.57	0.77	0.57	80.18	82.94	78.68	77.15	304.7	258.9	63343	55723
T-9 + Zn	0.79	0.61	0.81	0.64	79.71	83.74	78.93	79.19	328.3	298.8	70380	69870
T-9 +S	0.79	0.60	0.79	0.61	78.25	80.78	78.42	77.44	343.9	294.9	75493	69403
T-9+Zn +S	0.79	0.60	0.79	0.63	78.21	79.90	77.08	77.88	345.6	303.7	76935	75945
Control	0.61	0.47	0.67	0.48	79.37	75.10	75.96	75.03	129.3	103.7	19733	14033
S.Em	0.01	0.01	0.04	0.04	2.74	2.07	3.02	2.99	12.3	10.3	-	-
CD%	0.03	0.03	0.11	0.13	NS	NS	NS	NS	36.0	30.2	-	-

H-I is first harvest and H-II is second harvest

§ Based on oil yield. Price of oil: Rs 300/kg, extraction cost: Rs 75/kg oil.

presynthesized l-menthone to l-menthol are more active. The enzyme menthol dehydrogenase, which catalyses the NADPH dependent reduction of l-menthone to l-menthol (10), seems to be more synthesized or assembled in higher quantities in plants supplied with recommended NPK+Zn indicating the enzyme activation by addition of Zn. As such fertility levels beyond recommended NPK might have retarded the rate of reduction of menthone to menthol (enzyme deactivation) and increased the rate of esterification of menthol to menthyl acetate (enzyme activation), leading to decrease in menthol percentage (3).

Economics:

Application of Zn, S or Zn +S with different NPK levels enhanced the net return compared to fertility levels alone (Table-3). Addition of Zn during both the years and S during 2000 along with recommended NPK gave more net return compared to their addition with 130% of recommended NPK. Recommended NPK along with Zn +S gave highest net return (77998 and 80338) followed by130% of NPK along with Zn+S compared to remaining treatments during both to years.

Future Research Need

To increase the oil and menthol content in *M arvensis*, critical time of nutrient uptake and its correlation with oil and menthol content should be determined. By knowing the right concentration of applied micronutrients oil and menthol yield could be increased.

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