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Role of Micronutrients on Growth and Rhizome Production of Ginger (*Zingiber officinale* Rosc.) in the Hilly Region of Darjeeling District

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Abstract

A field trial was conducted for two consecutive years during 1992 and 1993 to study the effect of micronutrients on growth and yield of ginger (*Zingiber officinale* Rosc.). Ginger cv Gorubathan was planted as a planting material weighing 40 g each with a spacing 25 cm row to row and 20 cm plant to plant. Five micronutrients zinc (Zn) as zinc sulfate 0.3%, Iron (Fe) as ferrous sulfate 0.2%, manganese (Mn) as manganese sulfate 0.2%, copper (Cu) as copper sulfate 0.2%, Boron (B) as boric acid powder 0.2% and their combinations were applied for two times during 90 and 120 days after planting. The results revealed that combined spray of Zn (0.3%), Fe (0.2%), Mn (0.2%), Cu (0.2%) and B (0.2%) for two times during 90 and 120 days after planting of rhizome resulted maximum plant height (77.81 cm), produced maximum number of pseudostem per clump (4.49), maximum number of leaves (59.52 per clump), highest leaf length (26.92 cm), highest leaf breadth (2.82 cm) and maximum yield (54.73 tonnes per hectare) compared to other treatments and control.

Key words : Micronutrient, Rhizome, Growth, Yield, Ginger.

The role of micronutrients in agricultural production has been viewed with greater importance in recent years as their limited availability in soils restricts crop productivity. Ginger (*Zingiber officinale* Rosc.) belongs to family Zingiberaceae is an exhaustive rhizomatus crop whose productivity is also affected by deficiency of micronutrients (1). Ginger is one of the earliest oriental spices known to Europe and is still in large demand. The main countries for ginger cultivation are India, China, Taiwan, Nigeria, Sieraleone, Jamaica, Thailand and Australia. India is the largest producer and exporter of ginger in the world. India's production alone constitutes about 32.75% of the total world production followed by China (21.41%), Nigeria (12.54%) and Bangladesh (10.80%) (2). In India, Kerala contributing 19% of the total ginger production is the leading state in area and production which also produces the best quality ginger (3). Meghalaya is the second leading state followed by Orissa, West Bengal. Andhra Pradesh, Karnataka, Sikkim, Mizoram, Madhya Pradesh. In other like Bihar, Gujarat Haryana, Himachal Pradesh and some North Eastern States, it is also grown on a limited scale (4). Ginger can be grown in wide range of soils. But it prefers to grow in light textured and well drained soils as it cannot grow and sustain in water logged condition. Besides, the hilly farmers usually do not use any chemical fertilizer to grow this spice crop. It is evident that ginger and turmeric are highly responsive to chemical fertilizers. Roy et al. (5). reported that micro-nutrients like Zn, Fe and B with increased rates progressively increased the growth and rhizome yield of ginger. Halder et al. (6) studied the effect of zinc and boron fertilization for maximizing yield of ginger in Hilly region of Chittagong, Bangladesh revealed that zinc and boron made an encouraging effect on the yield and yield attributes of ginger. Similar observations were also made by other investigators (7—14) who stated that with the addition of micronutrients with chemical fertilizers remarkably increased the yield of ginger rhizome. Very little work or no work , has so far been done on ginger in this aspect. Possibility of using micronutrients in ginger has not been explored systematically though there was immense scope and possibilities to increase growth and yield and thus present investigation was undertaken in the hilly region of Dajeeling district, West Bengal, India.

Methods

The experiment was laid out in a radomized block design with three replications at the Horticultural Research Station, Bidhan Chandra Krishi Viswavidyalaya, Pedong, district Darjeeling on a sandy loam soil for the two consecutive years with a pH 5.65 to 5.80 and having 1.45% organic carbon, total nitrogen 0.158%, available phosphorus (kg/ha) 11.50, potash (kg/ha) 75.00 (kg/ha). The farm is situated 26.05^{0}N, 88.26^{0}E and 1,066m above mean sea level. The winter was strong and prolonged beginning from November and continued till February. Coldest month was January with average minimum temperature 8.2C. Hottest month was May with average maximum temperature 27.80C.

The annual rainfall during the first and second year were 1,064.48 and 1,022.40 mm respectively. Major part of the rain was received during June to August. The experiment was started in the first week of March and continued upto first week of November. Five micronutrients like zinc (Zn) as zinc sulfate 0.3%, iron (Fe) as Ferrous sulfate 0.2%, Manganese (Mn) as Manganese sulfate 0.2%, copper (Cu) copper sulfate 0.2%, boron (B) boric acid power 0.2% and control (water spray) and their combinations were included. The planting material cv Gorubathan 40 g each were sown on a raised bed of 2 m × 1 m at a spacing 25 cm × 20 cm R × R and between plants during March. The crop was fertilized at the rate of NPK 60 : 40 : 60 kg/ha. Nitrogen fertilizer as urea was applied in two equal splits i. e., at the time of planting of seed rgizome and 90 days after planting. Phosphate as SSP and potassium as MOP fertilizers were applied at the time of planting. Mother rhizomas were removed from the plant at 90 days after planting. Foliar spray of micronutrients at two times was given 90 and 120 days after planting. The crop was harvested in November. When the leaves are turned yellow and started dry up. Other cultural operations were done as per the common package of practice schedule for ginger cultivation. Mean value of 15 plants in each treatment were used for statistical analysis by the analysis and variance method at 0.05 level (15).

Results and Discussion

Plant Height (cm)

Table 1 shows that highest plant height was recorded in treatment where all the combination of micronutrients were applied and it was statistically at par with all the treatments except the treatments T_1,T_2, T_6, T_7, T_{12}, T_{13} and T_{19} in the first year. The lowest plant height was recorded in treatment T_{19} and it was statistically at par with the treatments T_1, T_2 and T_6. In the second year highest plant height was recorded in treatment where all the combination of micronutrients were applied and it was statistically at par with all the treatments except the treatments T_1, T_2, T_9, T_{12} and T_{19}. The lowest plant height was recorded in treatment T_{19} and it was statistically at par with T_1, T_2, T_3, T_6, T_7, T_9, T_{10}, T_{11}, T_{12}, T_{13} and T_{17} . In pooled data of two years it was revealed that there was no significant variation among the five different micronutrients (Zn, Fe, Mn, Cu and B) and their 13 combinations (total 19 treatments including control) on the plant height of the crop. However, Cu and B when applied alone or in combinations showed better results than either Zn, Fe or Mn application alone. The maximum plant height was obtained when all five micronutrients were applied in combinations (77.81 cm) and the lowest (70.49 cm) in control (water spray) treatment. The results of pooled data thus obtained could be summarized as follows.

Pooled (plant height) — $T_{18} \geq T_{16}$, $T_{15} \geq T_8$, T_{14} ,T_5 T_4 > T_{13} T_{11},T_3 > T_7 ,T_{10} ,T_{17} ,T_9,T_6 < $T_{12} \geq T_1$,T_2 > T_{19}

Number of Pseudostem per Clump

The results showed that in both the years maximum number of pseudostem per clump was obtained when all five micronutrients in combinations were applied (4.44 and 4.55 respectively) and minimum as usually from control (water spray) treatment (3.86 and 3.82 respectively) but the treatment differences were not statistically significant at 5% level of significance (Table 1). In pooled mean data of two years, maximum number of pseudostem per clump was obtained when all five micronutrients in combinations were applied (4.49) and it was statistically superior to all other treatments and minimum as usually from control (water spray) treatment (3.85) and it was statistically at par with T_9. The results of pooled data thus obtained could be presented as follows.

Pooled (pseudostem) T_{18} > T_{16} > $T_{15} \geq$ $T_8 \geq$ $T_{14} \geq$ T_5 $T_4 \geq$ T_3, T_{10},T_1,$T_2 \geq$ T_7, $T_{17} \geq$ $T_{12} \geq$ T_6,T_{13},T_{11},$T_9 \geq T_{19}$

Table 1. Effect of micronutrients on the plant height, no. of pseudostem and no. of leaves per clump.

Treatments	Plant height (cm)			Number of pseudostem per clump			Number of leaves per clump		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
1. Zn 0.3%	72.25	74.26	73.25	4.10	4.02	4.06	52.55	54.40	53.47
2. Fe – 0.2%	72.77	72.04	72.40	4.04	4.08	4.06	53.37	55.35	54.36
3. Mn – 0.2%	74.80	74.15	74.47	4.08	4.13	4.10	53.15	55.59	54.37
4. Cu – 0.2%	75.81	75.35	75.58	4.08	4.15	4.11	53.75	55.59	54.64
5. B – 0.2%	76.15	75.83	75.99	4.08	4.17	4.12	54.64	56.22	55.43
6. Zn + Fe	72.63	74.83	73.73	3.86	4.04	3.95	50.68	52.86	51.77
7. Zn + Mn	74.55	73.72	74.13	4.10	4.99	4.04	53.52	55.28	54.40
8. Zn + Cu	76.54	76.57	76.55	4.17	4.24	4.20	55.90	56.62	56.26
9. Zn + B	74.71	73.11	73.91	3.95	3.84	3.89	52.37	53.97	53.17
10. Zn + Fe + Mn	74.73	73.70	74.06	4.10	4.06	4.08	52.82	52.06	52.44
11. Zn + Fe + Cu	75.71	73.29	74.50	3.90	3.93	3.91	51.08	53.70	52.39
12. Zn + Fe + B	74.42	72.66	73.54	3.97	4.01	3.99	51.64	52.30	51.97
13. Zn + Mn + Cu	74.05	74.97	74.51	3.88	4.01	3.94	52.48	52.02	52.25
14. Zn + Mn + B	76.16	76.55	76.35	4.15	4.21	4.18	54.66	56.55	55.60
15. Zn + Cu + B	76.85	76.78	76.81	4.26	4.24	4.25	56.48	56.93	56.70
16. Zn + Fe + Cu + B	77.57	77.20	77.38	4.26	4.48	4.37	56.62	57.44	57.03
17. Zn + Fe + Cu +Mn	74.80	73.32	74.06	3.95	4.11	4.03	52.06	51.22	51.64
18. Zn + Fe + Cu + Mn +B	78.36	77.26	77.81	4.44	4.55	4.49	58.42	60.62	59.52
19. Control	69.99	70.99	70.49	3.86	3.82	3.85	49.02	51.17	50.09
SE ±	1.790	2.148	0.350	0.214	0.216	0.025	3.193	2.910	0.309
CD at 5%	3.770	4.140	0.970	NS	NS	0.069	5.048	4.819	0.856

Number of Leaves per Clump

The results indicated that the number of leaves per clump was recorded in treatment where all the combination of micronutrients were applied and it was statistically at par with the treatments T_1, T_2, T_6, T_9, T_{10}, T_{11}, T_{12} and T_{13} in the first year (Table 1). The lowest number of leaves per clump was recorded in treatment T_{19} and it was statistically at par with all the treatments except T_5, T_8, T_{14}, T_{15}, T_{16} and T_{18}. In the second year highest plant height was recorded in above earlier treatment and it was statistically at par with the treatments T_5,T_8, T_{14},T_{15} and T_{16}. The number of leaves per clump was recorded in control treatment and it was statistically at par with all the treatments except T_5, T_8, T_{14}, T_{15}, T_{16} and T_{18}. The pooled data of two years data revealed that there were significant variations amongst the various treatments on the number of leaves per clump. The maximum number of leaves per clump (59.52) was obtained when all combinations of micronutrients was applied and found superior to all other treatments and the minimum number of leaves (50.09) was recorded in control (water spray) and it was found statistically inferior to all other treatments at 5% level of significance (Table 1). The results thus obtained could be presented as follows.

Pooled (number of leaves/clump) – $T_{18} > T_{16}, T_{15} \geq T_8, T_{14} \geq T_5 \geq T_4, T_7, T_3, T_2 > T_1 \geq T_9 \geq T_{10}, T_{11}, T_{13}, T_{12}, T_6, T_{17} > T_{19}$

Leaf Length (cm)

Table 2 shows that in first year and second year, maximum leaf length was obtained when all five micronutrients (Zn, Fe, Cu, Mn and B) in a combination were applied (26.99 and 26.86 respectively) and minimum in control (water spray) treatment (25.25 and 25.18 respectively) but treatment differences were not statistically significant. In pooled mean data of two years, maximum and minimum leaf length was recorded in above treatments and they were statistically superior and inferior respectively to all other treatments. The results of pooled data thus obtained could be summarized as follows.

Pooled (leaf length) – $T_{18} \geq T_{16}, T_{15} \geq T_3 \geq T_8 \geq T_{14}, T_5 \geq T_4 \geq T_6 \geq T_7, T_{11}, T_1, T_{12}, T_{13}, T_{10}, T_{17} > T_9 > T_2 > T_{19}$

Leaf Breadth (cm)

Table 2. Effect of micronutrients on the leaf length, leaf breadth, plant yield and total yield.

Treatments	Leaf length (cm) per plant			Leaf breadth (cm) per plant			Plant yield (kg)			Total yield (Tonnes per ha)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
1. Zn 0.3%	26.30	25.71	26.00	2.68	2.72	2.70	0.224	0.249	0.236	44.80	49.93	47.36
2. Fe – 0.2%	25.57	25.39	25.48	2.68	2.67	2.67	0.218	0.247	0.232	43.66	49.46	46.56
3. Mn – 0.2%	26.79	26.30	26.54	2.73	2.72	2.72	0.226	0.249	0.237	45.20	49.53	47.56
4. Cu – 0.2%	26.31	26.30	26.30	2.74	2.72	2.73	0.230	0.250	0.240	46.13	50.00	48.06
5. B – 0.2%	26.32	26.45	26.38	2.74	2.73	2.73	0.232	0.253	0.242	46.53	50.66	48.59
6. Zn + Fe	26.13	26.17	26.15	2.69	2.66	2.67	0.194	0.246	0.220	38.80	49.20	44.00
7. Zn + Mn	25.98	26.09	26.03	2.71	2.70	2.70	0.220	0.236	0.228	44.00	47.26	45.63
8. Zn + Cu	26.41	26.54	26.47	2.78	2.75	2.76	0.246	0.256	0.251	49.20	51.26	50.23
9. Zn + B	25.54	25.81	25.67	2.60	2.70	2.69	0.206	0.244	0.225	41.33	48.93	55.13
10. Zn + Fe + Mn	25.81	25.96	25.88	2.67	2.68	2.67	0.210	0.242	0.226	42.00	48.40	45.20
11 Zn + Fe + Cu	26.10	25.93	26.01	2.70	2.70	2.70	0.200	0.227	0.213	40.13	45.53	42.82
12. Zn + Fe + B	25.99	26.00	25.99	2.70	2.68	2.69	0.209	0.236	0.222	41.86	47.20	44.53
13. Zn + Mn + Cu	25.96	25.99	25.97	2.72	2.72	2.72	0.200	0.247	0.223	40.13	49.53	44.83
14. Zn + Mn + B	25.32	26.48	26.40	2.76	2.74	2.75	0.233	0.255	0.244	46.66	51.13	48.89
15. Zn + Cu + B	26.45	26.73	26.59	2.79	2.75	2.77	0.251	0.260	0.255	50.36	52.00	52.73
16. Zn + Fe + Cu + B	26.79	26.75	26.77	2.80	2.76	2.78	0.267	0.260	0.263	53.46	52.00	52.73
17. Zn + Fe + Cu + Mn	26.03	26.69	25.86	2.71	2.72	2.71	0.202	0.241	0.221	40.40	48.33	44.36
18 Zn + Fe + Cu + Mn + B	26.99	26.86	26.92	2.82	2.82	2.82	0.268	0.279	0.273	53.60	55.86	54.73
19. Control	25.25	25.18	25.21	2.65	2.62	2.63	0.190	0.216	0.203	38.06	43.26	40.66
SE ±	0.572	0.657	0.068	0.060	0.063	0.005	0.012	0.008	0.004	2.794	1.743	0.776
CD at 5%	NS	NS	0.188	NS	NS	0.013	0.033	0.022	0.011	7.722	4.817	2.150

Similar results were obtained as in the case of leaf length (Table 2). The results of pooled data thus obtained could be summarized as follows.

Pooled (leaf breadth) $T_{18}, T_{16} \geq T_{15} \geq T_8, T_{14} > T_5, T_4 \geq T_3, T_{13} \geq T_{17} \geq T_1, T_7, T_{11}, T_9, T_{12} > T_{10}, T_6, T_2 > T_{19}$

Plant Yield (kg)

Significant variations in plant yield were observed in both the years (Table 2) due to application of different micronutrients in combination or alone. Second year was recorded more yield than first year. Higher yield was obtained when all the five micronutrients (Zn, Fe, Cu, Mn and B) were applied in a combination (0.268 kg, 0.279 kg and 0.273 kg/plant respectively) i.e. first year, second year and pooled mean of two years data. The data showed that the treatments where Mn, Cu or B were applied produced significantly higher yield than the control (water spray) plots. The plots where received both Zn or Fe did not yield significantly than the control plots in most of the cases. The lowest yield was obtained in control (water spray) treatment (0.190 kg, 0.216 kg and 0.203 kg/plant respectively) i. e. in first year, second year and pooled mean of two years data. The results of pooled data thus obtained could be represented as follows.

Pooled (plant yield) – $T_{18} \geq T_{16} \geq T_{15} \geq T_8, T_{14} \geq T_5 \geq T_4, T_3, T_1 \geq T_2, T_7, T_{10}, T_9 \geq T_{13}, T_{12}, T_{17}, T_6 \geq T_{11}, T_{19}$

Total Yield (tonnes/ha)

The total yield or yield per hectare of the crop as summarized in Table 2 showed more or less similar trend to that of plant yield. Here also second year showed more yield than first year. In the second year most of the treatments alone or in a combination showed significant variations in total yield unlike in the second year where only Cu and B trend plots showed better results. The highest yield was obtained from the plots received all the five micronutrients in a combination was sprayed (53.60 tonnes, 55.86 tonnes and 54.73 tonnes/ha respectively) and the lowest in control (water spray) treatment where (38.06, 43.26 and 40.66 t/ ha respectively) i. e. first year, second yr. and pooled mean of two years data. When consider pooled mean data. The resuls of pooled data thus obtained could be represented as follows.

Pooled (total yield) $T_{18} \geq T_{16} \geq T_{15} \geq T_8, T_{14} \geq T_5, T_4, T_3, T_1 \geq T_2, T_7, T_{10}, T_9 \geq T_{13}, T_{12}, T_{17}, T_6, T_{11} > T_{19}$

Thus it could be concluded that the combined application of Zn, Fe, Cu, Mn and B along with the soil application of NP and K increased the yield and all yield attributes of ginger which confirmed the find-ing s of Devi and Singh (12). Gucchait et al. (13), Halder et al. (6), Velmurugan et al. (14) where they reported that with the addition of micronutrients with chemical fertilizers remarkably increased the yield of ginger rhizome.

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