Agric. Res J. Kerala, 1987, 25 (2): 191—200

NUTRIENT DEFICIENCY IN BLACK PEPPER (*PIPER NIGRUM* L.)

4. ZINC AND BORON

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Zinc and boron are two most important micronutrients essential for the growth and development of higher plants. Brenchly (1936) assigned B to first place among trace elements based on its relations with plants. Growth characteristics and leaf symptomatology of Zn deficiency are so well defined with many crops like citrus, apple etc. that supplementary leaf or soil analysis tests are often unnecessary to confirm the deficiency. However, the effects of these elements on pepper have not been investigated in India or elsewhere. Therefore, studies were undertaken at the College of Horticulture, Vellanikkara to induce deficiency symptoms of Zn and B and to study their effects on growth and development of pepper.

Materials and Methods

To induce of deficiency symptoms of macro and micronutrients sand culture studies were undertaken at the College of Horticulture, Vellanikkara from 1983 to 1985. But the present paper deals with only Zn and B. The materials used and the methodology adopted for conduct of the experiment, description of deficiency symptoms, recording of observations and chemical analyses were dealt in detail in the previous paper dealing with N,P and K (Nybe and Nair 1986). The treatments given were as follows: 1) Complete nutrient solution 2) Complete nutrient solution minus Zn, and 3) Complete nutrient solution minus B.

Results and Discussion

Deficiency of zinc

The first visible symptom of Zn deficiency was manifested during the twelfth month after treatment. The characteristic symptom was the interveinal chlorosis of the laminae of the younger leaves (initial stage). Within a period of one month, the chlorosis developed further so that a network of green veins could be clearly seen in pale yellow background (medium stage). Chlorosis spread to the lower immature leaves also.

By about two months, the colour of the interveinal chlorotic area became more deep with dark green veins. The new leaves produced were smaller in size (severe stage).

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The young flush produced also showed the deficiency symptoms. The terminal growth was retarded and the internodal length reduced. A number of lateral branches with shortened internodes and small leaves were produced from the terminal portion of the vine which resulted in bunching or rosetting. Abscission of leaf was seldom noticed (very severe stage).

The results of the studies conducted by Nair *et al.* (1968) in citrus agree with the present findings. Chapman (1975) also reported interveinal chlorosis, reduced internodal length and little leaf as the characteristic symptoms of Zn deficiency in most of the perennial crops.

The results on the effect of Zn deficiency on vegetative growth are presented in Table 1. The decrease in length of vine ranged between 23.5 cm (initial) and 80.2 cm (very severe) within a period of 16 months after treatment as compared with healthy vines. The magnitude of reduction was six per cent during the initial stage which increased upto 16 per cent in about four months. In contrast to other vegetative characters the number of leaves which was two percent less than the normal vines during initial stage recorded an increase by six per cent during the very severe stage. The internodal length was reduced by four per cent during the initial stage and by 20 per cent in about four months after the occurrence of initial symptoms. The reduction ranged between 0.2 cm (initial) and 1 .0 cm (very severe) in a period of 16 months. The quantum of reduction in leaf area index ranged between 12.8 cm^2 and 33.8 cm^2 within a period of four months after the initiation of deficiency. The magnitude of reduction was 16 per cent during the initial stage which increased upto 40 per cent at very severe stage.

The dry matter content of root, shoot and leaves recorded a reduction by 14, 16 and 1 per cent respectively during the very severe stage of deficiency. The reduction in total dry matter content varied between 8.8 g (initial) and 19.2 g (very severe) in 16 months. The extent of reduction was nine percent during very severe stage which was six per cent at initial stage. However, complete cessation of growth was not observed.

Tsui (1948) established the necessity of Zn for the synthesis of tryptophan (from indole and serine), a precursor of IAA, the principal endogenous hormone responsible for cell elongation. Tsui's conclusion has been supported by Salami and Kenefick (1970). The profound decrease in internodal length due to Zn deficiency may be attributed to the aforesaid function of the element. When Zn is deficient within the plant, RNA concentration gets reduced by the activation of oxidative enzyme resulting in decreased protein synthesis which may also contribute to the reduction in vegetative growth. The increase in number of leaves could be well explained by the increased production of small lateral shoots during Zn deficiency.

Table 1

Effect of deficiency of zinc on vegetative characters

Stages of zinc deficiency	Months after treatment	Length of vine (cm)	No. of leaves	Internodal length (cm)	Leaf area index (cm²)	Dry matter production			
						Root	Shoot	Leaves	Total
Initial	12	365.2 (-6)	67.7 (-3)	5.3 (-4)	65.2 (-16)	3.5 (-10)	81.3 (-7)	70.6 (-3)	155.4 (-6)
Complete*	12	388.7	70.1	5.5	78.0	3.9	87.8	72.5	164.2
Medium	13	394.8 (-5)	78.9 (+2)	5.0 (-7)	61.3 (—21)	3.8 (-7)	87.6 (—5)	76.2 (-3)	167.6 (-2)
Complete*	13	416.7	77.5	5.4	77.6	4.1	92.3	74.3	170.7
Severe	15	405.0 (-13)	94.1 (+6)	4.3 (-16)	55.4 (-32)	5.0 (-9)	90.0 (-13)	95.1 (-3)	190.1 (-8)
Complete*	15	466.0	89.0	5.1	81.6	5.5	103.2	98.0	206.7
Very severe	16	410.6 (-16)	101.1 (+6)	4.0 (-20)	50.0 (-40)	5.6 (-14)	91.2 (-16)	100.4 (-1)	197.2 (-9)
Complete*	16	490.8	95.0	5.0	83.8	6.5	108.9	101.0	216.4

* Plants receiving complete nutrients

Figures given in parenthesis indicate percentage variation from healthy vines

Table 2

Foliar composition of nutrients at different stages of zinc deficiency

Stages of zinc deficiency	Months after treat-ment	Macronutrients (%)						Micronutrients (ppm)				
		N	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Initial	12	3.25	0.285	3.15	2.20	1.400	0.200	192	88	122	32	45
		(+0.3)	(—5)	(+2)	(+1)	(-7)	(—7)	(-2)	(+1)	(—2)	(-54)	(-10)
Complete*	12	3.24	0.300	3.08	2.18	1.500	0.215	195	87	125	70	50
Medium	13	308	0.300	3.00	2.34	1.450	0.216	196	90	125	25	47
		(-8)	(-3)	(—1)	(+4)	(-3)	(-1)	(-1)	(+5)	(-2)	(-64)	(-4)
Complete*	13	3.33	0.310	3.04	2.25	1.501	0.219	198	86	127	70	49
Severe	15	3.00	0.315	3.25	2.19	1.511	0.219	200	92	128	20	46
		(-10)	(+4)	(+0.3)	(-5)	(+6)	(-4)	(—5)	(+2)	(-2)	(-72)	(-8)
Complete*	15	3.35	0.302	3.24	2.31	1.431	0.218	210	90	126	71	50
Verysevere	16	3.23	0.311	3.00	2.20	1.500	0.218	208	91	128	15	49
		(-4)	(+2)	(-3)	(-5)	(0)	(-1)	(-1)	(+1)	(0)	(-79)	(+2)
Complete*	16	3.35	0.305	3.10	2.31	1.500	0.221	210	90	128	72	48

* Plants receiving complete nutrients

Figures given in parenthesis indicate the percentage variation from normal value

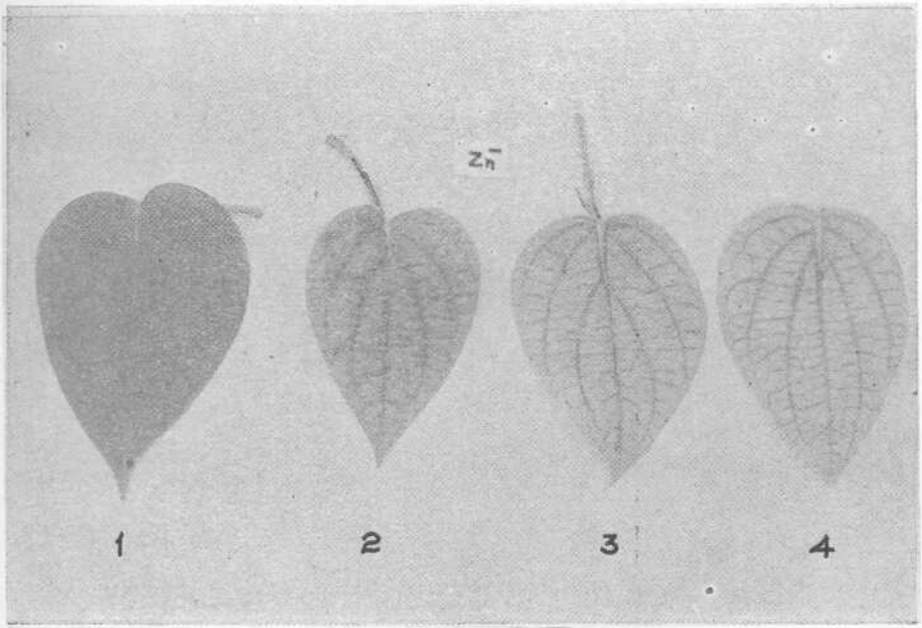

Fig. 1 Leaves showing different stages of zinc deficiency symptoms

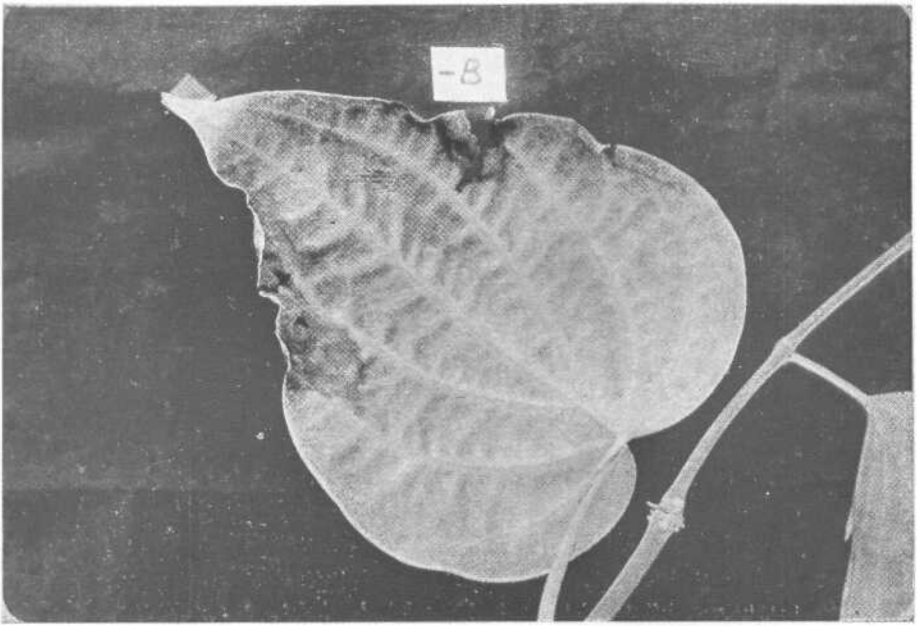

Fig. 2 A leaf showing boron deficiency symptom

The data furnished in Table 2 revealed that visual symptoms of Zn deficiency concurred with a profound drop in foliar concentration of Zn. The quantum of reduction ranged between 38 ppm and 57 ppm from initial to very severe stage (in a period of 16 months). At the initial stage the extent of reduction was 54 per cent (32 ppm) which increased with the increase in severity of deficiency and registered 79 per cent (15 ppm) decrease in about four months (very severe stage). The variation in other nutrients due to Zn deficiency was negligible.

Medium and severe stages of Zn deficiency could be corrected within two and three weeks respectively after the application of full nutrient solution. The foliar concentration of Zn in recovered vines of medium and severe stages has also increased to 57 ppm and 54 ppm respectively.

Deficiency of boron

Boron deficiency was first noticed nine months after treatment. The initial symptom was observed as the failure of development of terminal bud. Small branches appeared below the terminals, young leaves were distorted (initial stage). The plants exhibited stunted growth. The terminal leaves became abnormal in size and when mature, interveinal chlorotic patches were visible on the laminae. This condition was noticed two months after the appearance of the initial symptoms (medium stage.)

One month after the occurrence of the chlorotic patches, the affected leaves became thick, brittle and presented a mottled appearance with bright orange coloured mottles. No symptom was expressed by the basal leaves (severe stage).

Within a period of four months after the expression of the initial symptom, the mottling became very severe. The area on the lower side of the lamina corresponding to the mottles on the upper surface became grey brown (very severe stage). The major as well as lateral veins became very prominent with pale green colour in grey brown interveinal background. Very severely affected leaves showed black necrotic areas with charred appearance which started from the lower leaf margins and progressed upward marginally and towards the centre of the laminae. Later on, cracks appeared on the necrotic area and small pieces of the same got detached from the lamina. The affected leaves were retained on the plant for a long period and only during extreme deficiency condition abscission occurred.

The failure of terminal bud development may be related to the effect on B on RNA metabolism (Gauch, 1972). During B deficiency water relations become abnormal and leaves and stem appear desiccated and hence have a stiff woody feel. Results of the studies conducted by Eaton (1944) in grapes fully conform to the B deficiency symptoms observed during the present investigation. Bradford (1975) also observed the general symptoms of B deficiency as die-back of terminal growth and thickening, brittleness, curling and chlorosis of terminal leaves.

Table 3

Effect of deficiency of boron on vegetative characters

Stages of boron deficiency	Months after treatment	Length of vine (cm)	No. of leaves	Internodal length (cm)	Leaf area index (cm^2)	Dry matter production (g)			
						Root	Shoot	Leaves	Total
Initial	9	265.5	50.9	5.2	85.8	3.0	58.8	58.2	121.0
		(-4)	(-8)	(0)	(+1)	(-6)	(-9)	(-0.3)	(-4)
Complete*	9	276.2	55.3	5.2	84.6	3.2	64.9	58.4	126.5
Medium	11	280.2	53.8	5.2	89.7	3.1	62.2	63.5	128.8
		(-23)	(-19)	(-2)	(+16)	(-11)	(—23)	(-8)	(-17)
Complete*	11	365.6	66.8	5.3	77.2	3.5	81.1	70.0	154.6
Severe	12	286.4	54.5	5.3	91.9	3.5	63.6	65.0	132.1
		(-26)	(-22)	(-4)	(+18)	(-10)	(-28)	(-10)	(-20)
Complete*	12	388.7	70.1	5.5	78.0	3.9	87.8	72.5	164.2
Very severe	13	286.4	54.5	5·3	91.9	3.7	63.6	650	132.3
		(-31)	(-30)	(-2)	(+18)	(-10)	(-31)	(-13)	(—22)
Complete*	13	416.7	77.5	5.4	77.6	4.1	92.3	74.3	170.7

* Plants receiving complete nutrients

Figures given in parenthesis indicate percentage variation from healthy vines

Table 4

Foliar composition of nutrients at different stages of boron deficiency

Stage of boron deficiency	Months after treatment	Macronutrients (%)						Micronutrients (ppm)				
		N	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	K
Initial	9	3.30 (+0.3)	0.305 (+0.3)	3.00 (-3)	2.10 (+4)	1.486 (-1)	0.209 (-3)	190 (-1)	82 (-4)	125 (-3)	70 (+ 1)	20 (-59)
Complete*	9	3.29	0.304	3.10	2.18	1.506	0.216	192	85	129	69	49
Medium	11	3.18 (-1)	0.312 (+4)	3,21 (+4)	2.15 (+5)	1.509 (+ 0.6)	0.200 (-5)	191 (-1)	85 (-2)	131 (+5)	65 (-4)	15 (-71)
Complete*	11	3.21	0.300	3.10	2.05	1.500	0.210	193	87	125	68	51
Severe	12	3.00 (—7)	0.298 (-0.7)	3.18 (+3)	2.00 (-8)	1.512 (+0.8)	0.210 (-2)	188 (-4)	85 (-2)	128 (+2)	68 (-3)	14 (-72)
Complete*	12	3.24	0.300	3.08	2.18	1.500	0215	195	87	125	70	50
Very severe	13	3.25 (-2)	0.311 (+0.3)	3.21 (+6)	2.20 (-2)	1.505 (+0.3)	0.216 (—1)	191 (- 4)	83 (-3)	126 (—0.08)	69 (-1)	12 (-76)
Complete*	13	3.33	0.310	3.04	2.25	1.501	0.219	198	86	127	70	49

* Plants receiving complete nutrients

Figures given in parenthesis indicate the percentage variation from normal value

The data related with the effect of B deficiency on vegetative growth are presented in Table 3. The results revealed that the deficiency of B could inhibit growth at comparatively early period. There was reduction in length of vine which ranged between 10.7 cm and 130.3 cm from initial to very severe stage as compared to healthy vines. The extent of decrease was four per cent at the initial stage which was increased upto 31 per cent in about four months (very severe stage). The number of leaves showed a reduction by 30 per cent during very severe stage whereas the leaf area recorded an increase by 18 per cent during the same stage. The reduction in leaf number during the initial stage was eight per cent and the increase in leaf area was one per cent. There was practically no variation in inter-nodal length as compared with that of the healthy vines. However, a slight reduction by four per cent was observed during the severe stage.

The dry matter of roots showed a reduction by six per cent (0.2g) during the initial stage and 10 per cent (0.4g) at very severe stage. The dry matter of shoot and leaves recorded a reduction by 31 per cent and 13 per cent respectively during the very severe stage. The quantum of reduction ranged between 6.1 g and 28.7 g in respect of shoot and from 0.2 to 9.3g in the case of leaves from initial to very severe stage. The total dry matter content showed a reduction by four per cent during the initial stage and 22 per cent during the very severe stage. The growth was practically arrested by twelfth month after treatment as could be seen from the data on total dry matter content.

Since B has a specific regulatory step in carbohydrate metabolism (Lee and Aronoff, 1967), the reduction in growth can normally happen due to B deficiency. Another contributing factor to the pronounced reduction in growth may be the effect of B in terminal bud development. Abnormal size of leaves due to B deficiency has also been reported by Gonzales and Camacho (1952) in coffee. However, the reason for such an abnormality has to be further investigated since the available literature on B fails to suggest a possible reason.

The data in Table 4 indicated that plants exhibited B deficiency symptoms when the concentration of the same in leaf was reduced to 20 ppm which was 59 per cent less than the normal value. The magnitude of reduction was increased with the advancement of deficiency and reached as high as 76 per cent (12 ppm). However, B failed to establish any pronounced effect on the foliar concentration of of other nutrients.

Boron deficiency at severe stage could not be rectified. However, when full nutrient solution was applied to the plant under medium stage of deficiency it was possible to recover the plants from the disorder within three weeks. The recovered vine has recorded 35 ppm of B in leaves.

The deficiencies of macronutrients and micronutrients such as Fe, Mn and **Cu** in black pepper have been described by Nybe and Nair (1986, 1987a and 1987b.)

Summary

Detailed investigations were conducted in black pepper (var. Panniyur-1) from 1983 to 1985 at the College of Horticulture, Vellanikkara to induce deficiency symptoms of Zn and B. The deficiency symptom of Zn was first manifested on the younger leaves as interveinal chlorosis. Reduced internodal length, little leaf and rosetting were the other symptoms specific to Zn deficiency. Failure of development of terminal bud was the initial symptom of B deficiency. The terminal leaves became large, thick and brittle with orange yellow mottles on the upper surface and grey brown interveinal patches on the lower surface. The vegetative growth of the vine was completely arrested by the twelfth month after treatment due to B deficiency whereas there was no cessation of growth due to Zn deficiency. Zinc deficiency resulted in increased production of leaves which were reduced in size and B deficiency was characterized by larger leaves. Visual symptoms of deficiencies were concurred with a marked reduction in the foliar level of the concerned element. The deficiency symptom could be recovered by the application of the deficient nutrient.

Acknowledgements

This paper forms a part of the Ph. D. thesis of the senior author submitted to the Kerala Agricultural University, 1986. The authors express their deep sense of gratitude to the Associate Dean and to the Professor and Head, Department of Plantation Crops and Spices, College of Horticulture, Vellanikkara for the facilities provided to carry out this work. The help rendered by Dr. P. A. Wahid, Professor (Radiotracer) and Dr. A. I. Jose, Professor and Head, Department of Soil Science and Agrl. Chemistry, College of Horticulture, Vellanikkara during the course of the investigations and in preparing the paper is gratefully acknowledged.

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