

## SOME AGRO-PHYSIOLOGICAL ASPECTS OF BORON NUTRITION IN AN INDIAN VARIETY OF GROUNDNUT

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**I**N India groundnut or peanut (*Arachis hypogaea* L.) is cultivated in the regions of Andhra Pradesh, Madras, Bombay, Bihar, Bengal, Madhya Pradesh, Mysore, Punjab, Rajasthan and Uttar Pradesh. In each of these areas suitable selected varieties are under large-scale cultivation. Groundnut variety TMV-2, a short duration (105 to 112 days) bunch type, is one of the varieties cultivated largely in Andhra Pradesh and Madras State.

The importance of boron in the nutrition of groundnut plant is well established<sup>1-4</sup>. In the present communication some of the aspects of boron nutrition in groundnut with particular reference to the variety TMV-2 are briefly summarized from the investigations carried out by the authors<sup>5-20</sup>. Some of the salient results obtained in the studies by Harris and co-workers and others are also included.

The experiments were carried out under the climatic conditions of Tirupati and nearby areas which are situated in Chittoor District of Andhra Pradesh.

### *Climate, soil and cultivation*

The locality of Tirupati, surrounded by low hills, is characteristic of the 'dry' districts of Chittoor, Anantapur, Kurnool and Cuddapah. The usual South-West monsoon is erratic and unpredictable. June, July and August are characterised by strong Westerly winds. North-East monsoon, generally starting in the beginning of November and extending for about 7 to 8 weeks, is relatively more reliable.

The area where the present investigations were carried out is of a semi-arid (sub-humid) type; the annual rains are low, natural water sources are inadequate and most of the crop plants including groundnut are cultivated by irrigating the fields with tube-well waters with impeded drainage. In the locality, groundnut (TMV-2) crop is generally

grown in sandy loam soils (reddish in colour) as well as in clay loam soils, both as an irrigated crop in summer months (February to May) and as a rainfed crop in other months.

### *Boron content of irrigation waters, cultivated soils and foliage of groundnut plants and their yield (from local fields)*

The boron content of well waters used for irrigation groundnut crops in the fields, the water-soluble (readily available) boron of the cultivated soils where the crops are grown, and the boron content of the mature middle leaves of the plants (at maturity) and the yield of pods are presented in Table I.

TABLE I  
Mean values from 30 different cultivated fields\*

Particulars	Mean boron (ppm)	Range of boron (ppm)	Mean yield/plant (pods)
Irrigation water	0.08 ± 0.01	0.02 to 0.15	..
Soil (0-6" depth)†	0.51 ± 0.03	0.30 to 0.78	16 ± 2 (range: 14 to 18)
Middle leaves‡	52 ± 3	45 to 65	..

\* All the samples were collected from local fields (opposite to Sri Venkateswara University, Tummala-gunta and Vurlapattidi areas) near Tirupati.

† Boron content of soils is expressed on air-dry soil basis.

‡ Ppm or µg/g oven-dry weight.

The boron content of the soil (soil + compost, 3 : 1), water (used for watering the plants), mature middle leaves of groundnut plants (at maturity) and the yield of pods are shown in Table II. The plants were grown in pot cultures.

### *Boron deficiency symptoms*

With boron deficiency groundnut plants were dwarf with stunted shoot growth; the leaves were small and leaf number was reduced when compared to normal (boron sufficient) plants. The root system was also stunted, brown in colour, brittle and had an unhealthy appearance. The lateral roots were short and their tips decayed. Sometimes water-soaked areas were formed in the

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TABLE II  
Mean values of 8 replications\* (from pot cultures)

Particulars	Mean boron (ppm)	Range of boron (ppm)	Mean yield/plant (pods)
Water <sup>1</sup>	.. 0.20 ± 0.01	0.18 to 0.22	..
Water <sup>2</sup>	.. 0.20 ± 0.01	0.19 to 0.21	..
Soil <sup>1</sup>	.. 0.24 ± 0.01	0.23 to 0.26	15.8 (range: 13.9 to 17.6)
Soil <sup>2</sup>	.. 0.25 ± 0.01	0.24 to 0.28	
Middle leaves ..	44 ± 2.4	44 to 46	

\* Boron content in the different samples is expressed similarly as in Table I.

<sup>1</sup> and <sup>2</sup> From two different experiments.

leaves, but death of the apical growing point was rarely observed<sup>6</sup>.

#### Boron toxicity symptoms

The initial symptom of boron toxicity in the plants was interveinal chlorosis (yellowing) in margins and tips of the leaves. Later with greater accumulation of boron, chlorosis reached almost the base of the leaves when the chlorotic tips and margins dried up showing typical necrosis (drying). Basal leaves (older foliage) often turned completely yellow. In mature middle leaves necrosis too gradually extended towards the centre of the leaves. In apical developing leaves, the interveinal chlorosis often resembled typical iron deficiency chlorosis. With severe toxicity the leaves were completely dried leaving a small yellow portion in the leaves at their base. With excessive accumulation of boron, premature defoliation occurred and with prolonged toxicity the plants were stunted<sup>5,16</sup>.

#### How to diagnose correctly the boron deficiency and toxicity under field conditions

In spite of the extensive work on morphological symptoms in various species and their varieties of crop plants with several nutritional disorders the visual examination method seems to be of not much help to identify correctly the element that produces the disorder (either deficiency or toxicity). However, this method may be useful in certain exceptional cases. Different patterns of foliar symptoms or other abnormalities are produced in different crop plants with the same nutrient disorder as well as with other nutrient elements either with deficiency or toxicity<sup>21-23</sup>. For example, marginal chlorosis and necrosis in leaves was reported with toxicities of zinc<sup>24</sup>, manganese<sup>25</sup>, and boron<sup>16</sup>, in groundnut plants. This method is only one of the many tools employed in diagnostic work.

Sometimes without the onset of clear visual morphological symptoms or even without manifesting any symptoms at all (upto maturity of

crops) the growth and yield of crop plants may be adversely affected by nutritional disorders. Even though the boron level of groundnut plants was lower than that at which deficiencies ordinarily develop, the symptoms failed to appear<sup>26</sup>. This indicates that light intensity as also the daylength may determine the boron requirement and the onset of symptoms. Boron requirements of plants increase with rise in temperature and deficiency symptoms occur more frequently and more severely during dry, hot years<sup>27</sup>. With 0.05 ppm available boron in Blanton fine sand, visible foliar deficiency symptoms of boron scarcely developed in Early Runner groundnuts; the symptoms were not observed until late in the growing season and even so, seed yields were greatly reduced and had "hollow heart" defect<sup>4</sup>. Harris<sup>3</sup> stated that a low level of boron in the soil did not always cause foliar deficiency symptoms. Under these circumstances, if the diagnosis is not made early (at the initial stage of the growth of the crop) and suitable measures to correct the deficiency suggested, the farmer will be at great loss due to the lower crop yields.

For these and other reasons, even from early times, plant analysis is considered a relatively rapid way of diagnosing correctly the nutritional disorders and needs of crop plants. In modern agriculture too, plant analysis in soil testing has become an acceptable method to have reliable knowledge of nutritional disorders and requirements of crop plants (even before any visual onset of foliar or other symptoms) by using the plant itself as an indicator for the economic future of agriculturists.

Immediately after one suspects boron deficiency or toxicity, the boron content of these plants as also of the apparently healthy plants (from the same field) should be determined using a reliable analytical method. Analysis of boron in the leaves is preferable and provides a more reliable basis for diagnosis of boron toxicity (perhaps for deficiency also) in crop plants over the method of visual examination of foliar symptoms or analysis of water or soil for boron<sup>28</sup>. With B-toxicity it was observed that excessive quantities of boron accumulated in leaves as compared to other organs of the plant not only in groundnut<sup>5,9,20</sup>, but also in several other crop plants,<sup>29</sup> making foliar analysis very effective. The difference between the boron content of leaves of normal and B-deficient plants was also more striking<sup>6</sup>.

The approximate ranges of normal, deficient and toxic levels of boron in the mature middle leaves of groundnut (TMV-2) plant are shown in Table III. However, the plant may not strictly manifest "foliar symptoms" or other "abnormalities"



in "short durations" with these limits of the levels of B-content in the leaves. The onset of symptoms also depends on the climatic factors around the plant cultures<sup>26</sup>, and also on the age of the plant<sup>5,16-20</sup>.

TABLE III

*Approximate ranges of normal, deficient and toxic levels of boron in the middle leaves of groundnut (TMV-2) plants*

Particulars	Boron content (ppm or $\mu\text{g/g}$ on oven-dry basis)
Deficiency	.. 20 and less
Critical for deficiency	.. 21 to 24
Low	.. 25 to 30
Normal	.. 31 to 130
High	.. 131 to 140
Critical for toxicity	.. 141 to 199
Toxicity	.. 200 and above

*Approximate ranges of boron concentrations in the rooting medium for optimum growth and yield and possible levels of boron to manifest deficiency and toxicity symptoms*

Under field conditions healthy growth and normal yield of plants were observed with a soil water-soluble (available to plant roots) boron of 0.30 to 0.78 ppm (on air-dry soil basis). In pot cultures with soil, good growth and yield were obtained with a range in the concentration of 0.23 to 0.28 ppm (on air-dry soil basis) water-soluble boron. This range in the soil of readily available boron content fell within the range (0.1 to 0.5 ppm) suggested by Berger<sup>30</sup> for optimum growth of groundnuts.

Groundnut (TMV-2) plants may show deficiency symptoms when the soil available boron is less than 0.1 ppm (on air-dry soil basis) under field conditions. But this aspect requires critical study. Boron deficiency symptoms were not observed until late in the growing season in Early Runner groundnuts grown with 0.05 ppm available boron in Blanton fine sand<sup>4</sup>. The threshold of boron deficiency may be considered as being slightly above 0.005 ppm in nutrient culture in the groundnut variety studied by Maistre<sup>31</sup>.

The plants (TMV-2) can tolerate a single application of 1 ppm boron to soil (on air-dry soil basis in pots) when they started flowering. With 3 ppm B-treatment the injury was evident by reducing the root and shoot dry weight and yield significantly. With 5 and 10 ppm B-treatments the plants were definitely injured resulting in reduced growth and yield. It appears the threshold toxicity of boron to this groundnut variety was around 3 ppm<sup>14</sup>.

*Natural and accidental occurrence of boron deficiency and toxicity in soils*

Boron deficiency is found to occur naturally in well-drained soils (acidic) of humid regions with high rainfall and heavy leaching. Boron deficiency may also occur (temporarily) in soils supplied with excess lime, but boron can be released afterwards. Continuous dry and hot weather may also cause B-deficiency in plants.

Boron toxicity is a matter of particular concern in irrigated soils of arid and semi-arid areas where water-soluble boron is reported to be present in relatively higher concentrations. Under such conditions low crop yields are often noted due to heavy irrigation, drought conditions and impeded drainage which favour the accumulation of soluble borates in surface and sub-soil layers. Boron toxicity may pose as an important problem in the economy of agriculture and crop production when it is present in toxic concentrations in cultivated soils or irrigation waters or even fertilizers due to its high solubility in water.

*Recovery of plants from boron deficiency*

In India sufficient results are not available on agronomical studies on the need of boron in the mineral nutrition of groundnut, var. TMV-2, under field conditions. Detailed researches are called for on this aspect to define precisely the critical ranges of soil available boron for the onset of B-deficiency under field conditions. These investigations could help to find out suitable doses of boron for application to recover the plants when they are suffering with B-deficiency.

*Recovery of plants from boron toxicity*

Leaching of cultivated soils with irrigation water (containing very low boron content) to flush out the toxic boron concentrations is at present the only real solution and the ameliorative method to boron toxicity problem and could recover satisfactorily the boron injured groundnut plants<sup>11-17</sup>.

*Concluding remarks*

In the experiments conducted by the authors, no beneficial effect was observed in groundnut (TMV-2) plants with additional boron supplied (as boric acid) to sandy loam soil (containing available boron between 0.23 to 0.28 ppm) in pot cultures. Without an application of boron to the above soil, the plants always grew healthy and vigorously and consistently yielded upto 16 pods (mean) per plant, with a range of 13.9 to 17.6 pods. This range of boron fell within the soil available boron range (0.10 to 0.50 ppm) according to Berger<sup>30</sup> for the optimum growth of groundnuts.

Harris and Gilman<sup>4</sup> stated that boron has been applied in field experimentation with groundnuts for years<sup>22-23</sup> and yet little or no effect has been reported on yield or quality. Harris and Gilman discussed on why boron application to the soil under field conditions may not be beneficial. However, boron application to the soil containing 0.05 ppm available boron under carefully controlled conditions increased the nuts in Early Runner and Dixie Runner varieties of groundnut.

Thus it appears from the work by different persons on boron nutrition of groundnut under field conditions that (1) the symptoms of B-deficiency may be developed with a concentration of boron (in the rooting medium) "slightly less" than the level that supports maximum growth, "late" in the growing season and (2) the symptoms may be manifested with a level of boron "much less" than the concentration required for optimum growth, somewhat "early" in the life span of the plant. Varietal differences with regard to their boron needs may also be there<sup>3</sup>. The requirement of boron may also vary with environmental conditions.

If the available-soil-boron is too low, application of boron in an appropriate dose may produce normal plants and increase the yield of the crop more or less equal to the yields of the plants when grown on soils containing boron concentration sufficient for their optimum growth and yield. But it is always necessary and safe to have reliable data on plant boron, soil boron, boron content of fertilizers and irrigation waters for critical evaluation of B-status before one thinks of boron application to soil for groundnut is desirable under field conditions.

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