CALCIUM AND BORON DEFICIENCY IN CUCUMBERS: SOIL-BASED SOLUTIONS

NIRAJ KUMAR PRAJAPATI[1]*, SANJAY KUMAR[1], RAJANEESH SINGH[2], AWANEESH CHANDRA[3]

[1]School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh; [2]Tilak Dhari Post Graduate College, Jaunpur, Uttar Pradesh; [3]Government Degree College, Jakhini, Varanasi, Uttar Pradesh

*Corresponding Author, E-mail: nkp.ofcl@gmail.com

Cucumber (*Cucumis sativus*), a Cucurbitaceae vegetable is widely cultivated in India for its culinary, nutritional, and economic value. India produces around 1.2–1.5 million tonnes of cucumber annually, with significant cultivation in Uttar Pradesh, Karnataka, West Bengal, and the Himalayan foothills including Himachal Pradesh. Despite its widespread cultivation, farmers frequently report unexplained fruit disorders, tip damage, and poor fruit set, that silently rob 15–30% of potential yield. Two soil-supplied nutrients, Calcium (Ca) and Boron (B), are responsible for a large proportion of these losses. What makes them particularly challenging is that the soil may contain adequate levels of both nutrients, yet plants still develop deficiency symptoms due to soil pH imbalance, faulty irrigation, or antagonism with competing ions. Understanding the soil-related causes of these disorders is therefore essential for targeted and effective management.

ROLE OF CALCIUM IN CUCUMBER GROWTH

Calcium is a secondary nutrient that plays a structural role in plant cell walls, where it forms calcium pectate, the compound that holds cell walls together and gives firmness to fruits. In cucumber, Ca is critical especially in rapid cell expansion phases such as fruit development phase and young leaf growth phase. Unlike nitrogen (N) or potassium (K), Ca cannot be remobilized from older tissues to younger ones, hence an uninterrupted supply of Ca from the soil-root interface is essential throughout the crop season. The primary symptoms of Ca deficiency in cucumber (Table 1; Figure 1) include blossom-end rot – a dark, sunken, water-soaked lesion develops at the flower end of the fruit, and tip burn of young leaves – leaf margins turn brown and die back. Internally, affected fruits show disorganized, pithy tissue. These symptoms become more severe during periods of rapid growth, water stress, or when soils are over-fertilized with K or ammonium nitrogen, both of which compete with Ca for root uptake.

CALCIUM IN INDIAN SOILS

Indian soils vary widely in Ca status. Alluvial soils of Indo-Gangetic plains are generally Ca-sufficient, while acidic red and laterite soils of peninsular India and the acidic hill soils of the northeast and western Himalayan regions are commonly Ca-deficient. Soil pH below 5.5 is a key indicator of potential Ca deficiency, as acidic conditions reduce Ca solubility and increase leaching.

ICAR studies have reported that more than 30% of vegetable-growing soils in India have a pH below 6.0, placing cucumber cultivation at a routine risk of soil acidity (Sharma and Arora, 2019; ICAR-IIVR, 2020).

ROLE OF BORON IN CUCUMBER PHYSIOLOGY

Boron is a micronutrient that have an irreplaceable role in the reproduction and cell wall structure of plants. In cucumber, B is essential for pollen tube germination and growth, hence its deficiency directly impacts fruit set and seed formation. Also, B facilitates sugar transport within plants and is involved in lignin synthesis. It is relatively immobile in plants; hence deficiency symptoms first appear in young growing tissues shoot tips, flower buds, and young fruits. Some typical symptoms of B deficiency in cucumber (Table 1; Figure 2) include distorted, thick, and brittle young leaves; shortened internodes giving a rosette appearance; hollow or corky centres in fruit; poor fruit set despite abundant flowering; and stem cracking near the growing tip. A key distinction from Ca deficiency is that B deficiency affects the growing tip and flower/fruit formation rather than the fruit end.

Table 1. Deficiency symptoms of Calcium and Boron in Cucumber Crop

Feature	Calcium Deficiency	Boron Deficiency
Primary symptom	Blossom-end rot (fruit tip)	Hollow/corky fruit; stem cracking
Leaf affected	Young leaf tip burn	Young leaves distorted, thick
Fruit symptom	Dark sunken lesion at blossom end	Hollow centre; irregular shape
Flower/fruit set	Not directly affected	Poor fruit set; flower drop
Stem symptom	Nonvisible	Cracking; shortened internodes
Soil pH risk zone	pH < 5.5 (acidic soils)	pH > 7.5 (alkaline) or sandy soils
Mobility within plant	Immobile - young tissues first	Immobile - growing tips first
Aggravated by	Irregular watering; excess K or N	Heavy rainfall; sandy texture

(Source: Gupta, 1993; Sharma and Arora, 2019)

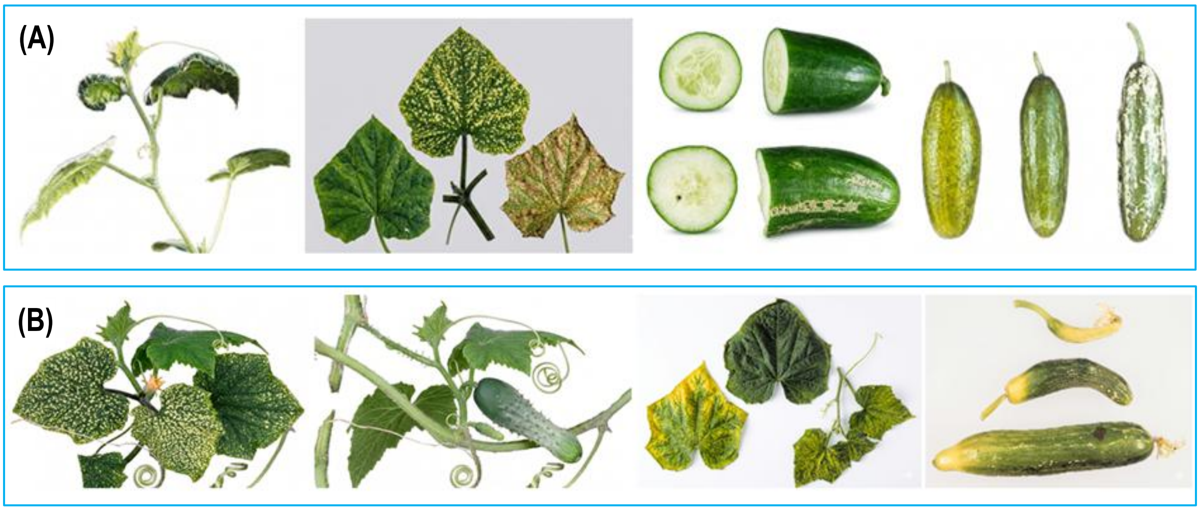

Figure 1 Deficiency symptoms of (A) Calcium and (B) Boron in Cucumber

(Source: Photographs compiled from publicly available educational resources)

BORON IN INDIAN SOILS

Indian soils have a serious and widespread B deficiency problem. Studies of ICAR-Indian Institute of Soil Science indicate that around 33% of Indian agricultural soils are deficient in available B (hot-water soluble boron <0.5 mg/kg). B deficiency is particularly prevalent in coarse-textured (sandy) soils, highly weathered soils, soils with pH above 7.5 (calcareous soils), and soils that receive heavy rainfall causing leaching. Soils derived from boron-poor parent material in peninsular India and Deccan plateau are especially problematic

SOIL-BASED CAUSES OF DEFICIENCY

A basic insight that is often overlooked is that "*deficiency symptoms in the plant do not always mean the nutrient is absent from the soil*". In many cases, the soil contains adequate Ca or B, but soil-related factors prevent the plant from accessing them. Addressing these soil factors is therefore as important as applying the nutrient itself.

Soil pH - The Master Variable: Soil pH controls the solubility and availability of almost every plant nutrient. For Ca, availability drops sharply when soil pH is below 5.5 as Ca is displaced from exchange sites by hydrogen and aluminum ions. The soil optimal pH for cucumber cultivation is 6.0–6.8. In the case of B, its availability is best between pH 5.0–7.0 and decreases sharply above pH 7.5, where it is adsorbed onto calcium carbonate surfaces in calcareous soils, becoming unavailable despite adequate total boron content.

Soil Moisture and Irrigation Patterns: Ca moves to plant roots almost entirely through mass flow – the bulk movement of water carrying dissolved nutrients. This means Ca delivery is directly linked to water uptake of plants. When soils dry out between irrigations, mass flow ceases and Ca supply is interrupted during periods of rapid fruit growth. Irregular irrigation is the single most common cause of blossom-end rot in cucurbits in India, even in Ca-sufficient soils. This makes drip irrigation, a potential option to reduce blossom end rot incidences than flood irrigation in cucumber.

Excess Nitrogen and Potassium: Over-application of ammonium nitrogen (from urea or ammonium sulphate) suppresses Ca uptake because ammonium ions (NH_{4+}) and calcium ions (Ca_{2+}) compete for the same root uptake sites. Similarly, high K application blocks both Ca and B uptake. This 'luxury consumption' of N and K at the expense of Ca and B is common in input-intensive fields where fertilisation is not balanced. The ideal N:Ca ratio in the soil solution for cucumbers should be maintained at around 1:1 by equivalents.

Soil Texture and Organic Matter: Sandy soils hold relatively less Ca and B than clay or loam soils due to lower cation exchange capacity (CEC). With each rainfall or irrigation, both nutrients leach rapidly from the root zone. Low soil organic matter further worsens the problem as it contributes significantly to CEC and acts as a reservoir that slowly releases B over time. Soils with < 0.5% organic matter represents a sizable proportion of irrigated vegetable fields in India are chronically B deficient (Patel et al 2017).

SOIL-BASED MANAGEMENT OPTIONS

Table 2 explains some corrective measures to address Ca and B deficiencies through soil management.

Table 2. Deficiency symptoms of Calcium and Boron in Cucumber Crop

Deficiency	Soil Amendment	Dose / Method	Timing
Calcium	Agricultural lime ($CaCO_3$)	Soil incorporation @ 2–4 t/ha	4–6 weeks before transplanting
	Gypsum ($CaSO_4 \cdot 2H_2O$)	Soil application @ 500–750 kg/ha	At transplanting or early growth phase
	Drip fertigation ($CaNO_3$)	3–5 kg/ha/week - via drip system	From transplanting to fruiting

Boron	Borax ($Na_2B_4O_7 \cdot 10H_2O$)	1–2 kg/ha; mixed with sand before broadcast	Basal application
	Solubor (disodium octaborate)	0.5–1 kg/ha; foliar or fertigation	At flowering and fruit set stage
Both	FYM/Compost	Soil incorporation @ 10–15 t/ha	3–4 weeks before planting
	Vermicompost	3–5 t/ha; in furrows	At transplanting

(Source: Gupta, 1993; Mortvedt, 1994; Patel et.al., 2017; Sharma and Arora, 2019)

Important Caution: Boron has the narrowest margin between deficiency and toxicity among various plant nutrients. Hence, the safe dose of borax should not exceed 2 kg/ha in a single application as soil treatment. Excess B application causes leaf margin scorch, premature leaf drop, and significant yield loss. Always conduct a soil test before boron application

PREVENTIVE MANAGEMENT STRATEGIES

Prevention is always better than correction, especially for immobile nutrients like Ca and B. Regular adoption of integrated soil management practices given below, can eliminate Ca and B related losses in cucumber:

- Soil testing before crop season: test for available Ca, hot-water soluble B, pH, and organic carbon. The critical threshold for B is 0.5 mg/kg (hot-water soluble) and it is 1,000 mg/kg for Ca.
- Maintain soil pH between 6.0 and 6.8 through liming of acidic soils. Even a unit increase in pH (from 5.5 to 6.5) can increase Ca availability by three to five times in acidic soils.
- Adopt drip irrigation or regular furrow irrigation to ensure continuous soil moisture. Avoid allowing soil to dry below 50% field capacity during flowering and fruiting stages.
- Incorporate well-decomposed farmyard manure or compost annually @ 10–15 t/ha. This directly improves soil CEC, adds boron, and buffers soil moisture.
- Avoid excessive urea application by limiting urea-based N to not more than 50% of total N requirement. Use calcium nitrate (15.5% Ca, 15.5% N) as a dual-purpose fertiliser that supplies both N and Ca simultaneously.
- Use balanced fertilization: K_2O application above 120 kg/ha in cucumber without compensatory Ca and B inputs is a reliable trigger for deficiency. Follow soil test-based fertilizer recommendation.
- Raised beds with good drainage prevent waterlogging which reduces root oxygen availability and thus nutrient uptake, further worsening calcium deficiency.

CONCLUSION

Ca and B deficiencies are among the most economically significant yet underdiagnosed disorders of cucumber cultivation in India. Their management requires moving beyond symptomatic foliar sprays to addressing the underlying soil conditions that cause or exacerbate deficiency. Soil pH, moisture management, organic matter, and balanced nutrient application are the four pillars of prevention. A simple soil test before every season costs a fraction of the yield losses these deficiencies cause and should be the starting point for every cucumber grower. When soil health is maintained, cucumbers supply themselves with the nutrition they need.

REFERENCES

Bhatt, R.M. and Srinivasa Rao, N.K. 2004. Influence of pod load on response of okra to water stress. Scientia Horticulturae, 99(1): 1–9.

Gupta, U.C. 1993. Boron and its Role in Crop Production. CRC Press, Boca Raton, Florida.

ICAR-IIVR. 2020. Annual Report 2019–20. Indian Institute of Vegetable Research, Varanasi.

Jayarama Reddy, P. 2009. The Handbook of Horticulture Statistics. Ministry of Agriculture, Government of India, New Delhi.

Mortvedt, J.J. 1994. Needs for controlled-availability micronutrient fertilizers. Fertilizer Research, 38(3): 213–221.

Patel, K.P., Ramani, V.P., George, V., Sutaria, G.S. and Hirpara, D.S. 2017. Boron status of soils and its requirement for field and horticultural crops. Advances in Plants and Agriculture Research, 7(4): 364–368.

Rengel, Z. 2001. Availability of Mn, Zn and Fe in the rhizosphere. Journal of Soil Science and Plant Nutrition, 164(2): 189–196.

Sharma, B.D. and Arora, H. 2019. Micronutrient Status of Indian Soils and Management Strategies. IISS Bulletin, 23: 1–12.

Singh, J.P. and Singh, M.V. 2003. Micronutrient deficiency map of India. Fertilizer News, 48(11): 13–22.

Yadav, D.S. and Kumar, R. 2016. Vegetable cultivation in Himachal Pradesh: constraints and opportunities. ICAR-CPRI Technical Bulletin, Shimla.

***

Article Received on: 26 May 2026