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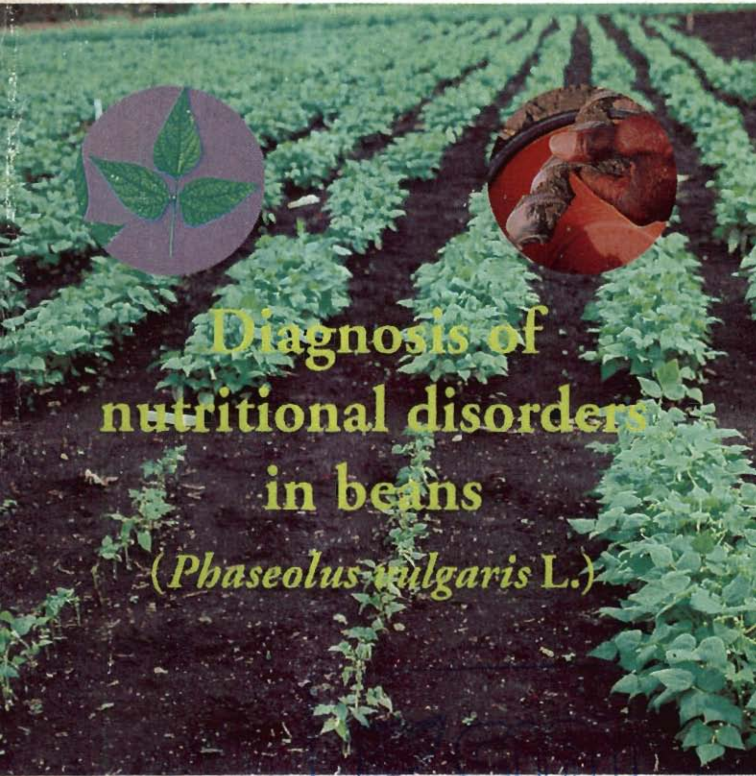

Diagnosis of nutritional disorders in beans (*Phaseolus vulgaris* L.)

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(*Phaseolus vulgaris* L.)

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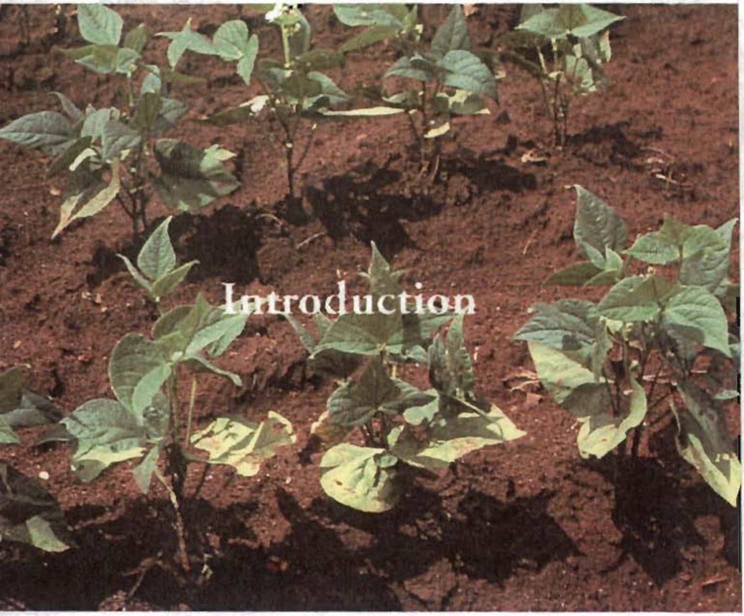
Contents


Introduction

Low soil fertility levels and mineral imbalances are major constraints to bean productivity. Symptoms of nutritional disorders due to low nutrient availability, as well as toxic levels of Al and Mn, are frequently observed on farmers' fields. Accurate diagnosis is required to correct nutritional disorders. Once the problem and its causes are known, corrective crop and soil management practices can be implemented. (Figures 1,2)

The diagnosis of nutritional disorders may involve one or more of seven steps.

These steps are:

1. Look at the plant

2. Examine the soil

3. Look at the surroundings

4. Interview the farmer

5. Analyze plant nutrient content

6. Perform soil chemical analysis

7. Conduct confirmatory and exploratory experiments.

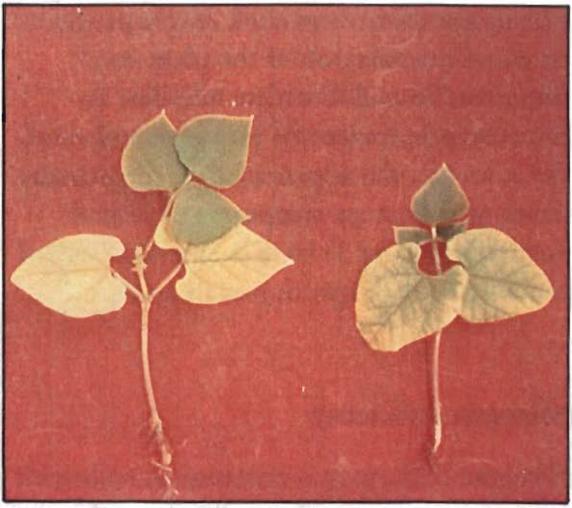


Figure 1. Al toxicity.

Figure 2. Mn toxicity.

The first step in nutritional diagnosis should be visual examination of the plant itself. Many nutritional disorders manifest as characteristic symptoms on leaves and roots. For example, the appearance on the primary leaves of deficiency symptoms of several nutrients (Figure 3) have been characterized enabling early diagnosis and treatment.

Nitrogen deficiency

Nitrogen deficiency is common in soils with low organic matter content, in leached sandy soils and in situations where nitrogen fixation is reduced. Low nitrogen symptoms are most prominent on the lower leaves (Figure 4) but generally occur throughout the whole plants. Mature leaves turn very light green and then yellow. Leaf chlorosis is uniform and necrosis may develop until lower leaves fall from the plant. Overall plant development is reduced.

Figure 3. Look at the plant.

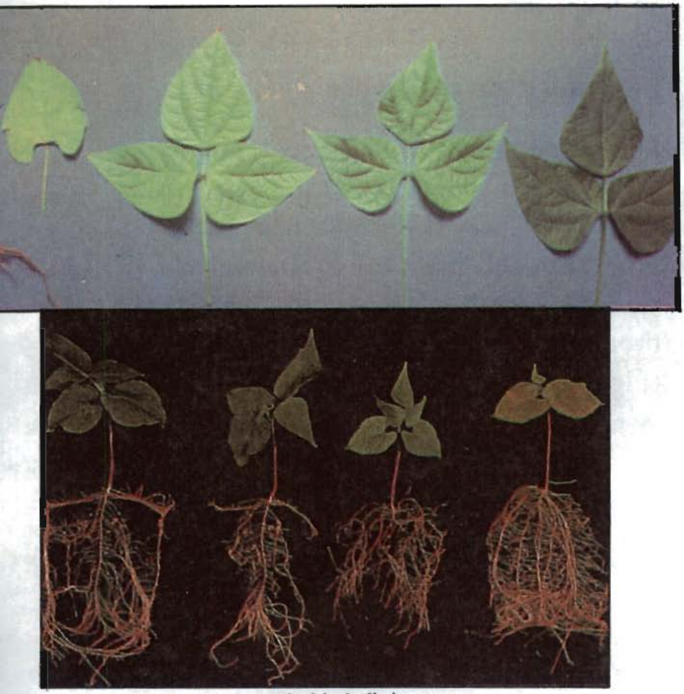


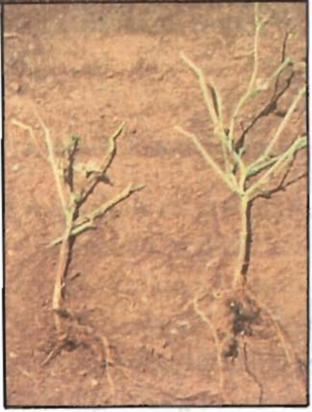
Figure 4. N deficiency.

Phosphorus deficiency

Phosphorus deficiency is probably the most common nutritional disorder of beans. Phosphorus deficiency appears as small, dark-green leaves, (Figure 5). Older leaves may senesce and fall earlier than normal. Plants have short internodes and reduced branching (Figure 6). Pod number and grains per pod are reduced.

Potassium deficiency

Potassium deficiency in beans is not common but is of localized importance on some highly weathered and infertile soils. Potassium deficiency causes interveinal chlorosis on older leaves which is most pronounced on the leaf margins and apexes. (Figure 7)



Figures 5 , 6.
P deficiency.

Figure 7.
K deficiency.

Calcium deficiency

Calcium deficiency is typically associated with acid soils. Calcium deficiency primarily affects root growth but can also stunt shoot apical growth (Figure 8). Younger leaves, are cupped shaped or otherwise distorted. In severe cases the shoot meristem dies.

Magnesium deficiency

Magnesium deficiency is associated with acid soils of low base saturation. It has also been observed on soils derived from volcanic ashes. Magnesium is very mobile in the plant and symptoms are initially observed on older leaves as a finely divided interveinal chlorosis (Figure 9)

Figure 8. Ca deficiency.

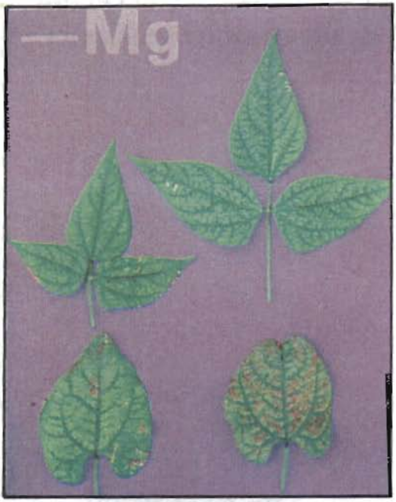


Figure 9. Mg deficiency.

Sulfur deficiency

Symptoms of sulfur deficiency are rarely observed in bean crops. The deficiency is manifested as generalized chlorosis that is somewhat less severe on the younger leaves (Figure 10). The symptoms are similar to those of low nitrogen.

Iron deficiency

Iron deficiency is associated with limestone-based soils and high pH. Symptoms appear on younger leaves as finely divided interveinal chlorosis ranging in color from light green to almost white (Figure 11).

Figure 10. S deficiency.

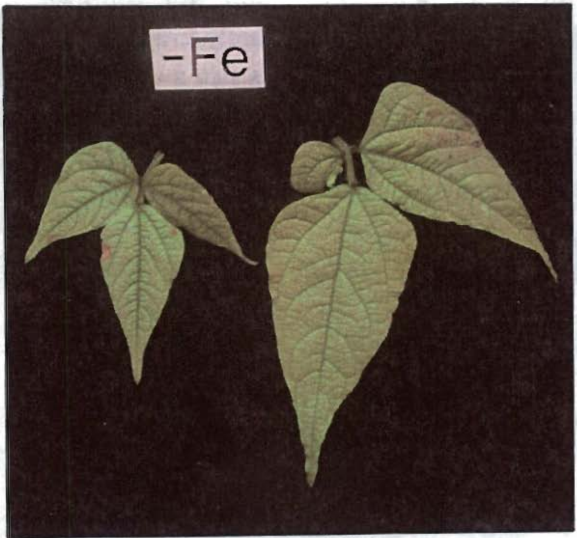


Figure 11. Fe deficiency.

Manganese deficiency

Manganese deficiency can occur in organic soils or in mineral soils with a high pH. It appears as finely divided interveinal chlorosis on younger leaves (Figure 12). Foliar lamina may become wrinkled and mottled with small necrotic lesions.

Manganese toxicity

Beans are very sensitive to manganese toxicity. Manganese is absorbed by the plants in the reduced form and this disorder occurs on soils of moderately low pH and on poorly drained soils. It is also a common problem on some volcanic soils. Symptoms of manganese toxicity vary, as can be observed in the leaves in Figure 13. Common symptoms are interveinal chlorosis on younger leaves and necrotic lesions on older leaves.

Figure 12.
Mn deficiency.

Figure 13. Mn toxicity.

Zinc deficiency

Zinc deficiency occurs in soils with high pH and it may be induced by liming or heavy applications of phosphorus fertilizer on soils with low zinc availability. Its symptoms are expressed as interveinal chlorosis of upper leaves which may progress to leaf bronzing. Leaflets are elongated and leaf margins can be wavy (Figure 14).

Copper deficiency

Copper deficiency is rarely observed in the field, but can occur on organic soils. Copper deficiency causes stunting and premature senescence of younger leaves (Figure 15).

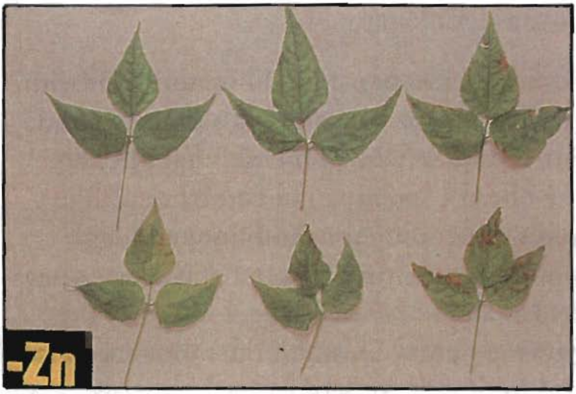


Figure 14. Zn deficiency.

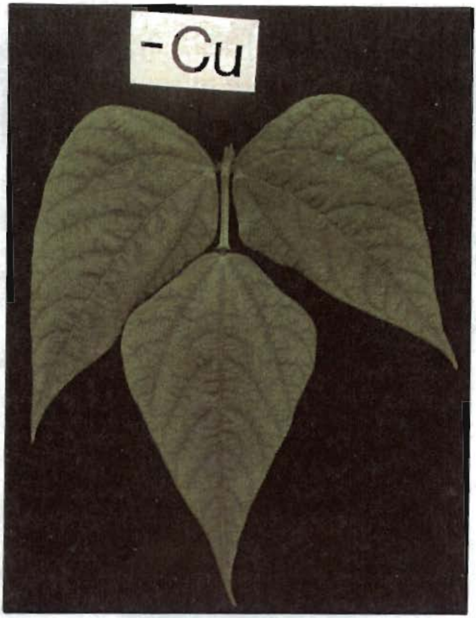


Figure 15. Cu deficiency.

Boron deficiency

Boron deficiency is found in sandy soils with low organic matter and high aluminum and iron levels; alluvial soils with high pH and low boron content; and neutral or alkaline soils under drought conditions and high luminous intensity. Boron deficiency causes deformation of the younger leaves and the growing point. Death of the shoot apex can lead to proliferation of lateral branches. Leaflets may be deformed and the texture of the leaves is brittle. Poor root development is associated with this deficiency. Symptoms of boron deficiency in adult plants may be similar to those of common mosaic virus (Figure 16).

Figure 16. B deficiency.

Aluminum toxicity

Aluminum toxicity is a common disorder on acid soils. Aluminum toxicity primarily affects root growth, inhibiting elongation and resulting in proliferation of adventitious roots. Leaves turn yellow and necrotic, usually beginning with the margins of older leaves. Leaves have rough surfaces and are slightly-cupped downward (Figure 17).

Aluminum toxicity is often associated with phosphorus deficiency. Uptake of phosphorus is reduced because of low availability in the soil and restricted root growth.

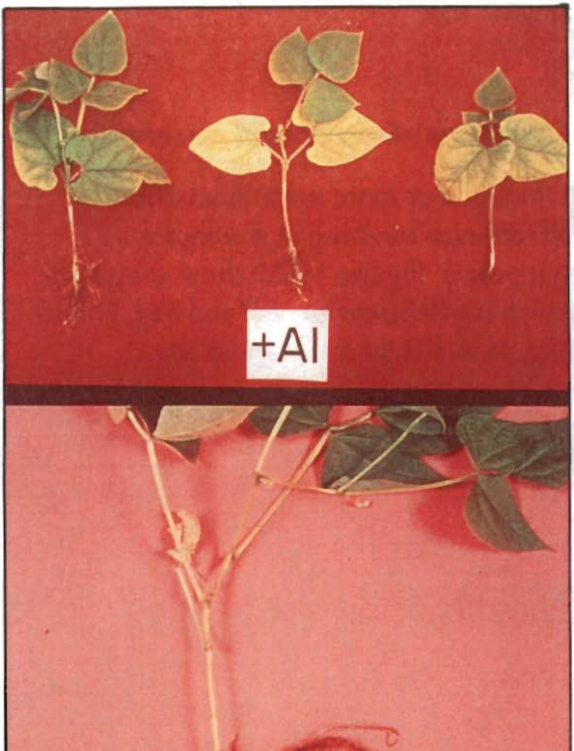


Figure 17. Al toxicity.

Toxicity to sodium and salts

Salt toxicity is most prevalent in semi-arid regions. Sodium toxicity manifest itself as necrosis beginning at the leaf margins (Figure 18).

Complexes of nutritional disorders

Often two or more nutritional disorders affect beans resulting in a complex of symptoms. Figures 19-22 show complexes involving deficiencies of P and Mg, N and Mg, N and B, and P, Ca and Mg.

Figure 18. NaCl toxicity.

Figure 19. P and Mg deficiency complex.

Figure 20. N and Mg deficiency complex.

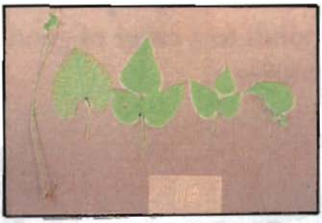


Figure 21. N and B deficiency complex.

Figure 22. P, Ca and Mg deficiency complex.

Phloem mobility of nutrients

Nutrients that move readily in the phloem pass easily to young tissues, leaving deficiency symptoms on older leaves. On the contrary, nutrients that do not move readily in the phloem will remain in older tissue, causing deficiency symptoms in young, growing tissue. Table 1 shows the relative mobility of mineral nutrients in the phloem.

Examination of the soil

Soil pH is a very important indicator of nutrient availability and can be easily measured in the field with pH paper or instruments. Figure 23 shows the relative availability of nutrients as influenced by soil pH. Wider bands indicate greater nutrient availability. Beans prefer soils from pH 5.5 to 7.0, which corresponds to a range of good availability of most nutrients.

Table 1. Relative phloem mobility of mineral nutrients

Mobile	Intermediate	Immobile
N	Fe	Ca
K	Mn	B
Mg	Zn	
P	Cu	
S	Mo	
Cl		

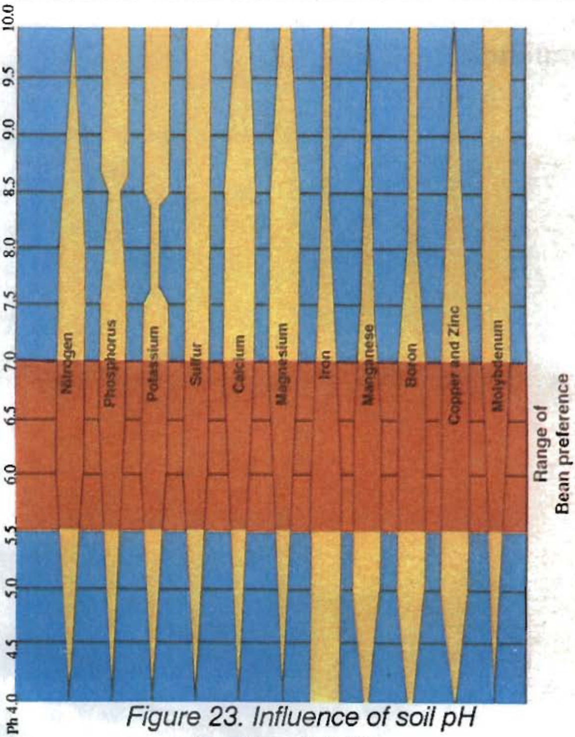


Figure 23. Influence of soil pH on nutrient availability.

Soil color is an indication of nutritional availability. Table 2 shows common relationships between soil color and nutrient availability. Exceptions occur and soil color should only be used to supplement other diagnostic indicators.

Soil texture is associated with soil nutrient availability. Table 3 shows associations of soil texture with nutrient availability. Exceptions occur and soil texture should only complement other diagnostic indicators.

Table 2. Nutrient status of soils, commonly associated with certain soil color

Red, yellow	
	Al toxicity
	P deficiency
	Ca, Mg deficiency
White	
	N deficiency
Black	
	Good fertility
	If volcanic P fixation, Mn toxicity
Grey, green	
	Mn Toxicity

Table 3. Nutrient status of soils commonly associated with soil texture

Sandy	
	N leaching
	K leaching
Loamy	
	Good fertility
Clayey	
	Possible problems with aeration and root growth

Observations of the surroundings

The surroundings may give clues to the origin, or parent material, of the soils.

Parent material may influence nutrient availability (Figure 24), but many exceptions occur.

Local terrain can be a useful indicator of nutrient availability. Nutrients tend to accumulate in low spots, while soils on slopes are often leached and shallow (Figure 25).

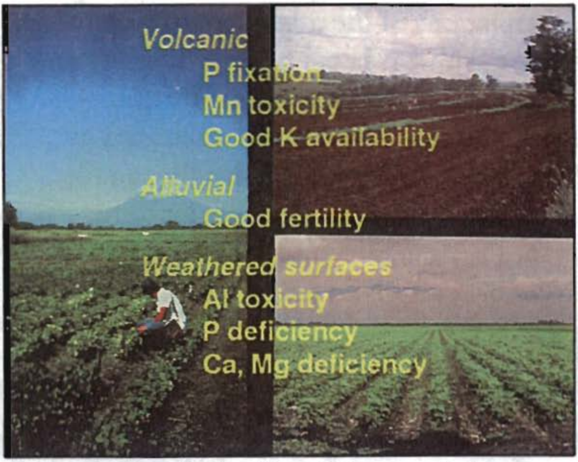


Figure 24. Nutritional characteristics of soil parent material.

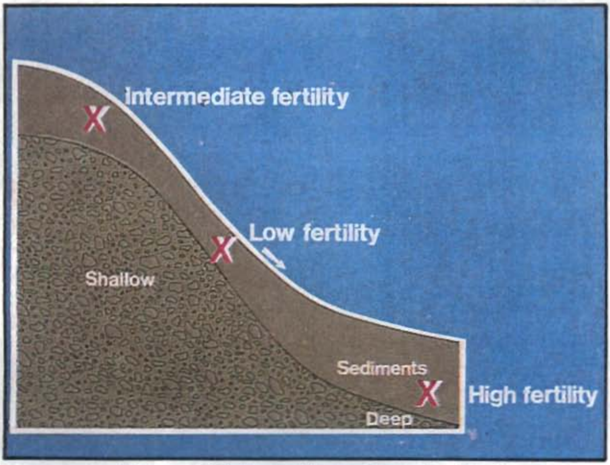


Figure 25. Local terrain as indicator of nutrient availability.

Observations of the other species growing in association with beans may give additional clues to nutritional disorders (Figure 26). Nitrogen and phosphorus deficiencies are readily expressed by maize plants. Banana plants show nitrogen deficiency symptoms before beans. The presence of ferns is an indicator of low soil pH and aluminum toxicity.

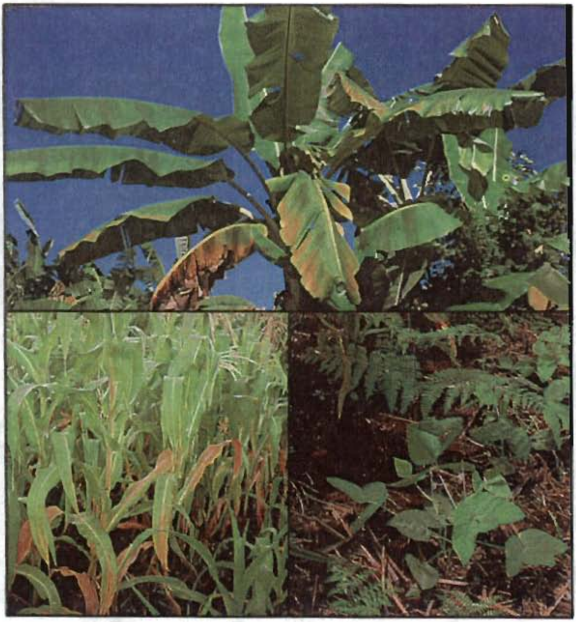


Figure 26. Associated species as indicators of nutrient disorders.

Interview with the farmer

The farmer can give valuable clues for the diagnosis of nutritional disorders (Figure 27). Useful topic guides may include:

1. Management and conditions of current crop, including tillage practices, application of organic or inorganic fertilizer, weed control,pest problems, moisture availability, etc;
2. performance of other crop species and indicator plants at the site;
3. responses of previous crops to applied organic or inorganic fertilizers;
4. longer-term trends in cropping and the effect on productivity; and
5. extent of the disorders.

Figure 27. Interview the farmer.

Plant tissue and soil analysis

Plant nutrient concentrations are affected by many factors other than nutrient availability, but information on foliar nutrient concentrations often provide clues useful to diagnosis. Soil analyses are useful in diagnosis. The information given in Tables 4 and 5 are guides to the interpretation of results of foliar and soil analyses, though the critical levels vary with soil and environment characteristics.

Table 4. Level of mineral nutritients in foliar tissue of beans

Element	Levels		
	Deficient (less than)	Adequate	Toxic (more than)
(%)			
Nitrogen	2.50	2.80-6.00	---
Phosphorus	0.20	0.25-0.50	---
Potassium	1.50	1.80-2.50	---
Calcium	0.50	0.80-3.00	---
Magnesium	0.20	0.25-0.70	---
(ppm)			
Iron	50	100-450	500
Zinc	15	20-100	200
Manganese	20	30-300	500
Boron	20	30-60	200
Cooper	5	10-20	30

Source:Wilcox and Fageria, 1976

Table 5. Approximation of critical levels of soil nutrients required by beans

Analysis	Method	Critical levels
Al saturation	Al/(Al + Ca +Mg +K) x 100	10% [1] 50% [2]
P	Bray I	11 ppm
	Bray II	15 ppm
	Olsen-EDTA	14 ppm
	North Carolina	13 ppm
K	Ammonium acetate, 1N	0.15 meq/100 g
Mg	Ammonium acetate, 1N	2.0 meq/100 g
Ca	Ammonium acetate	4.5 meq/100 g
Conductivity	Saturation extract	0.08 d S/m
Na saturation	Ammonium acetate, 1N	4%
B	Hot water	0.4 ppm
Zn	North Carolina	0.9 ppm
Mn	North Carolina	5 ppm
Cu	0.5 M-EDTA	0.6 ppm
Fe	Ammonium acetate	2.0 ppm
pH	Soil/Water 1:1	range 5 - 7.8 optimum 5.5 - 6.5

Toxicities : [1] Mineral soil [2] Organic soil

Source: Flor, 1989; Howeler and Medina, 1977