ICAR-Indian Institute of Spices Research
Post bag No. 1701, Marikunnu P. O.,
Kozhikode- 673 012, Kerala, India.
Phone: 0495-2731410, Fax: 0495-2731794,
e-mail: mail@spices.res.in
Web site: www.spices.res.in

Guide on diagnosis and correction of nutritional disorders in major spice crops

ICAR-Indian Institute of Spices Research
Kozhikode-673012, Kerala

Compiled and Edited by
S. Hamza
V. Srinivasan
R. Dinesh
A.K. Sadanandan

Published by
K. Nirmal Babu
Director
ICAR - Indian Institute of Spices Research
Kozhikode, Kerala, India

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6) Ginger (for soils with pH above 7)
   - M/s. Hi-7 Agro Bio Solutions, Bengaluru, Karnataka Ph: 9945753391
   - M/s. Natura Nursery & Agro products, Kozhikode, Kerala Ph: 9495083753

Guide on diagnosis and correction of nutritional disorders in major spice crops

Introduction

In India spices are grown in around 3.46 million ha with an annual production of about 6.9 million tons (2015-16). Out of this, about 9.4 lakh tons valued at 2.63 billion US $ was exported and the balance is used for internal consumption. But our productivity is low compared to competing countries. In our country, spices are grown mainly in red and laterite soils of South India and North Eastern states where soils are highly weathered and low in nutrient status especially secondary and micronutrients. The major reasons for low productivity of spices are low soil pH, high clay and low sand content, low Cation Exchange Capacity (CEC) base saturation, low status of organic C, Potassium (K), Calcium (Ca), Magnesium (Mg) and Zinc (Zn). Except turmeric and seed spices, which are grown in wide range of pH varying from 5.0 to 7.5, all the other major spices are grown in slightly acidic soils which are being grouped under red loams or laterites. These soils are generally deficient in available P, Ca, Mg, Zn and B with low CEC. Because of the indiscriminate use of fertilizers, occurrence of nutrient related problems are rampant. Moreover, in most of the cases, these disorders may be akin to symptoms related to pest and diseases.

Plant nutrients

Plant nutrients are those elements, which are required by the plant for its normal growth and development. These nutrients must be available to plants for promoting development at all stages of growth. A nutrient is called essential if the plant cannot grow or complete its life cycle without that nutrient. Such nutrients cannot be replaced completely with some other nutrients as they directly influence the growth of plant and are involved in their metabolic activities. Though majority of the plants have more than 40 elements in their system, only 20 are found to be essential for growth. Out of the 20, carbon, hydrogen and oxygen are required in large quantities and are found abundant in nature and are called natural elements. N, P and K are the next important nutrients for plant growth and as they required in large quantities they are called major nutrients. Ca, Mg and S usually occur in plants in smaller amounts unlike the macronutrients and are called secondary nutrients. Fe, Mn, Zn, Cu, B and Mo are usually needed for plants in very small amounts and are, therefore, called micronutrients. Each of these nutrients in plant system have definite role in plant growth. Generally secondary and micronutrients improve quality, size, color, taste, appeal and also increase the post-harvest life of the produce.

Role of Nutrients their status and deficiencies

Nitrogen (N)

It is a constituent of proteins, nucleic acids, chlorophyll, and growth hormones. Plants depend for growth on

inorganic N taken up from the soil as nitrate or as ammonium ions. With increases in N supply, there are increases in both soluble amino compounds and proteins. In general, in soil organic carbon status of 2.0 to 3.5 % is optimum to get sufficient N levels in leaves of spice crops. Leaf N status of 1.42 to 3.33% in black pepper and 0.51 to 1.38% in cardamom was found to be optimum.

Phosphorus (P)

Phosphorus is present in the soil solution as $H_2PO_4^-$ and HPO_4^{2-} Ions and is generally believed to be taken up by plants mainly as $H_2PO_4^-$. It plays an important role in the very large number of enzyme reactions that depends on phosphorylation. It has a key role in the conservation and transfer of energy for a wide range of biochemical processes. Phosphate is also a constituent of nucleic acids and of phospholipids, including those of cytoplasmic membranes. It was found that for spices soil available P status of 12-26 mg/kg is optimum to get sufficient P levels in leaves. Leaf P status of 0.11 to 0.26% in black pepper and 0.10 to 0.20% in cardamom was found to be optimum. The most commonly used P sources are organic manures, oil cakes, bone meal, rock phosphate, super phosphate and DAP.

Potassium (K)

Potassium is the most abundant cellular cation. It has several physiological and biochemical roles, in protein synthesis. It is required in large concentrations to activate many enzymes and to neutralize anions, and anionic grips of macromolecules, thereby contributing to the osmotic potential. It plays a specific role in the mechanism of opening and closing of stomata. It is also involved in the transport of photosynthate from the leaves. It was found that for spices soil, available K status of 91 to 286 mg/kg is optimum to get sufficient K levels in leaves. Leaf K status of 1.18 to 2.84% in black pepper and 1.1 to 3.4 % in cardamom was found to be optimum. The most commonly used K sources are ash, muriate of potash (MOP) and sulphate of potash (SOP).

Calcium (Ca)

Calcium is essential for the growth of meristems and is a constituent of cell wall. It stimulates the development of root system and is necessary for the normal leaf development. It is also essential for neutralizing the various organic acids that are produced in the plant. It prevents the accumulation of excess quantities of aluminium and manganese in harmful concentration. The uptake of P, K, Mg and other nutrients are controlled by Ca. It influences the translocation of carbohydrates and proteins and their storage during seed formation. It was found that for spices soil, available Ca status of 261 to 1390 mg/kg is optimum. Leaf Ca status of 1.42 to 3.33% in black pepper and 0.50 to 1.38 % in cardamom was found to be optimum. The most commonly used calcium sources are the ground limestone, hydrated lime and burnt lime.

Magnesium (Mg)

Magnesium is a constituent of chlorophyll. It has role in synthesis of fats and oils and for the formulation of phosphorus compounds and nucleoproteins. The movement of carbohydrates from leaves to stem is controlled by magnesium. It was found that for spices growing soils, available Mg status of 40 to 194 mg/kg is optimum. Leaf Mg status of 0.40 to 0.69% in black pepper and 0.18 to 0.31 % in cardamom was found to be optimum.

Sulphur (S)

Sulphur is considered very important and essential for the amino acids like cystine and methionine and is a constituent of glutathione. Its utility is earmarked for synthesis of essential oils. It has role in the development of chlorophyll and is essential for the synthesis of proteins as it is a constituent of important amino acids like cystine and methionine. It was found that for spices soil available S status of 10 to 20 mg/kg is optimum. Leaf S status of 0.09 to 0.29% was found to be optimum in black pepper and cardamom.

Iron (Fe)

Iron has a role in the synthesis of common precursors of chlorophyll and iron porphyrin enzyme such as catalase, peroxidase and cytochrome oxidase. Iron supply will affect the protein and chlorophyll content of the plants. A status of 12 to 65 (average 39) mg/kg DTPA extractable Fe is optimum in soil. In black pepper leaf Fe concentration of 126 to 1145 (average 635) and for cardamom 135 to 370 (average 253) mg/kg is found to be optimum.

Manganese (Mn)

In plants, it is believed to function as activator to enzyme in fatty acid synthesis and N metabolism. A soil status of 5 to 35 (average 20) mg/kg DTPA extractable Mn and a leaf status of 109 to 721 (average 415) for black pepper and 261 to 480 (average 370) mg/ kg for cardamom were found to be optimum.

Copper (Cu)

Copper functions as an electron carrier and as part of several enzymes. It helps to enhance the uptake of other elements like zinc. Further it enhances the disease resistant power of crop. A soil status of 0.51 to 7.7 (average 4.1) mg /kg DTPA extractable Cu and a leaf status of 16 to 120 (average 68) for black pepper and 10 to 46 (average 28) mg/ kg for cardamom were found to be optimum.

Boron (B)

It is required for carbohydrate transport through phloem. Further it is reported that B has got great role in flowering and fruit set. A soil status of 0.8 mg/kg water-soluble B is desirable generally for proper growth of plants.

Zinc (Zn)

Zinc is required for plant system for formation of hormone indole acetic acid, activator to

enzyme alcohol dehydrogenase, lactic acid dehydrogenase, and glutamic acid dehydrogenase and carboxyl peptides. It has got major role in enhancing uptake of N, P and Cu. Soil status of 2.1 to 4.0 (average 3.0) mg/kg. DTPA extractable Zn and a leaf status of 21 to 67 (average 44) for black pepper and 20 to 45 (average 33) mg/kg for cardamom were found to be optimum.

Molybdenum (Mo)

Molybdenum has got major function in N assimilation. It acts as an electron carrier for N_2 fixation. Ammonium oxalate extractable Mo of 0.2 mg/kg is desirable for spice growing soil.

Soils of spices growing areas

Most of the spices like black pepper, cardamom and ginger prefer acidic soil environment. Black pepper plantations are established on a wide variety of soils with varying texture from sandy loam to clayey loam that are acidic (pH 5.0-6.2) and in coastal sandy soils. The major pepper growing soils of India can be broadly classified into four major orders viz., Oxisols (6%), Alfisols (70%), Mollisols (10%) and Entisols (4%). The soils of high yielding black pepper gardens are sandy to loam textured with near neutral pH, high in exchangeable bases, organic carbon and low in micronutrients especially Zn.

Soils most suited for cardamom are red lateritic loam with layers of organic debris present in evergreen forests. Ginger adapts widely to different soils. In India, ginger is gown on sandy loams, clay loams and laterite soils but virgin forest soils rich in fertility are ideal. Maximum ginger yield was realized in soils with moderate acidity (pH 5.5) and high organic matter (> 1.0%). Turmeric can be cultivated in most areas of the tropics and subtropics provided the rainfall is adequate or facilities for irrigation are available. As it requires a hot and moist climate, it is usually grown in regions with an annual rainfall of 1000 to 2000 mm. Turmeric thrives best on loamy or alluvial, loose, friable, fertile soils and cannot stand water logging. Well-drained sandy or clayey loam or red loamy soils having acidic to slightly alkaline soil is ideal for its cultivation.

The main constraints faced in the potential zones for spices are steep sloping landform leading to excessive erosion, risk of water logging in valleys during heavy monsoon periods and acidic soils due to heavy leaching of bases from soil leading to low soil fertility status. Among micronutrients, deficiency of Zn is more predominant in acid soils of India with highest deficiency rate of 57% in acid soils of Meghalaya followed by Jharkhand, Orissa and West Bengal (23-54 %). About 50% of turmeric growing soils in Andhra Pradesh are Zn deficient, more than 80% are deficient in Fe and 80 % of them are calcareous. Recent studies at Calicut and Wayanad districts, the main spice growing areas of Kerala showed an alarming trend of nutrient imbalance. The exchangeable K levels were low-medium (69%) and

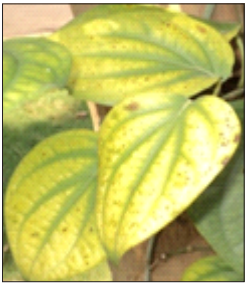
38% of samples were low in exchangeable Ca. A major percentage of the samples were low in exch. Mg (44% low and 13% very low), available S (29%), B (32%) and Zn (29%). Hence, technologies to alleviate macro and micro nutrient deficiencies in location specific soil-crop systems have to be given priority.

Methods for correction of nutritional disorders in spices

Black pepper

Manuring and fertilizer application is critical for proper management of nutrient deficiency and growth of plants. Recommended package of practices (POP) nutrient dosage for black pepper vines (3 years and above) are as follows Application of lime or dolomite @ 500 g/vine in April-May during alternate years is recommended under highly acid soil conditions. Organic manures in the form of cattle manure or compost can be given @ 10 kg/vine during May. Neem cake @ 1 kg/vine can also be applied. NPK @50: 50: 150 g/vine/year (general recommendation) and site specific soil test based nutrient recommendation are to be followed. The fertilizers are to be applied in two split doses, one in May-June and the other in August-September and sufficient soil moisture must be ensured. Foliar application of micronutrient mixture specific to black pepper (developed by ICAR-IISR, Kozhikode) is also recommended (dosage @ 5 g/L water) twice, starting at flowering and followed by monthly intervals for managing micro and secondary nutrient deficiencies and getting higher yield.

Nutrient deficiency symptoms in Black pepper	Management measures
Nitrogen  General chlorosis and stunted growth. Yellowing of older leaves followed by younger ones. Bottom leaf tips and margins become brown and necrotic.	Application of organic manures and NPK fertilizers as per the recommended POP mentioned above. If severe yellowing and soil moisture deficit is noticed, foliar application of 0.5-1% urea can be done.
Phosphorus  Bronzing of older leaves accompanied by necrosis of leaf tips and margins and stunted growth	Application of organic manures and NPK fertilizers as per the recommended POP. If severe deficiency is noticed foliar application of 0.5% DAP can be done
Potassium Browning and necrosis of older leaf tips and margins. Symptoms later spread to younger leaves.  	Application of organic manures and NPK fertilizers as per the recommended POP. If severe deficiency is noticed, foliar application of sulphate of potash (SOP) @0.5-1% can be done.

Calcium Young leaf develops tiny, brown necrotic pin-head spots which later spread to older leaves. Interveinal chlorosis can also be seen.	Application of lime /dolomite in acid soils @ 1-2 t/ ha to avoid the symptoms to manifest. If symptoms appear, apply calcium nitrate ($CaNO_3$) as foliar spray @ 0.5-1% to correct the problem, so that the new emerging leaves can be saved from the deficiency.
Magnesium Pale yellow discoloration of leaf margins and tips, followed by necrosis and defoliation. Major veins remain green and lamina turns yellow.  	Basal soil application of dolomite @ 1-2 t /ha or magnesium sulphate ($MgSO_4$) @ 20 kg/ ha after top dressing. In severe cases of symptom manifestation, foliar application of $MgSO_4$ @ 0.5-1% can be done.
Sulfur Late stage chlorosis in younger leaves, turning to bright yellow color in interveinal areas. Premature leaf fall and die back of growing tip.	Application of sulphur (S) @ 5-10 kg/ha as elemental sulphur or gypsum or sulphur containg fertilizers like ammonium sulphate, or potassium sulphate will manage the symptoms.

Zinc  Stunted growth, interveinal chlorosis of younger leaves. Leaf margins pucker, reduction in petiole, leaf size, internodal distance especially on younger plants.	Basal soil application of zinc sulphate ($ZnSO_4$) @ 5 kg /ha to prevent the occurrence. Foliar application of 0.5% $ZnSO_4$ in case of symptom manifestation to prevent further expression.
Manganese Interveinal chlorosis, with major veins remaining green. Chlorotic leaves turn yellow or white later and necrotic mature leaves.	Basal soil application of manganese containing fertilizers such as $MnSO_4$. $3H_2O$, Mn-EDTA etc @ 2-10 kg/ha after top dressing. In severe cases of symptom manifestation, foliar application of Mn-EDTA @ 0.1% can be done.
Iron Interveinal chlorosis in younger leaves, youngest leaves becoming totally chlorotic.  	Spraying of 0.5% ferrous sulphate ($FeSO_4$) can be done to rectify the problem on visual observation of the symptoms.

Copper Interveinal chlorosis in younger leaves, necrosis on leaf tips and margins.	Applications of copper containing fungicides such as Bordeaux mixture or copper oxychloride (COC) will take care of the deficiency.
Boron Stunted growth, necrosis and interveinal chlorosis. Necrotic lesions are seen on main vein.	Soil application of either borax or boric acid based on the soil test data or general recommendation of borax @ 2-5 kg /ha. After the appearance of symptom, foliar application of boric acid 0.2% at monthly intervals is recommended.

Cardamom

For managing nutrient deficiency symptoms in cardamom and proper growth of plants recommended package of practices (POP) nutrient dosage are to be followed. The recommended POP for cardamom are NPK @75, 75,150 kg/ha under rain fed and 125, 125, 250 kg/ha under irrigated conditions and site specific soil test based nutrient recommendation are to be followed. Apply agricultural lime @ 1 kg/plant/year for soils with pH below 5.0 in one or two splits during May and September. Fertilizers shall be applied only after 15-20 days of lime application. Organic manures like cowdung/compost @ 5 kg/plant may be applied during May/June along with rock phosphate and muriate of potash. Under irrigated condition, manuring can be done in three splits (May, September and December). Application of neem cake, bone meal or vermicompost @ 1 kg/plant improves root proliferation and plant growth. Before applying

fertilizer, the plant basin should be demulched and the panicles are coiled. Fertilizer is applied in a circular band of width 15 cm, leaving 30 cm from the plant basin and thoroughly mixed with top 5-7 cm of surface soil. After fertilizer application, the basin should be mulched. Foliar application of micronutrient mixture developed by ICAR-IISR specific to cardamom is also recommended (dosage @ 5 g/L water) twice, in May – June and September-October, for managing secondary and micronutrient deficiencies and for getting higher yield.

Nutrient deficiency symptoms in Cardamom	Management measures
Nitrogen First older leaves become yellowish. Reduction in leaf size occurs. Production of suckers is reduced and newly formed suckers dry up after some time.	Application of organic manures and NPK fertilizers as per the recommended POP as mentioned above. If severe yellowing is noticed and if there is no moisture in the soil, foliar application of 0.5-1% urea can be done.
Phosphorus Symptoms appear 4-5 months after planting. Small purplish patches appear on leaves followed by premature leaf drop. Stunting growth and reduction in sucker number on advanced stages.	Application of organic manures and NPK fertilizers as per the recommended POP If severe deficiency is noticed foliar application of 0.5% DAP can be done

Potassium Deficiency symptoms first appear in older leaves. Reduction of growth in shoots and roots and plants show browning of leaf tips, extending downwards later, finally the entire leaf turning dark brown in color. Further sucker production completely stop and plants die at severe stages. 	Application of organic manures and NPK fertilizers as per the recommended POP. If severe deficiency is noticed, foliar application of sulphate of potash (SOP) @0.5-1% can be done.
Calcium Deficiency symptoms appear on young leaves after 75 days. Reduction in growth of shoots and roots and further growth of aerial shoot ceased. Thickening of aerial stem showing bulb-like growth. Scattered yellow spots on leaves and margins which turn brown with golden-yellow band underneath.	Application of lime /dolomite in acid soils @0.5-1 t ha^{-1} to avoid the symptoms to manifest. If symptoms appear, apply calcium nitrate ($CaNO_3$) as foliar spray @ 0.5-1% to correct the problem, so that the new emerging leaves can be saved from the deficiency.
Magnesium Reduction in internodal length and plant appears broom-like growth. Twisting of top leaves, leaf tip drying. Later the whole leaf becomes pale yellow, mid rid turning green. White papery spots on leaf lamina, which is the most commonly observed symptom in the nursery. Inhibition of sucker production.	Basal soil application of dolomite @0.5-1 t/ha or magnesium sulphate ($MgSO_4$) @20 kg /ha after top dressing. In severe cases of symptom manifestation, foliar application of $MgSO_4$ @0.5% can be done.

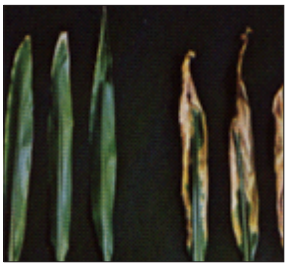
Sulfur First chlorosis appear on young leaves and growing leaf becomes whitish in color, followed by death of leaves starting from the margins.	Application of sulfur (S) @5-10 kg/ ha as elemental sulfur or gypsum or use of sulfur containing fertilizers like ammonium sulphate or potassium sulphate will manage the symptoms.
Zinc Poor plant growth, curled leaves, interveinal chlorosis of younger leaves.	Basal soil application of zinc sulphate ($ZnSO_4$) @5 kg/ ha to prevent the occurrence. Foliar application of 0.5% $ZnSO_4$ in case of symptom manifestation to prevent further expression.
Boron Reduction in leaf size and cracking of lamina.	Soil application of either borax or boric acid based on the soil test data or general recommendation of borax @ 2-5 kg/ ha. After the appearance of symptom, foliar application of boric acid 0.2% at monthly intervals is better

Ginger

For managing nutrient deficiency symptoms in ginger and proper growth of plants recommended package of practices (POP) nutrient dosage given below are to be followed. Farmyard manure (FYM) or compost @ 30-40 t/ha is to be applied by broadcasting and ploughing at the time of preparation of land or as basal dressing by spreading over the

beds or in to the pits at the time of planting. Organic manures like oil cakes can also be applied @ 2 t/ha. In such case, the dosage of FYM can be reduced. Recommended blanket nutrient dosage for Kerala is 75 kg N, 50 kg P_2O_5 and 50 kg K_2O per hectare or site specific soil test based nutrient recommendation are to be done. The fertilizers are to be applied in 2 - 3 split doses. Full dose of phosphorus is applied as basal at the time of planting. Equal split doses of N and K is top dressed at 45, 90 (and 120) DAP. The crop is to be mulched immediately after planting with green leaves @ 12-15 t/ha. Mulching may be repeated @ 7.5 t/ha at 40 and 90 days after planting after weeding, application of fertilizers and earthing up. Foliar application of micronutrient mixture specific to ginger is also recommended (dosage @ 5 g/L water) twice, 60 and 90 DAP, for managing secondary and micronutrient deficiencies and getting higher yield.

Nutrient deficiency symptoms in Ginger	Management measures
Nitrogen First older leaves become yellow. Reduction in leaf size. Production of tillers is reduced and newly emerging leaves starts drying up after some time. 	Application of organic manures and NPK fertilizers as per the recommended POP. If severe yellowing is noticed and soil moisture is less foliar application of 0.5-1% urea can be done to save the crop from complete loss.

Phosphorus  Symptoms appear 3-4 months later. Small purplish patches appear on pseudo stem and leaves followed by premature leaf drop. Stunting reduction in tiller number.	Application of organic manures and NPK fertilizers as per the recommended POP. If severe deficiency is noticed foliar application of 0.5% DAP can be done.
Potassium Deficiency symptoms first appear in older leaves. Reduction of growth in shoots and roots and plants show browning of leaf tips, extending downwards later, finally the entire leaf turning dark brown in color. Further tiller production completely stop and plants starts drying up. 	Application of organic manures and NPK fertilizers as per the recommended POP. In the case of symptom initiation apply MOP in the soil provided there is soil moisture. In the later stages of symptom manifestation, foliar application of sulphate of potash (SOP) @0.5-1% can be done.
Calcium Deficiency symptoms appear on young leaves after 60 days. Reduction in growth of shoots and roots and further growth of aerial shoot will be ceased. Scattered yellow spots on leaves and margins which turn brown with golden-yellow band underneath. 	Application of lime or dolomite in acid soils @1-2 t/ ha to avoid the symptoms to manifest. If symptoms appear, apply calcium nitrate ($CaNO_3$) as foliar spray @ 0.5-1% to correct the problem, so that the new emerging leaves can be saved from the deficiency.

Magnesium At start interveinal chlorosis of older and middle leaves which gradually spreads to younger leaves, followed by leaf tip drying. Later the whole leaf becomes pale yellow, mid rid turn green. Inhibition of tiller production. 	Basal soil application of dolomite @1-2 t/ ha or magnesium sulphate ($MgSO_4$) @20 kg/ha after top dressing. In severe cases of symptom manifestation, foliar application of $MgSO_4$ @0.5% can be done depending upon the sensitivity of the crop to sulphate injury.
Sulfur First appear on young leaves and growing leaf becomes whitish in color, followed by death of leaves starting from the margins.	Application of sulfur (S) @5-10 kg/ha as elemental sulfur or gypsum or use of sulfur containing fertilizers like ammonium sulphate, or potassium sulphate will manage the symptoms.
Zinc  Interveinal chlorosis of younger leaves, reduction in intermodal length and plant appears broom-like with poor tiller production.	Basal soil application of zinc sulphate ($ZnSO_4$) @5 kg/ha to prevent the occurrence. Foliar application of 0.5% $ZnSO_4$ in case of symptom manifestation to prevent further expression.

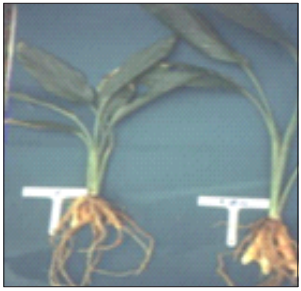
Copper  Interveinal chlorosis in younger leaves, necrosis and curling of leaf tips and margins.	Applications of copper containing fungicides such as Bordeaux mixture or copper oxy chloride (COC) will cure the deficiency.
Boron Reduction in leaf size and cracking of lamina. 	Soil application of either borax or boric acid based on the soil test data or general recommendation of borax @ 2-5kg/ ha. After the appearance of symptom, foliar application of boric acid 0.2% at monthly intervals.
Iron Interveinal chlorosis in younger leaves, youngest leaves becoming totally chlorotic. 	Spraying 0.5% ferrous sulphate ($FeSO_4$) can be done to rectify the problem on visual observation of the symptoms.

Turmeric

For managing nutrient deficiency symptoms in turmeric and proper growth of plants recommended package of practices (POP) nutrient dosage given below are to be followed. Farmyard manure (FYM) or compost @ 30 t/ha is applied by broadcasting and ploughing at the time of preparation of land or as basal dressing by spreading over the beds or in to the pits at the time of planting. Organic manures like oil cakes can also be applied @ 2 t/ha. In such case, the dosage of FYM can be reduced. Recommended blanket nutrient dosage for turmeric is 60 kg N, 50 kg P_2O_5 and 120 kg K_2O per hectare or site specific soil test based nutrient recommendation are to be done. The fertilizers are to be applied in 2 - 3 split doses. Full dose of phosphorus is applied as basal at the time of planting. Equal split doses of N and K is top dressed at 45, 90 (and 120) DAP. The crop is to be mulched immediately after planting with green leaves @ 12-15 t/ha. Mulching may be repeated @ 7.5 t/ha at 45 and 90 days after planting after weeding, application of fertilizers and earthing up. Foliar application of micronutrient mixture specific to turmeric (developed by ICAR-IISR, Kozhikode) is also recommended (dosage @ 5 g/L) twice, 60 and 90 DAP, for managing secondary and micronutrient deficiencies and getting higher yield.

Nutrient Deficiency symptoms in Turmeric	Management measures
Nitrogen First older leaves get affected and become yellow. Reduction in leaf size. Production of tillers is reduced and newly emerging leaves start drying up after some time. 	Application of organic manures and NPK fertilizers as per the recommended POP given above. If severe yellowing is noticed and less moisture in the soil, foliar application of 0.5-1% urea can be done to save the crop from complete loss.

Phosphorus Symptoms appear 3-4 months later. Small purplish patches appear on pseudo stem and leaves followed by premature leaf drop. Stunting reduction in tiller number.	Application of organic manures and NPK fertilizers as per the recommended POP. If severe deficiency is noticed foliar application of 0.5% DAP can be done.
Potassium Deficiency symptoms first appear in older leaves. Reduction of growth in shoots and roots and plants show browning of leaf tips, extending downwards later, finally the entire leaf turning dark brown in color. Further tiller production completely stop and plants starts drying up. 	Application of organic manures and NPK fertilizers as per the recommended POP. In the case of symptom initiation only, apply MOP in the soil provided there is sufficient moisture. In the later stages of symptom manifestation, foliar application of sulphate of potash (SOP) @0.5-1% can be done
Calcium Deficiency symptoms appear on young leaves after 60 days. Reduction in growth of shoots and roots and further growth of aerial shoot will be ceased. Scattered yellow spots on leaves and margins which turn brown with golden-yellow band underneath.	Application of lime /dolomite in acid soils @1-2 t/ ha to avoid the symptoms to manifest. If symptoms appear, apply calcium nitrate ($CaNO_3$) as foliar spray @ 0.5-1% to correct the problem, so that the view emerging leaves can be saved from the deficiency.

Magnesium At start interveinal chlorosis of older and middle leaves which gradually spreads to younger leaves, followed by leaf tip drying. Later the whole leaf becomes pale yellow, mid rid turning green. Inhibition of tiller production. 	Basal soil application of dolomite @1-2 t/ ha or magnesium sulphate ($MgSO_4$) @20 kg /ha after top dressing. In severe cases of symptom manifestation, foliar application of $MgSO_4$ @0.5% can be done depending upon the sensitivity of the crop to sulphate injury.
Sulfur First appear on young leaves and growing leaf becomes whitish in color, followed by death of leaves starting from the margins.	Application of sulfur (S) @5-10 kg/ ha as elemental sulfur or gypsum or use of sulfur containing fertilizers like ammonium sulphate, or potassium sulphate will manage the symptoms.
Zinc Interveinal chlorosis of younger leaves, reduction in internodal length, reduced leaf size, poor tiller production, plant growth and yield. 	Basal soil application of zinc sulphate ($ZnSO_4$) @5 kg/ha to prevent the occurrence. Foliar application of 0.5% $ZnSO_4$ in case of symptom manifestation to prevent further expression.

Iron 	Interveinal chlorosis in younger leaves, youngest leaves becoming totally chlorotic.	Spraying 0.5% ferrous sulphate ($FeSO_4$) can be done to rectify the problem on visual observation of the symptoms.
Copper	Interveinal chlorosis in younger leaves, necrosis and curling of leaf tips and margins.	Applications of copper containing fungicides such as Bordeaux mixture or copper oxy chloride (COC) will cure the deficiency.
Boron	Reduction in leaf size and cracking of lamina.	Soil application of either borax or boric acid based on the soil test data or general recommendation of borax @ 2-5 kg/ ha. After the appearance of symptom, foliar application of Boric acid 0.2% at monthly intervals.

ICAR-IISR crop specific foliar micronutrient formulations for spices

Crop specific micronutrient formulations have been developed and commercialized by ICAR-IISR for enhancing yield and quality of spice crops.

- For black pepper, foliar spray of pepper formulation @ 5g per litre water once during spike initiation and another after two months.
- For cardamom, foliar spray of cardamom formulation @ 5 g per litre water once during panicle initiation and another after three months.
- For ginger and turmeric, foliar spray of ginger/ turmeric formulation @ 5g per litre water at 60th and 90th days after planting.