Calcium Deficiency Disorders and their Management in Vegetables

Technical Report · August 2017

DOI: 10.13140/RG.2.2.31933.36323

Dr FAROOQ Khan
Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir

Dr Sumati Narayan
Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir

Raj Narayan
Indian Council of Agricultural Research

Calcium Deficiency Disorders and their Management in Vegetables

F. A. Khan, Sumati Narayan, Manoj Kumar Prajapati* and Raj Narayan#

Sher-e-Kashmir University of Agricultural Sciencesand Technology of Kashmir, Shalimar-190025, Distt. – Srinagar (Kashmir), J&K (India)
**Janata Post Graduate College* (CSJM University, Kanpur), *Ajeetmal, Auraiya (U.P.)/*
#*Regional Station, CITH, Mukteswar, Nainital, india*
E mail: drkhan_387@skuastkashmir.ac.in

1. Introduction

In today's era of diversification of agriculture, farmers are now shifting from traditional subsistence agriculture to commercial agriculture. Land holdings are in general decreasing in our country. This makes a farmer to adopt vegetable production that is of extreme importance from the economic as well as health point of view. In addition to more monetary return per unit of land (cost effective) compared to traditional grain crop production vegetables are vitally important part of human diet as they are cheaper and easily available source of carbohydrate, proteins, minerals and vitamins. In a broader sense the term vegetable refers to dibble plants or plant parts commonly collected and/or cultivated for their nutritional value for Humans (Agudo, 2005). The increasing scientific evidence that consumption of fruits and vegetables decreases the risk of several chronic disease has created a firm basis for making policy of improved fruit and vegetable production. The dietitians recommend the consumption of at least 200 grams of leafy vegetables and 150 grams of root vegetable daily for balanced diet. Improved cultivation technologies and availability of high yielding vegetable cultivars have played imperative role in enhancing the much demanded vegetable production. However, various biotic and abiotic problems often come into the way of the potential vegetable production. Biotic problems are caused by living organisms such as pathogens, nematodes and insects and other pests while as abiotic problems are caused by non-living factors for instance temperature and moisture extremes, mechanical damage, chemical nutrient deficiencies or excess, salt damage and other environmental factors. Abnormalities in economically important parts of fruits/ vegetables (or other parts that contribute to yield and quality) caused by non-pathological conditions such as poor light, adverse weather, water logging, phytotoxic compounds or a lack of nutrients, and affect the functioning of the plant system are called as physiological disorder.

2. Role of Calcium

Calcium is one of the essential mineral elements plays important biochemical functions and supports many metabolic processes, in addition to activating several enzymatic systems, thus contributing to the proper development of plants. Fundamental role of Ca is in the stability of the membrane and cell integrity. Among all organs, the leaves contain the highest concentration; Ca abundant in the leaves may be due to the formation of calcium pectate in the middle lamella of cells. As calcium is not mobile in the phloem, it cannot be retranslocated from old shoot tissues to young tissues, and its xylem transport into organs that do not have a high transpiration rate is low. Calcium is associated with the transport of nitrogen (N) and interaction with potassium (K) and phosphorus (P). Abiotic stress often leads to an increase of free calcium in the cytoplasm of cells, which leads to gene expression which activates biochemical responses that allow the plant to adapt to adverse conditions of various kinds. Thus, the Ca is involved in the regulatory mechanisms that will enable the plant to make adjustments under adverse conditions such as high temperature, chilling, water stress and salinity. Since calcium has many roles in the physiology and metabolism of plants, failure to play out one or a few these roles may be enough to derange the normal functioning of a plant sufficiently to cause the appearance of the symptoms that are ultimately seen. Some symptoms of calcium deficiency are visible to the naked eye but others are only apparent under the microscope or in cell-free preparations for enzyme assay.

3. Development of Ca Deficiency Disorders

Ca deficiency in plants can be caused by insufficient level of available calcium in the growing medium, but is more frequently a product of low transpiration of the whole plant or more commonly the affected tissue. Fruits and vegetables with symptoms of calcium-related disorders have lower calcium content than the leaves of the plants that bear them. This difference in calcium content can be related to the mechanisms involved in the movement of calcium within plants. Leaves are supplied with calcium from the roots through the xylem. On the other hand, fruits only receive an initial supply of calcium via the xylem for, after the first few weeks of development, transpiration rate falls and later input of nutrient enters via the phloem in which calcium is relatively immobile. Hence, once xylem transport starts the enlarging fruits receive little further calcium so that its calcium concentration falls as the fruits make further growth.

Plants are susceptible to such localized calcium deficiencies in low or non-transpiring tissues because calcium is not transported in the phloem. This may be due to water shortages, which slow the transportation of calcium to the plant, poor uptake of calcium through the stem, or too much nitrogen in the soil. Acidic, sandy, or coarse soils often contain less calcium. Uneven soil moisture and overuse of fertilizers can also cause calcium deficiency. At times, even with sufficient calcium in the soil, it can be in an insoluble form and is then unusable by the plant or it could be attributed to a "transport protein". Soils containing high phosphorus are particularly susceptible to creating insoluble forms of calcium. Calcium deficiency symptoms appear initially as localized tissue necrosis leading to stunted plant growth, necrotic leaf margins on young leaves or curling of the leaves, and eventual death of terminal buds and root tips. Generally, the new growth and rapidly growing tissues of the plant are affected first. The mature leaves are rarely if ever affected because calcium accumulates to high concentrations in older leaves. Once the symptoms of calcium deficiency develop in plants, there is often a stage in which the tissue are water-soaked and one involving cell breakdown with loss of turgor. Eventually the tissue may become desiccated, yielding a dry, more or less extensive area of necrosis. Two mechanisms are proposed. There is evidence that calcium deficiency renders membranes permeable which would account for a loss of turgor and permit cell fluids to invade intercellular spaces. An alternative situation may develop in soft, succulent fruits, the cells of which burst under hypotonic conditions *in vitro.* It is suggested that exogenous water may enter a fruit from the atmosphere or through the phloem. Such exogenous water in the intercellular spaces of the fruit may cause cells to swell, so cracking the fruit or it may result in a bursting of the cells. Many of the physiological disorders afflicting both storage organs (such as fruits, certain vegetables, roots) and young enclosed leafy structures are related to the calcium content of the respective tissue. Improving their calcium content normally diminishes the occurrence of the respective disease. Important physiological disorders of vegetables believe to be due to an insufficient distribution of calcium rather than poor Ca uptake is discussed in this article.

4. Blossom End Rot

Blossom-end rot (BER) is a common nutritional disorder of tomato, pepper, eggplant, pumpkin, squash and watermelon that is caused by a shortage of calcium in enlarging fruits. Calcium is taken up constantly by plant roots as a dissolved nutrient and travels first to the growing points- new leaves and shoots. Fruits may experience a shortage of calcium if water becomes less available to plant roots (drought). This disorder typically occurs when plants are growing rapidly and the first fruits are developing. As fruit cells breakdown due to a lack of calcium, dark blemishes appear on the blossom-end of affected fruits. These may enlarge until the entire bottom of the fruit becomes dark, shrunken and leathery. Factors that encourage blossom-end rot include: low soil pH and low levels of calcium, inconsistent watering, shallow watering or droughty conditions, and excessive use of nitrogen fertilizers. Symptoms are rarely seen in cherry tomatoes and are most often seen in large plum or paste-type tomato cultivars and long pepper fruits. The following steps can be taken to prevent this problem:

i. Maintain soil pH in the 6.3-6.8 range.
ii. Mix in a handful of ground limestone with the soil from each planting hole prior to transplanting.
iii. Keep plants well mulched and watered through the growing season. Water deeply at least once per week if rainfall is lacking. A mature tomato plant may require 2-3 gallons of water per week.
iv. Avoid high nitrogen fertilizers like ammonium nitrate.
v. Where symptoms appear, remove fruits immediately. Spraying affected plants with a calcium chloride solution may offer some temporary relief. Regular, deep watering will alleviate the problem if calcium levels in the soil are adequate.

5. Tip Burn

Tipburn is a major concern in head forming brassicas, because it develops approaching maturity, or during storage, after the majority of investment has been made in the crop. Tipburn is a breakdown of plant tissue near the centre of the head in cabbage and Brussels sprouts, and on the inner wrapper leaves of cauliflower. It is a physiological disorder associated with an inadequate supply of calcium in the affected leaf margins causing a collapse of the tissue and death of the cells. Symptoms usually appear at the leaf tips. Margins turn brown and then black. High temperatures and fluctuating soil moisture conditions hinder the movement of calcium into the leaves, leading to tipburn. Because tipburn is found in the inner layers of the head, it cannot be seen without slicing open the cabbage. In cauliflower and broccoli, tipburn shows up on the margins of the younger leaves.

High nitrogen levels result in large outer leaves that accumulate calcium at the expense of young, expanding leaves. Environmental conditions that favor rapid growth also increase tipburn. Adequate soil moisture promotes rapid growth, while excess soil moisture reduces soil oxygen levels and reduces calcium uptake. Tipburn and internal browning are often associated with alternating dry and abundant moisture cycles and are more common where plants are grown on sandy soils. Margin of leaves turn brown and later dessicate, becoming papery. Affected tissue may turn brown or black and is occasionally invaded by secondary, soft rot bacteria. Avoid conditions that favor rapid growth such as excess nitrogen. Maintain optimum fertility with a phosphorous to potassium ratio of 1:1. Irrigation may be necessary to maintain even soil moisture. Additions of calcium to soil or as a foliar application do not alleviate the problem. Prompt harvesting of crops reduces this disorder. Cultivars differ in susceptibility.

6. Black Heart

Celery is a member of the family Umbelliferae amongst whose other members are carrots, fennel, parsley and dill. It is most often grown for its crunchy, slightly salty stalks, but celery roots and leaves are also used in food preparation. With a small root system, celery is an inefficient nutrient forager, so additional organic matter is essential. This inability to efficiently absorb nutrients is the cause of celery blackheart disorder, the result of a calcium deficiency in celery. Calcium absorption is essential for cell development. Blackheart is a physiological reaction of celery associated with poor calcium assimilation that occurs in most celery growing regions and is closely linked to growing conditions. If conditions favorable for the development of blackheart persist the entire crown may be destroyed in a few days. In minor cases, the plants may recover or seem to recover, although symptoms can return. Symptom development is much more severe as plants approach maturity. The appearance of symptoms is closely linked to fluctuating water levels and available calcium. Environmental conditions that favor rapid growth such as heavy rain or irrigation subsequent to drought favor symptom development. High nitrogen, potassium, and sodium levels may also play a role. Certain celery cultivars are more susceptible to blackheart. Blackheart is prevented by ensuring steady plant growth, avoiding wide fluctuations in moisture and nutrients. Drench applications of soluble calcium can lessen or prevent the development of blackheart. Plant celery cultivars that are not prone to the syndrome. Drip irrigation which provides more even moisture levels can help reduce risk.

Celery blackheart deficiency presents itself as discoloration of the tender young leaves at the center of the plant. These affected leaves turn black and die. Blackheart is also common in other veggies such as Lettuce Endive Radicchio Spinach Artichoke. It is known as tip burn when found among these veggies, and as the name suggests, manifests itself as light to dark brown lesions and necrosis along the edges and tips of new leaves developing on the interior of the vegetable. This calcium deficiency in celery is found during July and August when environmental conditions are most optimal and plant growth is at its peak. To combat blackheart in celery, prior to planting, work in 2-4 inches of well-rotted manure, organic compost and a complete fertilizer (16-16-8) at a rate of 2 lbs. per 100 square feet. Dig the mixture into the garden soil down to a depth of 6-8 inches. Good irrigation is also essential to thriving celery plants. Consistent irrigation prevents stress on the plants and allows the inferior nutrient absorbing root system to better increase its calcium intake.

7. Internal Browning

Hollow heart and internal browning of potato are different stages of the same internal defect however they commonly occur separately. Internal browning is most likely to develop at tuber initiation or when the tubers are small but hollow heart can develop at any tuber growth period. Rapid growth after a period of slow growth can initiate the problems, such as a cold period during early tuber development or prolonged rain after a period of drought. After the discolouration develops, a period of slow uniform growth can diminish the disorder before harvest. However, rapid growth can split the discoloured cells, forming small to very large cavities. Dark brown periderm can form on the inner surface of the cavity. Internal discolouration will usually appear as a short reddish brown discolouration along the central long axis of the tuber, usually at the middle of this line or slightly offset. Colour intensity and defect size can vary widely. Hollow heart usually shows as lens shaped cavities in the longitudinal or transverse plane and sometimes both (star shaped). Sometimes multiple transverse splits occur along the longitudinal axis. Tiny initial cavities may not be discoloured but larger ones generally are. Often hollow heart is restricted to very large tubers. Control measures begin at cultivar selection as some are more susceptible than others. Take care to maintain uniform growth.

8. Cavity Spot

Calcium deficiency in carrots is implicated in a number of diseases such as Cavity Spot, Sclerotinia and shading of the skin etc. Many carrots are grown on sandy soils which are subject to nutrient leaching .Growers are aware that high levels of N will encourage top growth but this is at the expense of the roots. Vigorously growing plants with plenty of foliage are more likely to suffer calcium and boron problems than plants which are less vigorous and grow steadily throughout the season. Calcium is very immobile within the plant and moves in the xylem with the water, hence crops with vigorous tops which are transpiring actively will transport virtually all of the calcium absorbed by the basal roots into the leaves and away from the roots. Calcium and boron applied to the leaves will not readily move either from old leaves to new nor from leaves down to roots. Therefore, in order to increase the levels of calcium in the roots it is important to place calcium into the actual root zone. Applying calcium and boron to the soil allows the plant a steady uptake throughout the growing season. Seedlings are totally reliant on nutrients stored in the seed until their roots are able to absorb nutrients. Applying urea nitrogen and calcium in the seed zone allows the developing plant to rapidly absorb the nutrients required for strong healthy plant growth resulting in more even growth and better shaped carrots

9. CONCLUSION

Calcium plays a very important role in plant growth and nutrition, as well as in cell wall deposition. Ca deficiency in plants can be caused by insufficient level of available calcium in the growing medium, but is more frequently a product of low transpiration of the whole plant or more commonly the affected tissue. Fruits and vegetables with symptoms of calcium-related disorders have lower calcium content than the leaves of the plants that bear them. Calcium deficiency symptoms appear initially as localized tissue necrosis leading to stunted plant growth, necrotic leaf margins on young leaves or curling of the leaves, and eventual death of terminal buds and root tips. Generally, the new growth and rapidly growing tissues of the plant are affected first. Ca deficiency disorders tend to occur during early fruit development. Appropriate liming programs, optimum soil moisture and tilth are primary considerations. Use of resistant varieties, non-ammonical nitrogen fertilizers and appropriate cultural practices need to be adopted.