



“Physiological Disorders in Cauliflower: A Comprehensive Review of Causes, Symptoms and Management Strategies”

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Article ID: 29012

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis*) is a thermo-sensitive cole crop whose vegetative growth, curd initiation, and subsequent curd development are strongly influenced by environmental conditions. Thompson and Kelly (1957) reported that cauliflower is among the most temperature-responsive cole crops, with departures from the optimum temperature range potentially causing substantial deterioration in curd development and quality. Besides insect pests and pathogenic diseases, the crop is affected by a range of physiological disorders that can adversely influence curd formation, size, appearance, market value, and overall productivity. Unlike infectious diseases, these disorders are non-pathogenic in origin and are generally associated with fluctuations in temperature, nutritional deficiencies or imbalances, inadequate or excessive soil moisture, unsuitable planting dates, varietal susceptibility, and mechanical or other environmental stresses. The occurrence and severity of these abnormalities are largely governed by complex genotype x environment interactions, particularly during the critical stages of curd initiation and development (Nonnecke et al., 1989). Since cauliflower has a narrow temperature range for optimum curd formation, exposure to unfavorable temperatures, even for relatively short periods, may produce persistent and sometimes irreversible defects in curd quality. The major physiological disorders reported in cauliflower include buttoning, riciness, fuzziness, whiptail, hollow stem, browning of curd, blindness, leafiness or bracting, multiple curds, pinking, chlorosis, tip burn, and black speck. The following section provides a detailed account of these disorders,



with emphasis on their symptoms, causal factors, predisposing conditions, and appropriate management practices.

1. Buttoning

Symptoms:- Buttoning is characterized by the **premature formation of small, compact curds** before the plant has developed sufficient foliage to support the production of a normal marketable head. The buttons remain small, exposed and poorly developed, and the plants generally possess a restricted leaf canopy (NHB, 2008).



Causes:- The disorder results from **premature curd initiation associated with restricted vegetative growth**. Important causes include inadequate nitrogen supply, transplanting of over-aged seedlings, transplanting shock, unsuitable planting dates, moisture stress, unfavorable temperatures, poor soil conditions, inappropriate planting time, cultivar susceptibility, and pest or disease damage, and unfavorable temperature conditions (NHB, 2008).

Management:- Buttoning can be effectively reduced by using **healthy, vigorous, appropriately aged transplants** and minimizing transplanting shock. Adequate and uniform soil moisture should be maintained, while balanced nutrition-particularly sufficient nitrogen-should be ensured to support adequate vegetative growth. Cultivars should be selected according to their adaptation to the prevailing temperature conditions, and sowing and transplanting should be timed so that curd initiation occurs under favorable environmental conditions.

2. Riceyness

Symptoms:- Riceyness or riciness, is characterized by an uneven, coarse and granular curd surface. Individual floral units elongate and become distinctly separated, producing an appearance resembling grains of rice. The curd becomes loose rather than compact, resulting in reduced market quality (VRI- Vegetable Research Institute, 2016).



Causes:- Riceyness is primarily associated with unfavorable temperature during curd development, particularly temperatures above the optimum for the cultivar, resulting in a loose, coarse, and rice-like curd with reduced market quality. Temperature fluctuations and rapid reproductive development can aggravate the disorder, (VRI- Vegetable Research Institute, 2016).



Management:- Cultivars should be selected according to their temperature adaptation.

Planting should be timed so that the period of curd development coincides with favorable temperatures. Excessive nitrogen and other practices that promote excessively rapid growth should be avoided, and curds should be harvested at the appropriate maturity stage (VRI- Vegetable Research Institute, 2016).

3. Fuzziness or Fuzzy Curd

Symptoms:- Fuzziness is characterized by a velvety or fuzzy appearance of the curd. The individual flower pedicels elongate and become visible, producing an irregular, soft-textured surface instead of a dense and compact curd. Fuzziness is recognized as a commercially undesirable quality defect in cauliflower. (AMS USDA, 2017)



Causes:- The disorder is associated with unfavorable environmental conditions during curd development, Rapid curd development, poor-quality seed, and environmental stress during reproductive growth may further increase the severity of the disorder, resulting in elongated floral structures and a loose, fuzzy curd, particularly temperature conditions outside the optimum range of the cultivar. Genetic susceptibility may also influence its expression.

Management:- Use cultivars adapted to the local production season and select high-quality seed. Planting should be scheduled so that curd formation occurs under favorable temperature conditions. Balanced nutrition and uniform crop growth should be maintained.

4. Whiptail

Symptoms:- Whiptail is a characteristic molybdenum-deficiency disorder. Young leaves develop marginal chlorosis and may become pale or almost white. Leaf blades fail to expand normally, and under severe deficiency only the midrib may develop, producing a characteristic whip-like structure. Severe deficiency can deform or kill the growing point and prevent normal curd formation (NHB, 2008).





Causes:- The primary cause is inadequate availability of molybdenum (Mo). Mo availability decreases markedly in acidic soils, and whiptail is particularly common when soil pH is below approximately 5.5 (NHB, 2008).

Management:- Soil pH should be determined before corrective treatment. Liming acidic soils can increase Mo availability. Where deficiency is confirmed, molybdenum should be supplied according to soil-test and locally recommended rates. Because Mo has a narrow range between adequate and excessive concentrations, indiscriminate application should be avoided (NHB, 2008).

5. Hollow Stem

Symptoms:- Hollow stem is characterized by formation of a longitudinal cavity within the stem, which may sometimes extend toward the curd. Internal tissues may show brown or water-soaked discoloration. In some plants the stem is hollow without obvious external symptoms, making longitudinal sectioning necessary for diagnosis (Utah State University Extension, 2017).



Causes:- Hollow stem has traditionally been associated with boron deficiency, particularly when accompanied by brown internal tissue. However, the disorder is not exclusively nutritional: excessive nitrogen and very rapid growth can also contribute to cavity formation. Research indicates that hollow stem is a complex trait and that boron deficiency does not explain every occurrence (PubMed Central, PMC, 2019).

Management:- Balanced fertilization and uniform plant growth should be maintained. Excess nitrogen should be avoided, while boron should be supplied only when deficiency is confirmed by appropriate soil or tissue testing. Irrigation should be managed to prevent severe moisture fluctuations (Utah State University Extension, 2017).

6. Browning of Curd

Symptoms:- Browning initially appears as water-soaked areas on the stem or curd, which subsequently become brown, rusty-brown or pinkish. Internal stem tissues may become discolored and the stem may develop a hollow cavity. In severe boron deficiency, affected curds may have an undesirable or bitter taste (NHB, 2008).



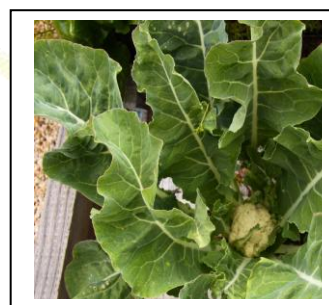


Causes:- Browning is strongly associated with boron deficiency. Boron is important for normal meristem and cell-wall development, and inadequate availability can result in abnormal stem and curd tissues (NHB, 2008).

Management:- Soil and plant analysis should be used to confirm boron deficiency. Where deficiency is established, boron should be applied at locally recommended rates. Uniform soil moisture and balanced fertilization should be maintained. Care should be taken because excessive boron can itself become toxic (NHB, 2008).

7. Blindness

Symptoms:- Blindness occurs when plants fail to develop a normal terminal curd. Affected plants may produce large, dark-green, thick and leathery leaves but lack a marketable head. The growing point may be damaged or fail to develop normally (Utah State University Extension, 2017).



Causes:- Blindness has been associated with low-temperature stress and injury to the growing point. Insect injury or other post-transplanting stresses can also destroy or impair the terminal growing point (Salter, P. J., 1957).

Management:- Plants should be handled carefully during transplanting and intercultural operations to protect the growing point. Appropriate planting dates and cultivars should be selected to minimize exposure to damaging temperatures, and pests affecting the growing point should be managed promptly.

8. Leafiness or Bracting

Symptoms:- Leafiness or bracting is characterized by the development of small green leaves or bracts through the cauliflower curd. These structures disrupt the normal white, compact appearance of the head and substantially reduce market quality (Utah State University Extension, 2017).



Causes:- The disorder represents a reversion toward vegetative growth during curd development. High temperatures, water stress and excessive nitrogen can promote the development of leaves within the curd (Utah State University Extension, 2017).

Management:- Planting should be scheduled so that curd formation occurs under favorable temperatures. Uniform soil moisture should be maintained and excessive nitrogen avoided.



Cultivars adapted to local climatic conditions should be preferred (Utah State University Extension, 2017).

9. Pinking of Curd

Symptoms:- Pinking is characterized by pink, reddish or purplish discoloration of portions of the curd. The abnormal pigmentation reduces the visual quality of the otherwise white curd.



Causes:- Pinking is associated with environmental conditions that stimulate accumulation of anthocyanin pigments. Genotype and environmental conditions influence the intensity and occurrence of the disorder. Pinking is included among the recognized physiological disorders of cauliflower (Think India Quarterly, 2019).

Management:- Cultivars with good curd coverage should be selected where the disorder is common. Appropriate planting dates, adequate irrigation and protection of developing curds from excessive environmental stress can reduce its occurrence.

Integrated Management of Physiological Disorders

Physiological disorders of cauliflower are best managed through preventive crop management, because many disorders originate before symptoms become visible. The most important measures include:

- **Appropriate cultivar selection-** Cultivars should be selected according to maturity group, temperature adaptation and local production season. Genotypic differences strongly influence susceptibility to disorders such as buttoning, riciness and fuzziness.
- **Correct planting time-** Planting dates should be adjusted so that vegetative growth and curd development occur under favorable temperature conditions. This is particularly important for buttoning, riciness, fuzziness, bracting and other curd abnormalities (VRI, Vegetable Research Institute, 2016).
- **Balanced nutrient management-** Nitrogen should be supplied adequately but not excessively. Soil testing should be used to identify deficiencies of boron, molybdenum and other nutrients. Boron deficiency is particularly associated with browning and hollow stem, whereas molybdenum deficiency causes whiptail (NHB, 2008).
- **Uniform soil moisture-** Both drought and excessive moisture can interfere with normal growth and nutrient uptake. Maintaining relatively uniform soil moisture is particularly



important for reducing buttoning, bracting and tip burn (Utah State University Extension, 2017).

- **Protection of the growing point-** Mechanical damage and insect injury to the terminal growing point should be minimized because such injury can contribute to blindness and multiple-curd formation. Soil pH management - Soil pH should be monitored regularly. Maintaining suitable pH is particularly important for molybdenum availability and prevention of whiptail in acidic soils (NHB, 2008).
- **Timely harvesting-** Cauliflower should be harvested at the appropriate maturity stage. Delayed harvest can increase curd deterioration and quality defects, including excessive opening, bracting and other undesirable changes.

Conclusion

Physiological disorders represent an important but frequently underestimated constraint to cauliflower production. Disorders such as buttoning, riciness, fuzziness, whiptail, hollow stem and browning directly affect curd development and marketable quality, whereas blindness, bracting, pinking, multiple curds, chlorosis, tip burn and black speck further contribute to yield and quality losses. Their development is governed by complex interactions among temperature, cultivar, nutrient availability, soil pH, moisture status and crop-management practices. Consequently, successful management depends primarily on prevention through appropriate cultivar selection, correct planting time, balanced nutrition, adequate irrigation, protection of the growing point and maintenance of suitable soil conditions.

All Physiological Disorders in Cauliflower



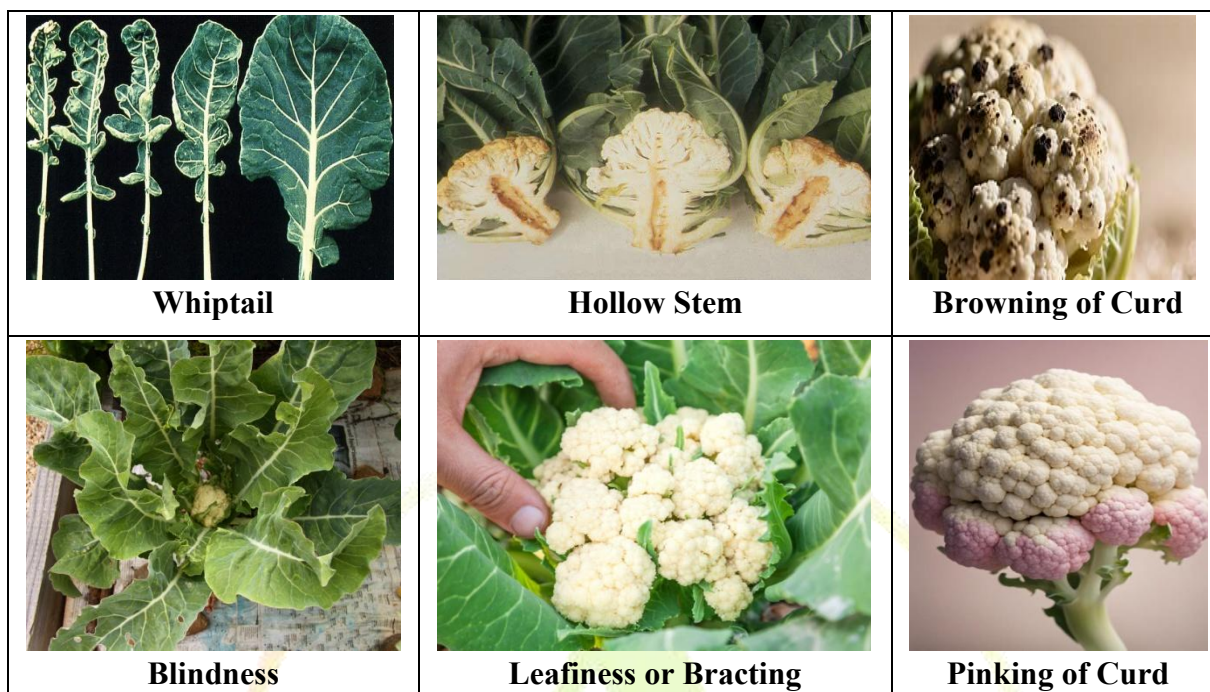
Buttoning



Riceyness



Fuzziness



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