



Flower Drop in Chilli: Unravelling the Physiological Basis of Poor Fruit Set

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Chilli (*Capsicum annuum* L.) is valued not only for its pungency but also for its nutritional, culinary and economic importance. However, poor fruit set is one of the main obstacles to the production of chilies. Farmers frequently witness profuse blossoming, which is followed by flower shedding and tiny developing fruits. Although inadequate pollination is frequently blamed for flower drop, the true explanation is far more complicated. It is the outcome of interactions among temperature, water availability, photosynthesis, plant hormones, nutrition and oxidative stress. Improving chili yield requires an understanding of these physiological mechanisms, especially under the increasingly variable climatic conditions experienced by farmers.

From Flower to Fruit: A Delicate Transition

Fruit development begins with successful flowering, pollen release, pollen germination, pollen-tube growth and fertilization. Any disturbance during these stages can result in flower abortion or poor fruit set. A chilli plant may produce many flowers, but producing flowers does not necessarily mean producing fruits. The reproductive organs are particularly sensitive to environmental fluctuations. Thus, a plant can appear healthy and vigorous while its reproductive performance is being adversely affected. The transition from flower to fruit can therefore be considered a most critical physiological bottleneck in chilli production.

Heat Stress: A Major Cause of Flower Drop

One of the most significant environmental elements influencing the flowering and fruit set of chilies is temperature. Pollen development, viability, germination, and pollen-tube growth can all be negatively impacted by high temperatures during the reproductive stage. Fertilization may therefore fail even when flowers seem normal. The physiological processes of leaves are similarly impacted by heat stress. Elevated temperatures have the potential to decrease photosynthesis and enhance water loss via transpiration. In extreme weather, plants cover their stomata to save water, which lowers carbon dioxide intake and, as a result, restricts photosynthetic carbon assimilation. The combined effect of reduced photosynthesis and impaired reproductive development can result in increased flower shedding and poor fruit set. This problem is particularly relevant in the present era of climate change, when episodes of high temperature and heat waves are becoming important challenges for vegetable production.

Water Stress: When the Plant Conserves Resources

Adequate water availability is essential during flowering and fruit development. Under drought conditions, chilli plants experience a decline in water status and respond by closing their stomata. Although this helps reduce water loss, it also restricts carbon dioxide entry into the leaves and decreases photosynthesis. Reduced photosynthesis means reduced production of carbohydrates, which are required for the growth and development of reproductive organs. In severe water stress, the plant may prioritize survival over reproduction. Flowers and young

fruits, which require continuous supplies of water and assimilates, may therefore be shed. Interestingly, both insufficient and excessive water can affect fruit set. Poor drainage and waterlogging can reduce root activity and oxygen availability, ultimately affecting nutrient uptake and overall plant functioning. Hence, maintaining appropriate soil moisture is critical during the flowering stage.

Photosynthesis and Carbohydrate Supply: The Hidden Connection

One of the less visible causes of flower drop is inadequate carbohydrate availability. Leaves are the major source of assimilates, while flowers and developing fruits act as sinks. During flowering, reproductive organs require a continuous supply of sugars produced through photosynthesis. Any factor that reduces photosynthetic activity such as heat, drought, nutrient deficiency, excessive shading or disease can reduce the supply of carbohydrates to flowers. Therefore, good fruit set is closely linked with maintaining healthy, photosynthetically active foliage.

Plant Hormones: The Internal Regulators

Plant hormones play a crucial role in regulating flower retention and fruit development. Auxins, gibberellins, cytokinins, abscisic acid (ABA) and ethylene participate in the complex hormonal regulation of reproductive development. Under favorable conditions, hormonal signals promote ovary growth and fruit development. Environmental stress, however, can alter hormonal balance. ABA is an important stress-related hormone that increases under water deficit and contributes to stomatal closure and stress adaptation. Ethylene, on the other hand, is closely associated with senescence and abscission. Increased ethylene production under stressful conditions may contribute to the shedding of flowers and young fruits. Thus, flower drop can be considered not merely a physical event but also the final outcome of complex hormonal signalling within the plant.

Nutrition Also Matters

Balanced nutrition is essential for successful flowering and fruit development. Excessive nitrogen may promote excessive vegetative growth and disturb the balance between vegetative and reproductive development, whereas inadequate nutrient supply can restrict plant growth and reproductive performance. Potassium plays an important role in stomatal regulation, water relations and stress tolerance. Calcium contributes to membrane stability and cell-wall structure, while boron is important for reproductive development, pollen germination and pollen-tube growth. However, nutrient application should be based on soil and crop requirements. Simply applying additional fertilizers is not a universal solution to flower drop.

Oxidative Stress: When Protection Becomes Damage

Stress conditions such as high temperature and drought can increase the production of reactive oxygen species (ROS) in plant cells. Molecules such as superoxide radicals and hydrogen peroxide are naturally produced during plant metabolism and also function as signaling molecules. However, excessive accumulation of ROS can cause oxidative damage to cell membranes, proteins and other cellular components. Plants possess an antioxidant defense system involving enzymes such as superoxide dismutase (SOD), catalase (CAT) and peroxidases (POD/APX). When antioxidant defense is unable to cope with excessive ROS production, oxidative stress develops. Reproductive tissues can be particularly vulnerable to such disturbances. Therefore, maintaining an effective antioxidant system is an important component of stress tolerance and reproductive success in chilli.

Is Flower Drop Always a Failure?

From the plant's perspective, flower shedding may sometimes represent a 'resource management strategy'. When environmental conditions become unfavourable, the plant may not have sufficient water, carbohydrates or nutrients to support all reproductive structures. Under such circumstances, shedding some flowers allows the plant to conserve resources for the organs that have a greater chance of developing successfully. Thus, the falling flower is not

simply a symptom of poor crop management—it can also be viewed as a physiological response to environmental stress and resource limitation.

Managing Flower Drop: A Physiological Approach

Since flower drop can have several causes, management should focus on maintaining favourable conditions during the reproductive stage.

- **Maintain adequate soil moisture:** Avoid severe drought as well as prolonged waterlogging.
- **Protect the crop from extreme heat:** Appropriate irrigation, mulching and microclimate management can help reduce heat stress.
- **Maintain balanced nutrition:** Avoid excessive nitrogen and ensure adequate macro- and micronutrient availability.
- **Maintain healthy foliage:** Healthy leaves are essential for sustained photosynthesis and carbohydrate production.
- **Minimize stress during flowering:** Avoid unnecessary root disturbance and manage weeds, pests and diseases effectively.
- **Support pollination:** Favourable conditions for natural pollination can contribute to better fruit set.
- **Use biostimulants or plant growth regulators judiciously:** Their effectiveness depends on crop stage, concentration, genotype and environmental conditions and should be based on validated recommendations.



Figure: Management strategies to reduce flower drop and improve fruit set in chilli

Conclusion

Flower drop in chilli is much more than a simple problem of poor pollination. It reflects a complex interaction between the environment and the plant's physiological machinery. High temperature, water stress, reduced photosynthesis, inadequate carbohydrate supply, hormonal changes, oxidative stress and nutrient imbalance can all contribute to poor fruit set. The key message is simple: successful chilli production depends not only on producing flowers but on helping those flowers survive, undergo successful fertilization and develop into fruits. Understanding the hidden physiology behind flower drop can therefore provide valuable insights for both farmers and researchers. As climate change continues to challenge crop production, a physiological approach to improving flower retention and fruit set will be increasingly important for sustaining chilli productivity and profitability.

References

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