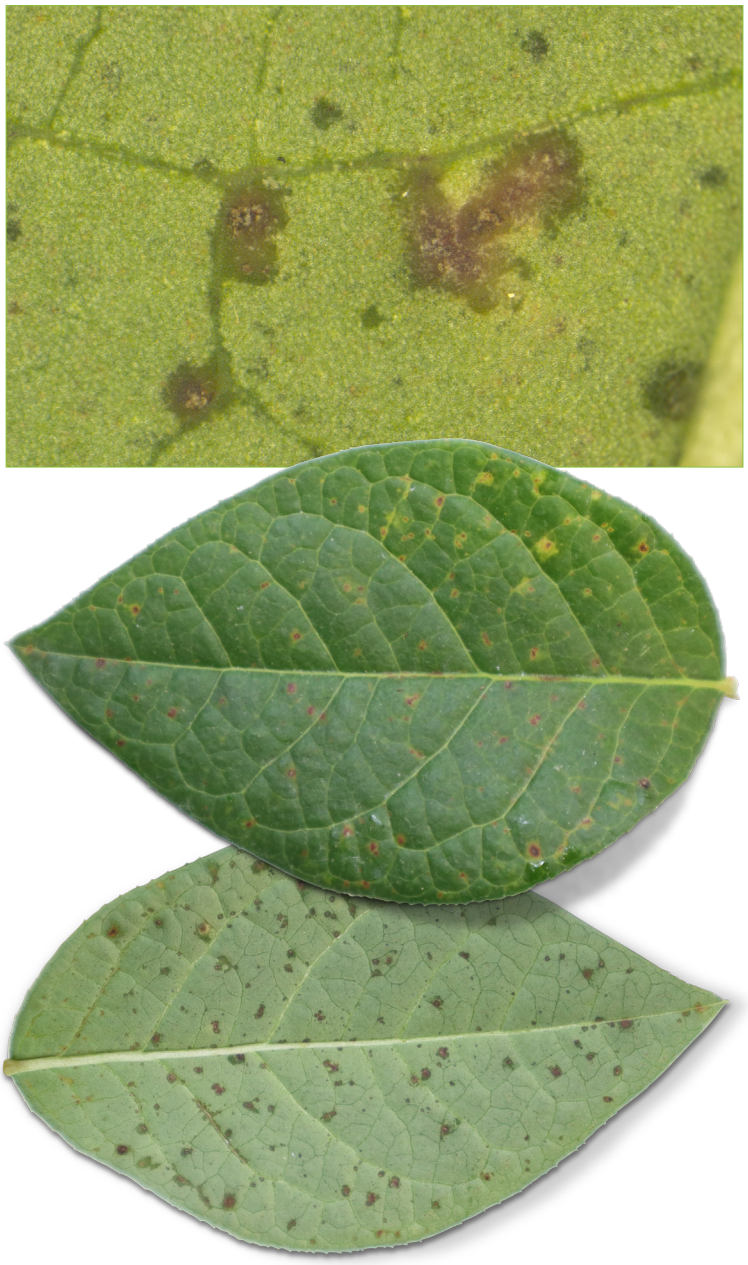
Edema and Intumescence

With the great diversity of ornamental and food crops grown in nurseries, it can be a challenge to consistently produce high-quality plants. A variety of production environments and cultural practices is often required to grow different types of plants under optimal conditions. However, plants can sometimes respond to these environmental and growing conditions with abnormal growth, sometimes resulting in an edema or intumescence.

They are not caused by pathogens and are therefore not transmissible from one plant to another. Rather, they are the result of physiological responses to specific situations. These two conditions are often mistaken for one another; however, research indicates that they are caused by different environmental factors and plant physiological responses. While edema is considered to be the result of an imbalance of water within a plant, intumescence is associated with low ultraviolet-B (UVB) radiation. Both of these conditions are commonly seen in the spring during prolonged stretches of cloudy weather.



Upper and lower blueberry leaves with edema. Topside of leaf shows chlorosis with brown spots and underside of leaf shows wet and corky lesions. Underside collapsed and corky lesions up close.

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EDEMA

Edema is a physiological disorder that develops when roots take up water faster than it can be used by the plant or transpired through the leaves. Symptoms vary depending on the plant species, variety and tenderness of the plant tissue. In general, the disorder appears as bumps, fluid-filled blisters, wart-like corky growths and/or water-soaked areas on the undersides of leaves that ultimately develop into brown lesions. Research conducted at Kansas State University in 2009 showed that this disorder was due to the swelling of epidermal cells that eventually collapse, leaving a sunken brown lesion in their place. The cells did not rupture, as was previously thought. Bumps may turn brownish or tan and become wart-like, corky growths that harden and darken with age.

As the condition worsens, leaves may turn yellow, droop, and may fall off in some species. In severely affected plants, blisters also form on the petioles and stems, although these are less common. The upper surfaces of these leaves will often have indentations above the engorged cells on the undersides. If the problem is not corrected, the plants may become spindly.

While edema is mostly a cosmetic disorder, extensive damage due to blistering, scarring and leaf loss may limit a plant's ability to photosynthesise, leading to poor growth and ultimately impact on saleability. Edema symptoms can be mistaken for those caused by leaf spot pathogens and damage may predispose plants towards secondary pathogen infection. Corky spots sometimes resemble damage from insects or mites that cause russetting damage (e.g. broad mite, erinose mites, flat mites and thrips).

Severe cases of edema may have symptoms on the stem, as occurred on this acacia cutting.

Geraniums, rhododendrons, begonias, peperomias, jade plants, ficus, schefflera, and camellias are particularly sensitive to conditions that lead to the development of edema, although almost any broadleaf plant may be affected.

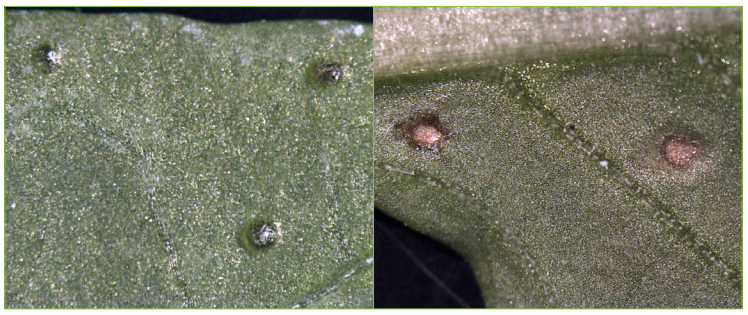
Gall-like abnormal growth resulting from physiological disorders have been called by a variety of names including intumescence, edema, oedema, oedemata, galls and enations. The most important and widely used are edema and intumescence.

INTUMESCENCE

Intumescences are a different disorder than edema based on the anatomy of affected cells and causal factors. Intumescence is a physiological disorder that is characterized by abnormal outgrowths of epidermal and/or palisade parenchyma cells on the leaf, petiole or stem surfaces of affected plants. As intumescences develop they protrude outward and are noticeably translucent. Intumescences do not rupture or collapse, rather, the cells increase in size and proliferate until they eventually desiccate and fall off the leaf surface.

When susceptible crops are grown under ultraviolet-deficient environments, such as light-emitting diode (LED) sole-source lighting that supplies only red wavelengths, intumescences are most severe. However, the incidence of the disorder can be diminished or prevented if crops are grown in environments providing ample blue or ultraviolet wavelengths of light. End-of-day far-red lighting has also shown some promise in mitigating the disorder.

This disorder is most often observed on crops produced in controlled environments and has been reported on a wide range of plant species, including ornamental sweet potato (*Ipomoea batatas*), cuphea (*Cuphea* spp.) and solanaceous crops such as tomato (*Solanum lycopersicum*) and potato (*S. tuberosum*).



Intumescence of capsicum with translucent blisters / galls can be green, white or tan in colour.

CAUSES

The exact causative factors of both intumescences and edema remain elusive. While atmosphere, plant and root medium water relations have been shown to play a role in causing edema, there is still some discrepancy concerning the specific mechanism involved. Similarly, intumescences appear to occur in response to a lack of UV light, but the disorder cannot be fully explained by this single environmental variable. By distinguishing the differences in these two disorders though, growers can more accurately identify which one their crops suffer from and subsequently have a shorter, more accurate list of causative factors to consider for management.

In general, overwatering, cooler temperatures and high humidity are factors which favour the development of edema in many plants. Lack of available calcium or potassium, and poor light conditions can also cause abnormal water retention leading to edema symptoms. Low UV and infrared light favour intumescence development.

OCCURRENCE

In Australia, edema appears to be most prevalent in spring and autumn, particularly when there are large differences in day and night temperatures. Particular locations and host plants may be more prone to symptom development during certain seasons. It is likely to develop when the soil/media is warm and moist while the air is cool and moist resulting in the rapid absorption of water by the roots and slow water loss from the leaves. These conditions are most frequently encountered in greenhouses or indoor situations rather than outdoors.

Note, a number of other conditions can also cause plants to uptake more water than can be transpired. For example, low light conditions and lack of available calcium or potassium.

Similarly it is more common to observe intumescence in the field during cloudy periods common in winter when days are shorter and light conditions are poor. Plants grown in protected cropping environments that may reduce exposure to a range of wavelengths, particularly ultraviolet radiation and far-red light, can be susceptible to intumescence.

TABLE 1. COMPARISON OF EDEMA AND INTUMESCENCE

DISORDER	SYMPTOMS	WHERE IT OCCURS	CAUSE	SUSCEPTIBLE PLANTS
Edema	Swollen bumps on the underside of the leaf surface that ultimately develop into brown corky lesions. The bumps may be green, white, or tan depending on the host and severity of the condition. Upper surfaces of these leaves will often have indentations above the engorged cells on the undersides. Cells may sometimes appear water soaked. Leaves may turn yellow, droop, and fall off and plants eventually become spindly.	Occurs on the underside of leaf tissue between veins. Can occur on petioles and stems in severe cases.	When roots take up water faster than it can be used by the plant or transpired through the leaves.	Geranium, rhododendron, begonia, peperomia, jade plants, ficus, schefflera, and camellias are particularly sensitive. Although almost any broadleaved plant may be affected. Vegetable crops such as tomato, cauliflower and capsicum are also sensitive.
Intumescence	Small bumpy outgrowths on the leaves that protrude outward and are noticeably translucent. Bumps do not rupture or collapse, rather, the cells increase in size and proliferate until they eventually desiccate and fall off the leaf surface. The bumps may be green, white, or tan depending on the host and severity of the condition.	Occurs in between or directly on top of the mid-rib and major leaf veins.	Poor light conditions, in particular low UV and infra-red light.	Sweet potato vine (ipomoea), tomatoes, peppers, kale, Cuphea, and Thunbergia

MANAGING EDEMA AND INTUMESCENCE

The initial step is to identify what is causing the symptoms. This may not be simple, particularly for crop plants that have not been well studied. Firstly, rule out pest damage by monitoring the crop using a hand lens (or microscope); check carefully for evidence of mites, thrips and other small insects. In particular, check the undersides of leaves along mid-veins and in growing points for living individuals and evidence of a previous infestation (e.g. caste off skins and eggs). Send plants or photographs to a diagnostic laboratory for testing if there is suspicion that symptoms could be caused by a pest or pathogen.

Once pest damage has been eliminated as the cause, put in place as many of the below management actions as possible, focussing on areas that are known to cause edema or intumescence for that crop plant (Table 2). Many of these actions are good general growing practices that will improve plant growth and reduce pest or disease pressure passively. Therefore, implementing them will only improve plant production, even if symptoms continue.

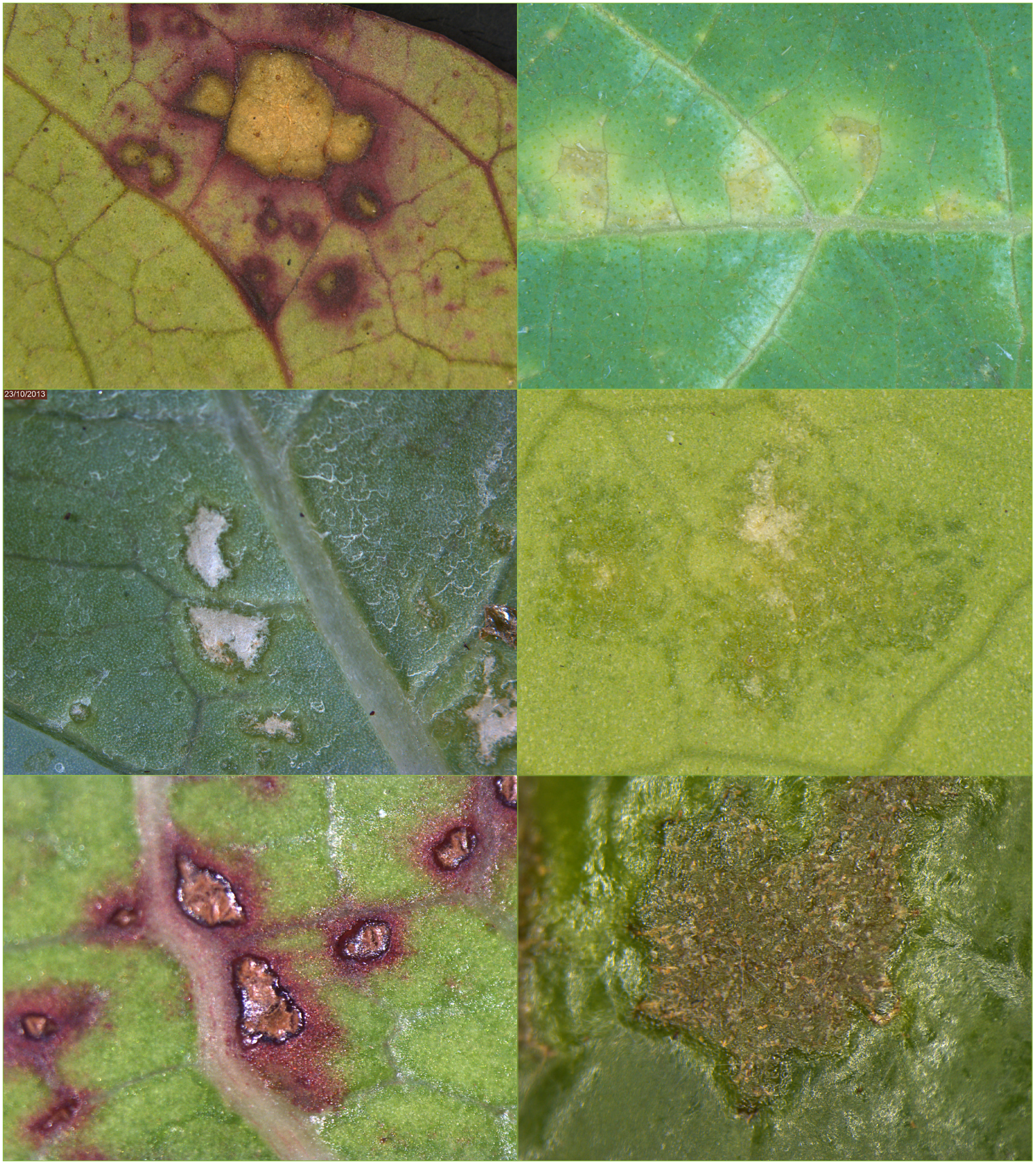
It is important to remember that edema and intumescence symptoms are permanent. Therefore, the effect of changes in management will not be observed until new growth emerges, free of symptoms. It is also worth keeping in mind that some plants may not respond positively to below management actions, i.e. symptoms may be caused by an unknown, unique factor, or perhaps a combination of factors.

It may be worthwhile placing a subset of plants in different growing conditions. Differences in symptom development across treatments or growing conditions provide powerful evidence that they had an effect on plant growth. Always record your methodology and results so that you can put in place proactive management actions next season.

Affected plants often recover from edema producing symptomless new growth with the return of more favourable growing conditions (e.g. relatively constant day-night temperatures or periods with increased sunlight, warm air and a reduction in atmospheric pressure improving transpiration).

TABLE 2. CAUSES AND MANAGEMENT OF EDEMA AND INTUMESCENCE DISORDERS.

DISORDER/S	CAUSES	MANAGEMENT RECOMMENDATIONS
Edema	Overwatering and cool temperatures	» Improve drainage and water less frequently especially during cooler winter months and high risk periods. » Water in the morning just after the sun is up whenever possible as roots tend to absorb water slower when the water is cool and the atmosphere is warm. » Place plants with similar watering requirements on each irrigation line or section, again to eliminate overwatering.
	High humidity leading to poor transpiration	» Avoid watering leaves as wet leaves will transpire less water. » Reduce humidity. Provide good ventilation and space plants to provide good air circulation around them. If possible, keep the relative humidity below 70% during high risk periods.
	Lack of calcium or potassium	» Provide optimal fertilizing for plants. Plants with low available potassium and calcium can be more susceptible to water retention edema. If cultural conditions seem correct for your plant, a soil test may be needed. Adjusting the pH can make more nutrients available, or you may need to add more of the nutrients that are lacking.
Edema and Intumescence	Poor light conditions	» Increasing the light intensity is helpful for many plants, but be sure not to burn them by moving them too quickly into brighter light. Make these changes gradually, over the course of a week or two, slowly leaving the plant in brighter light for an increasing length of time, until it no longer wilts in response to the sun. » Increase light exposure by increasing spacing between plants. » Delay application of shade cloth or shade paint in spring.
	Susceptible varieties	» Select varieties and cultivars that are less susceptible to edema or intumescence
Intumescence	Low UVB radiation	» Exposing indoor grown plants to some UV radiation, especially UV–B, or far-red light (such as found outside) can prevent the development of intumescence in some plants.



Symptoms of edema on the underside of the leaves will vary between plants and even varieties. From left to right and down; snow gum, pumpkin, brassica, *Fontainea*, *Ficus* and sweet viburnum.

This document was prepared by Sarah Dodd and Andrew Manners (Agri-science Queensland, Department of Agriculture and Fisheries, Ecosciences Precinct, GPO Box 267, Brisbane QLD 4001) as part of the nursery levy and Hort Innovation funded project Building the resilience and on-farm biosecurity capacity of the Australian production nursery industry (NY15002) in 2020. All photos by DAF.