



# Physiological Disorders in Grapevine and its Management



**National Research  
Centre for Grapes,  
Pune**



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## **Physiological Disorders in Grapevine and its Management**

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## **Preface**

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Among the fruits grape is an important commercial crop of India from income and employment generation point of view. Improper management not only results in wasteful expenditure but also it affects the productivity and quality of produce and has detrimental long term effect on vine. Presently grape cultivation is facing serious problems due to various disorders and therefore, an attempt has been made to compile all the available information generated so far in the form of manual entitled 'Various Disorders and Their Management' considering the importance of timely diagnosis of symptoms and injuries.

The manual covers almost all disorders with their symptoms and economic losses, photographs for identification and also preventive measures for their management. The injuries and symptoms observed and its impact on productivity and quality have also been illustrated in various forms with their effective preventive measures. The disorders / injuries with their preventive measures will help the grape growers for the management of productivity and quality of produce. The marks and symptoms due to disorder cause drastic loss due to the quality of produce and therefore, preventive measures with early diagnosis, hold the key for effective management and can help in better production.

The information given in the manual will certainly serve as guidelines to identify and prevent the losses due to these disorders to the grape growers for better quality and production. This manual will also serve as guide to the researchers and students who are working in various areas of viticulture.

Place: Pune

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(P. G. ADSULE)



## Introduction

As grape is cultivated in tropical regions against its natural habitat, the vine physiology undergoes change. With heavy inputs of water, nutrients and growth substances, their productive potential is over-exploited and they are depleted, making them vulnerable to various disorders of complex and unknown etiology. When the environmental factors and input become limiting or exceed their optimal conditions, grapevines suffer a setback in their physiological balance and express certain disorders. Direct injuries from unfavourable weather-frost, hail, excessive heat and winter freezing are also in connection with disorders.

The following discussions are designed to give a description of the each disorders and the effect of disorders and injuries in India so that each may be recognized; to indicate its importance; and to list the known measures for control or remedy. Grape disorders observed in India can be grouped into ecological, physiological, ecophysiological and disorders of unknown etiology and are discussed as follows.

## 1. Ecological disorders

These disorders caused by the direct effect of abiotic stresses of the climate or soil on grapevines and are grouped under this head.

### 1.1 Dead-arm and Trunk splitting

**Symptoms :** The symptoms include yellowing and withering of leaves followed by rapid drying up of the shoots, canes and arms leading to partial or total loss of arms and productive canes.

Dead-arm symptoms are found in vines suffering from moisture stress and where the limbs were exposed to hot and dry weather during back pruning. Symptoms were generally noticed two to three weeks after summer pruning under the desiccating effects of high temperature ( $41^{\circ}\text{C}$ ), intense sunlight ( $550 \text{ cal/cm}^2/\text{day}$ ) and low atmospheric humidity (20%).



Fig. 1 : Dead arm due to exposure to sunlight

No fungal pathogens have been found to be associated with dead arm symptoms in major grape growing areas in India. Fungal growth normally seen on dead arm during monsoon and symptoms of growth of saprophytic fungi appears on dead wood.

In the light of foregoing observations, it is clear that high temperature, intense radiation, and soil and atmospheric humidity are the contributory factors for the occurrence of dead-arm and trunk splitting in grapes in the tropical regions of the country. The reasons for this

disorder to confine to certain spots in a vineyard might be due to the general condition of the vine, their depletion through cropping and poor soil condition.

**Economic Losses :** The vine growth is impaired and the productivity is considerably reduced. In extreme cases, the vine is killed.

**Preventive measures :** Prevention of the occurrence is the best possible method of controlling it. The suggested preventive measures are given below.

**Early summer pruning :** Since the dead-arm incidence is directly correlated to the high temperature and intense radiation, the vines should be pruned in early March at least one month before the maximum temperature goes above 40°C in Peninsular India. This prevents the direct exposure of vine limbs and stem to the direct sunlight and high temperature during April-June. This also enables the new shoots to grow 45-60 cm long and provide shade to the stems of the vine during April-June.

**White-washing trunk and arms of vine :** Painting the vine limbs with white-wash was found to reduce their temperature from 52.5 to 39.5°C (Satyanarayana 1981). Hence, it is advisable to paint the trunk and arms with white-wash immediately after summer pruning. The white-wash paint is prepared by taking slake 2.5 kg of quick lime with an adequate quantity of water add 200g of common salt and 100g of sulphur to the slaked lime. Allow the mixture to age for about a week in an earthen or cement container. Dilute the mixture to the required consistency for painting with a brush.

**Maintenance of adequate soil moisture :** Maintenance of adequate water in the plant system minimizes the splitting of arms and stem, and the incidence of dead-arm in grapevines. Therefore, adequate irrigation is given to the vines during summer months. It is also advisable to use soil mulches to prevent the evaporation of moisture from the soil. Artificial cooling of the environment by sprinkler irrigation during the first month after pruning is also recommended.

**Removal of dried arms :** To maintain adequate number of fruiting canes in a vine, the dead-wood (dried arms) are cut to the healthy point and new shoots are encouraged to grow into arms. On these arms, the fruiting canes are developed in the subsequent seasons and cordon renovation carried out if necessary.

**Reduced angle between two arms :** Angle between two arms should not be larger than 60°. This can be achieved by originating arms about 12 to 15 inches below the level of secondary arms on main stem as shown in picture.



Fig. 2 : Reduced angle between two arms



In newly planted vineyards, train the sprouted shoots on bamboo initially and tie with wire. This will help in achieving the straight trunk and avoid formation of dead wood.

### 1.2 Barrenness of vines

**Symptoms :** The symptoms include too much of waste wood, inadequate bearing shoots/canes, finally leading to a thick jungle of unproductive wood.

Development of unproductive wood, failure of vine to bear normal crop and the reduced span of productive life are the important features of barrenness. It is the reflection of negligence and defective cultural practices received by the vines. The important contributory factors for barrenness are :



Fig. 3 : Barrenness of vines

**Defective training and pruning practices :** Barrenness is being when arms are not developed step-by-step. In majority of cases, vines are not systematically trained to develop primary arms, secondary arms and then fruiting canes. Due to apical dominance only terminal bud grows.

Faulty pruning practices are also the major contributory factor for making the productive vines barren. Due to faulty pruning all the canes are pruned long for fruiting and too many shoots are allowed to grow by increasing the budbreak leading to a dense mass of barren thick limbs around the stem. And over a period leads to dead arm.

**Bud failure :** Barrenness of vines is basically due to the failure of buds to throw bearing shoots. The bud failure can be due to one or more of the following reasons

**Failure of flower bud formation :** Fruit bud formation is the consequence of transformation of vegetative primordium into reproductive primordium. The transformation is carried out in three stages namely anlagen formation, formation of inflorescence primordium and formation of flowers.

The process of fruit bud formation is initiated by the triggering mechanism of various factors like light, cytokinins or ribonucleic acid which help to proliferate the anlagen into several minute entities. If the triggering agents are inadequate, the gibberellins and other growth promoting substances are in excess and the soil and environment conditions are conducive for vegetative growth, the anlagen do not proliferate resulting in the formation of either tendrils primordia or shoot primordia and sometimes do not differentiate which results into bud failure.

The fruiting primordia which develop in a bud is also influenced by cultivar. In older vines, the shoots are very succulent and more carbohydrate material is used than the leaves produce and hence the reserve foods in the spurs, canes and arms are reduced to the point where growth is checked. Water stresses arising from increasing transpirational losses may also retard the growth and results into the development of woody shoots which fails to flower bud formation and results into bud failure.

**Flower bud killing :** Inadequate plant protection measures during July- September are the main contributory factors for the flower bud killing and finally bud failure.

**Failure of sprouting of the flower bud :** Temperature was found to influence greatly to the rate of flower development and sprouting of flower bud.

**Preventive measures :** Barrenness of vines can be prevented or delayed by following proper training and pruning practices, and taking adequate plant protection measures during non bearing period. Initially the sprouted shoots should be trained properly. Avoidance of taking heavy yields in the young vines can prolong their productive life span and delay the setting in of barrenness.

At flowering do not treat the clusters with heavy doses of bioregulators when the bearing shoots has inadequate leaf area and the shoots are less vigour. This may weaken the vine leading to barrenness of the vine during next year.

Barren vines can be rejuvenated by heading them back to retain healthy and sound limbs. If the main trunk and primary arms are healthy and sound, the secondary arms are cut back close to the primary arms and the new secondary arms are developed and if the trunk is also damaged, it should be cut back leaving 30-45 cm above the ground and the new stem or a pair of stems are developed; and then the vine framework.

### 1.3 Sun scald

This injury often occurs when fruit that has developed in shade is exposed to direct sunlight, such as when leaf removal, summer pruning, shoot positioning or other canopy management practices occur in mid-to late season. Direct sunlight or the UV rays of the sun can damage grapes. Fruit exposed to sunlight for the entire growing season may also develop sun scald when drought conditions develop. Sometimes injury may cause during thinning which also results in sun scald.

**Symptoms :** Sun scald causes grape berry surfaces to become brown and possibly shriveled. These symptoms appear on the portions of the cluster exposed to direct sunlight.

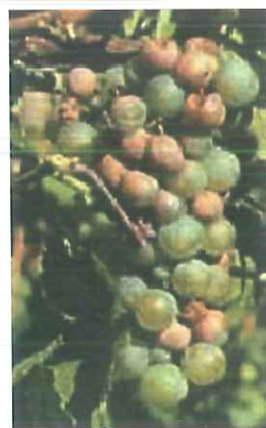


Fig. 4 : Sun scald



**Economic losses :** Fruit damaged by sun scald may develop various fruit rots and deteriorate further.

**Preventive measures :** To protect these grapes from sunburn, one should have a well-planned vineyard, a well-developed canopy, a practical but effective trellis system, proper canopy management and also some knowledge of when and what grapes are most vulnerable to sunburn.

**The layout and row orientation of the vineyard :** Properly laying out the vineyard will ensure that during the hottest time of the day, the leaves on the canopy will protect the grapes from hanging directly in the sun.

While laying out the vineyard design the layout as per the location of the plot and approach the roads. In general rows should be in North South direction in case of 'Y' or 'T' trellis so as to maintain N-S direction of arms. However, east west direction is preferred in 'Bower' training system for easy spray convenience, but in any case the direction of arms should be North South.

**The trellis system :** Having a trellis system that expose as many leaves possible, to direct sunlight is ideal, but at the same time, that trellis system should allow you to train the grape vine so the canopy will also protect the grapes from direct sunlight. This is possible in Flat Roof Gable system where the angle is more (130-135°) that protect the bunches from direct sunlight.

**Close planting in Light soil :** Avoid planting of own rooted vines at a longer spacing under which bunches comes under direct exposure due to reduced vigour and hence close planting should be preferred.

**The canopy :** To avoid sun scald proper canopy management is needed. There should be atleast 10-12 leaves above bunch which will protect bunches from direct sunlight. You must tie down the shoots, or pull leaves so that direct sunlight should not allow penetrating in the rows.

The newly sprouted shoot is trained to bamboo stick with the help of sutali. This helps in growing the plant straight to the bamboo and problem of sunburn on the trunk can be avoided in the near future.

**Use of Shed net and Paper bags :** Grapes are most susceptible to sunburn from pea-size to just before veraison (colouring). During this stage you must ensure your grapes are protected. Under the situation of reduced canopy, protect bunches by covering them with paper bags or shed net.

Handling or touching the grapes of susceptible varieties during this stage should be minimized. Naturally, the grape berries have layer to protect them from sunlight and diseases, but will rub off when you touch the berries, making it more susceptible to sunburn.

## 1.4 Hail damage

Hail is generally associated with spring thunderstorms but may occur at any time of year. Hail is formed in huge thunderhead (cumulonimbus) clouds (Munez, 2000). Hail damage to grapevines can range from occasional tears in leaf blades to defoliation.

During days when the soil is heated by the sun, the air near the ground is also heated. Hot air is much lighter than cold air, so it rises and cools as it comes in contact with the colder air. Hot air's capacity for holding moisture decreases as it cools. When the warm air has cooled to a degree that it can't maintain its moisture, the water vapour condenses and forms clouds. The moisture that is condensed during the process of cooling releases heat into the surrounding air, thus causing the warm air to rise faster and release more moisture.

The severe hail storm was occurred in Naryangaon and Junnar area in Maharashtra during 2008. There was a heavy rainfall of 130 mm within 20 minutes followed by hailstorm.

**Symptoms :** It tends to cause much localized damage, destroying some vines completely while leaving others planted nearby completely unscented. All parts may be turned to the extent of heavy damage and complete cane defoliation. The symptoms are varying at different growth stages. The plant tissues that have been injured are not replaced or repaired (in most cases) to their previous condition.

**Hail storm at young sprouts :** Hail storm at young sprouts stage damage all young and partially matured canes with number of spots on each cane. Many canes and buds may directly damage and may not sprout normally and due to sudden shock of hailstorm injury the process of bud differentiation may not be completed.



Fig.5 : Severe early-season hail damage on cane



Fig.6 : Damage on young sprout



Fig.7 : Tears in leaf blades due to hail



**Hail storm at full canopy :** Hail storm at full canopy often results in tears in leaf blades to defoliation. Shoots and petioles become scarred. Petioles may remain attached to shoots while leaf blades are shredded from the vine. Defoliation also may occur from hail and in severe instances can lead to a delay in fruit maturation

**Hail storm at post veraison/pre harvest stage :** Damage to berries on exposed clusters during light to moderate hail will be associated with torn leaf blades. During early stages of berry development, berries will be scarred or will die without onset of fruit rot. Hail during or after veraison will promote fruit rot.

Bunch stem necrosis can occur around bloom (when it is called early bunch stem necrosis) or at veraison or later. When hail damage occurs to fruit, the results can be devastating and lead to complete berry loss. Defoliation also may occur from hail and in severe instances can lead to a delay in fruit maturation and excess lateral shoot development. In rare instances retraining of vine parts may be necessary if damage is extensive.

**Economic losses :** Fruit maturity will be greatly retarded after severe defoliation. During early stages of berry development, berries will be scarred or will die without onset of fruit rot. Hail during or after veraison will promote fruit rot.

**Preventive measures :** No practical protective measures are known that are applicable to vine yards. Hail can cause wounds that harm young grapevines, but unless the damage is extensive the vine will often recover quickly.

Trellis systems with upward shoot positioning appear to provide more protection to the bunches from leaves above compared to the open tree canopies used for tree crops and even when some berries on a bunch get damaged, the remaining undamaged berries retain full market value.

On hail storm damage the vineyards should be well cared and properly managed; it helps in closing wounds quickly and without long-term effects. At young sprout stage the affected canes should be cut back and retraining a new shoot should be considered. Dormant pruning may need to be adjusted to obtain sufficient buds in appropriate locations for next year's crop, and growers may wish to retain some extra buds to compensate for mid-season or later injury. Because hail injury is both unpredictable and localized, it is not something for which growers can prepare.

## 1.5 Lightning

Lightning can cause sudden browning and death to portions of vines, portions of rows or entire rows of grapevines. The most severe damage to plants by lightning may be caused by the extreme heat and shock waves generated by the current, although other damaging effects probably occur.

**Symptoms :** Symptoms develop rapidly; they appear in days rather than weeks. Symptom onset coincides with recent thunderstorms. There is rapid wilting or collapse of plants or stems, in combination with structural damage or carbonization (burning or black scorching) of the internal stem tissues, and/or browning or blackening of leaves, fruits, or stems.



Fig. 8 : Circular area affected by lightning

Circular areas of plants in a field or orchard are affected, or there are other areas of the farm with similar symptoms. There is premature mass dropping of green fruit. There are burns or strange scars on plants or organs. Roots may be blackened or cooked. Interior plant tissues such as stem pith, xylem and phloem are blown out of the stem.

**Economic losses :** A circular patch of affected plants (3- 20 m or 10- 66 ft. in diameter) suddenly appears in the field. Initially, leaves at the ends of branches will begin to drop, followed by wilting, and in severe cases, death of the plant. One side of the stem may be caved in, like a furrow, down its length. If the stem is cut, it will appear hollow, or have a ladder-like arrangement of tissue. Plants toward the outer edge may show less damage.

## 2. Physiological disorders

### 2.1 Unfruitfulness and rudimentary panicles

Formation of rudimentary panicles appears to be due to inadequate nourishment for the development of the panicle due to competition between too many sinks (growing shoot apices and developing panicles) on a limited source (small and weak canes). The more damage has been observed because of excess nitrogen (N). Excess N reduces the carbohydrate accumulation. Shoots tend to have long internodes and become flat and cause excessive shoot growth and delays cane maturity.

**Symptoms :** Panicles after their emergence fail to grow to their normal size. Their growth is stopped at about one cm length. They do not turn green; development of floral parts is confined to calyx only. Corolla, stamens and pistil do not form. These rudimentary panicles



are dropped down. Shoots bearing rudimentary panicles are weak and short. Leaves are pale-green in color and small in size.

The disorder is observed in following situations :

- i) Too many fruiting canes, particularly in young (one or two years old) vines.
- ii) Too many growing shoots and panicles on a cane, particularly on a thin cane.
- iii) Water stagnation in the root zone for a week immediately after bud break.
- iv) Prevalence of chill weather at flower emergence.
- v) Presence of excess N in soil promotes vegetative growth and adversely affects the fruitfulness.



Fig. 9 : Too many fruiting canes/growing shoots

**Economic Losses :** Chill weather and poor aeration in the soil due to water stagnation, add to the inadequacy of nourishment in retarding the shoot growth. Dropping down of the rudimentary panicles seems to be due to the formation of abscission layer on account of poor aeration in the root zone and inadequate availability of carbohydrates.

**Preventive measures :** This problem may due to cultural practices, development of excess number of fruiting canes and forcing excess number of buds to open after pruning with an aim to obtain high yields even in young vines aggravate this problem. Therefore, limiting the number of canes to 5 per m<sup>2</sup> in Thompson Seedless and allowing only two shoots to grow on each cane (one shoot only on canes of less than 6 mm thickness) either by limiting the bud break or shoot thinning at 3-leaf stage can avoid this problem.

## 2.2 Water berries

It is associated with fruit ripening and most often begins to develop shortly after veraison (berry softening). Water berry is thought to be a physiological disorder which appears more in certain cultivars, and individual vineyards.

**Symptoms :** The berries are almost normal in size but their flesh is not firm. In several cases, the berries are dull in color and watery. They shrivel and dry by the time of harvest.

Vine canopy shading and/or cool weather during veraison (berry softening) and fruit ripening can increase water berry.



Fig. 10 : Water berries

Water berries have much chances of fungal infection during the storage or in transit. The water berries infected with fungus is shown in Fig 8.



Fig. 11 : Fungal growth on water berries

### Preventive measures :

**Fertilizer applications :** Water-berry formation can be reduced by potash application during berry growth period. The application of oil cakes also reduces the proportion of water berries in a bunch.

**Plant growth regulators :** Crop load differences or gibberellic acid treatments have not been shown to affect water berry. Ethephon may possibly hasten its development but not increase the overall incidence by harvest. It has been well demonstrated that no pathogen is involved; fungicidal spray treatments are ineffective.

**Cultural practices :** Trellising and canopy management practices such as shoot thinning that minimize shading within the canopy may be beneficial. Trimming off affected berries during harvest and packing is a common practice, although labor intensive. A delay between picking and packing may enhance the ability to see affected berries for trimming. This is because water berries will tend to wilt first on a cluster. However, the advantage of this practice must be weighed against the effects of water loss from the fruit to be packed.

### 2.3 Shot berries

Berries that are smaller, round and seedless as compared to the normal berries in a cluster are commonly called shot berries. Boron deficiency and incorrect stages of gibberellic acid (GA) application and girdling are the known reasons for

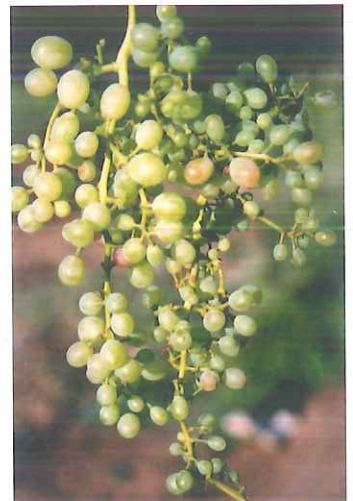


Fig. 12 : Shot berries



shot-berry formation. Winkler (1926) showed that flowers may fail to develop into normal berries because of poor pollination or fertilization, defective flower parts, or poor carbohydrate nutrition to the flowers.

**Symptoms :** Shot berries, in a seeded variety, are seedless and small, while in a seedless variety, they are smaller in size than the normal ones. In any case, they are sweeter than the normal berries. Often berries, that might drop, remain on the cluster and develop into shot berries.

**Economic losses :** Normally, the small berries shatter after 7-10 days after set due to failure of embryo to form or lack of nourishment. But some berries do not drop, and even they do not have embryos, get adequate nourishment and eventually develop into shot berries.

**Preventive measures :** Fertilization of ovary is impaired due to restricted growth of the pollen tube. Application of auxins at bloom helps the growth of even unfertilized ovaries by the stimulus they impart. Application of GA<sub>3</sub> or girdling immediately after set and before the shatter stage retains those berries which have fallen due to lack of nourishment.

Pre-bloom application of GA<sub>3</sub> and other means of berry thinning can reduce the shot berries. Vineyards with a history of hen and chickens are likely to be affected in certain growing seasons with inconsistent, recurrent, fruit set and berry asynchrony disorders. In other seasons or during normal weather conditions especially with warm, calm conditions leading to no disorders are evident.

### 2.4 Post-harvest berry drop

Post-harvest berry drop is due to weak pedicle attachment to the berries. If the bunches are retained on the vines even after the berries are ripen, the berries drop even at harvesting.



Fig. 13 : Post-harvest berry drop

**Causes of berry drop :** Wet drop is varietal character, mainly associated with the length and branching of torus. Cultural practices those increase the firmness of pulp and attachment of berries to the torus and brush and compact packing of clusters in packing boxes minimizing the shaking of berries during transit and storages help reducing this type of drop. Brittle and weak pedicel is a characteristic feature of certain varieties. This is common in Sharad Seedless and Thompson Seedless. In the absence of pre-cooling, harvest during hot weather can aggravate this problem. Means to increase the pedicel thickness can reduce the berry drop of this nature. The factor responsible for dry drop is mainly attributed to the synthesis of high levels of endogenous ABA (Abscissic acid) and growth inhibitors like ethrel. Soil moisture stress in hot dry weather just before harvest increases the dry drop increasing higher levels of endogenous ABA and on the contrary, lowest levels of auxins or growth promoters are responsible for dry drop.

**Economic losses :** Berry drop in table grapes not only reduces the physical appeal of the bunch, but also causes economic loss and encourages the post-harvest diseases as the berries are exposed at the point of detachment.

**Preventive measures :** Naphthalene acetic acid (NAA) application @ 50-100 ppm at 8-10 days prior to harvest reduced the post-harvest berry drop appreciably. If the pedicels are thick, it will take some time to dry, which is also responsible for dry drop. The use of growth regulators like GA<sub>3</sub> and N-(2-chloro-4-pyridyl)-N'-phenyl urea (CPPU) at 3-4 and 6-7 mm berry size stage helps in increasing the pedicel thickness and in turn increase the shelf life (Table 1). The application of calcium (nitrate or chloride) @ 0.5-1.0%.

**Table 1.** Effect of bioregulators on shelf life of table grapes.

Bioregulators concentration	Stage of applicaion	Purpose
NAA (Naphthaline acetic acid) 50-100 ppm	10 days prior to harvest	To reduce wet drop
GA <sub>3</sub> (Gibberellic acid) CPPU (Forechlorofenuron) in combination 40-50 ppm GA <sub>3</sub> and 1-2 ppm CPPU	3-4 and 6-7 mm berry size stages	To reduce dry drop
Calcium (Nitrate or chloride) 0.5-1.0%	75 or 90 or 105 DAP (Days after pruning)	To increase the cell wall turgidity

## 2.5 Bud or flower drop

Flower bud or flower drop is a disorder observed the world over. In French, it is known as 'Coulure' or 'Shelling'. This problem is very serious in north India, but not in the south.

**Symptoms :** When panicles are fully expanded, the flower buds drop before anthesis, generally 8-10 days before full bloom. All buds may drop even with a slight jerk to the panicle. Generally, the ovaries of flowers that fail to develop into berries drop down from the clusters within a week or ten days after anthesis. This is called shatter. Sometimes, excessive shattering occurs leading to very loose and straggly bunches.

**Factors contributing to coulure :** The contributory for weak abscission layer are environmental stress, low C/N ratio, and low levels of endogenous auxins, gibberellins and cytokinins.

**Environmental stress :** Flower drop appears to be related to a temporary water deficiency in the developing flower cluster created by the high rate of transpiration from the young foliage.



Fig. 14 : Bud or flower drop



**C/N ratio :** Flower drop was observed more when C/N ratio was less than 6.0 in the petioles opposite to inflorescence sampled at full bloom. Girdling and ringing, which increase the carbohydrates levels in the vines when carried out at flowering, were found to reduce the drop of young berries.

**Growth substances :** Endogenous growth substances and their balance have a profound bearing on the formation of abscission layer, drop of flower buds and young berries. While auxins inhibit the abscission formation, cytokinin can prevent abscission by delaying senescence. On the other hand, higher levels of ABA increase the flower bud and young berry drop. Ultimately, the ratio of ABA to auxins and cytokinins determines the bud and berry drop. If higher ratio of growth inhibitors to promoters prevails in the panicles before bloom, the unopened flower buds drop and if it occurs after berry set, the young berries drop.

**Preventive measures :** Prolonged soil moisture stress prior to bloom lead to abscission formation. At the same time, insufficient irrigation with saline water can also cause moisture stress due to high solute potential and lead to abscission. Excessive soil moisture and poor aeration to the roots can also cause abscission. Therefore, judicious irrigation practices during the flower development can minimize the flower bud and young berries drop. The foliar application of micro-nutrients especially zinc may prevents berry drop during the berry growth period.

### 2.6 Berry cracking and rotting

This disorder is basically associated with rains during ripening of grapes. It is very common in Thompson Seedless. If rains occur during the late ripening period berries gets cracks and then rots.

In south India, Bangalore Blue is less prone to this disorder even if rains occur during their ripening period. Gulabi is sometimes affected. The predisposing factors for this problem are:

- i) Advanced stage of ripening with TSS content more than  $16^{\circ}\text{B}$ ,
- ii) Adherence of skin to pulp, and
- iii) Heavy rains (more than 10 mm a day) associated with the build-up of atmospheric humidity.



Fig. 15 : Cracked berries

The impact of splashing rain drops on the soft berries was supposed to be the cause for berry cracking. But the turgor pressure build-up in the ripe berries as a result of water absorption by the roots and lack of transpiration from the leaf surface due to rain and high

atmospheric humidity seems to be the basic reason for berry cracking. High soil moisture and high atmospheric humidity are basic pre- requisites for berry cracking and rotting.

**Symptoms :** Berry cracking was also observed in clusters protected by the foliage from getting hit directly by the rain drops (Fig. 16). Rotting of berries was also observed in compact bunches of Thompson Seedless which ripen during February due to early pruning in this region.

The rotting symptoms appear on the third day after a heavy rain of more than 10 mm within a day.

**Preventive measures :** High level of available soil moisture before the rain, bower system of training and the cluster compactness aggravate this problem.

Early pruning to avoid the coincidence of ripening with the normal rainfall occurring period in the peninsular India and hastening of ripening by suitable means in north India can reduce the chances of berry cracking and rotting.

## 2.7 Pink berries

This disorder is commonly observed in Thomson Seedless and its clones mainly in Maharashtra. The berries become pink during berry ripening and close to harvest.

The incidence of pink berry development seems to be more in vineyards, in which large diurnal variation in temperature occurred during the period of veraison stage. If the day temperature ranges from 30-35 °C while the night temperatures down below 10 °C during veraison stage. Hence the pink berry formation was relatively more in vineyards in which berry softening took place in the first week of February (low temperature conditions (< 10°C) prevails during this time) and was less in vineyards in which the softening occurred in the first week of march (temperature starts rising).



Fig. 16 : Pink berries

**Symptoms :** The berries become pink in colour. Initially red tinch appear on the skin on a few berries in a bunch. Gradually the pink blush spreads to the entire surface of berry and many berries in a bunch become pink. The pink colour is minimum and starts at veraison stage and reaches to its maximum within a fortnight. The pink colour changes to dull red colour rendering bunch unattractive.



**Economic losses :** The pink discolouration of white grapes reduces the acceptability in the export market. These berries are not preferred in international market and as a result grower loses crores of rupees every year. The phenolic content was also found to be reduced.

**Preventive Measures :** The exact nature and causes of the disorder are not properly understood yet. But it is minimised with some practices. The covering of bunches with paper bags, Tyvek bags and Nonwoven fabric bags reduces the pink berry percentage hence covering of bunches at veraison with either of it should be done.

The vines should be pruned either in the last week of October or first week of November. Soil moisture stress from berry softening until 10 days prior to harvest should be avoided.

### 3. Ecophysiological disorders

#### 3.1 Berry shrivel

Severity of this disorder occurs in seeded grapes, particularly in Red Globe. One major hurdle to unravelling the causal factors of berry shrivel is that it does not appear on the same vine and location year after year. Thus, no one knows what initiates this disorder or the factors favouring its development. Growers and viticulturists have differences of opinion regarding berry shrivel. But under normal conditions, the xylem typically stops functioning at veraison and phloem become responsible for inflow into the berry and hence water is not exiting the berry through the pedicle which may be cause, other potential factors linked to berry shrivel include inadequate potassium supply with improper water management and environmental stresses such as drought, heat, temperature etc.



Fig. 17 : Berry shrivel

**Symptoms :** It begins after ripening, Red Globe berries become flaccid and sunken. Some affected berries develop color; some remain white. The flaccid berries are usually interspersed with normal ones, but occasionally several berries at the tip of a lateral or at the cluster apex are affected.

The clusters may be a slightly dull green but the berries must be touched to confirm the flaccid condition. The amount of fruit involved usually increases up to harvest.

**Economic losses :** Berry shrivel affects Emperor, particularly on resistant rootstocks, and sometimes older, own-rooted vines. 5 to 30% of clusters may be discarded. Occasionally so severe that vineyard is removed. Affects own-rooted Calmerias; up to 20% of clusters may be culled. Both varieties are decreasing in importance.

**Preventive measures :** Till date the cause of berry shrivel is unknown. GA<sub>3</sub> applied about two weeks after fruit set when the berry diameters average 10-15 mm will reduce the shrivel by 50 to 70%. The bunches covered with papers may also reduce the intensity of berry shrivel. This should be done 80-90 days after pruning.

### 3.2 Sun scars / Scorching on berry

Sun scars or sun scorching may be most damaging disorder amongst all disorder, which burns the berries and bunches before veraison and causes considerable losses in the grape industry. Due to inadequate foliage and improper orientation of the shoots or even in the presence of adequate foliage sometimes the clusters exposes to sun rays and it causes physiological disorder in berries. There should be at least 10 leaves above the cluster and the shoot bearing cluster should be oriented horizontally or diagonally at 40-45 degrees angle. If the bearing shoots are allowed to grow upright on a vertical trellis or straight down on a single wire trellis, even with more leaves on the shoot, the bunches are exposed to sun. Therefore, in addition to adequate foliage, shoot orientation (shoot positioning) is important. Shoots have to be tied to the trellis in such a way that the bunches are not exposed to afternoon sun. This operation has to be carried out as the veraison (fruit softening/coloration) starts.



Fig. 18 : Sun scars

The other type of scorching also observed due to very heavy incidence of thrips, and chemical scorching by wettable formulation of fungicides when sprayed in high concentrations on the young berries.

**Symptoms :** When the bunches are exposed to sun during ripening berries get tanned and develop amber brown colour or red to yellow colour on the portion, particularly on the south-west side of the bunch exposed to sun, while berries will be green on the unexposed portions of the bunch.

The symptom of scorching by thrips shows irregular corky scars (Fig. 20) while that of powdery mildew shows blemishes on the berries and also cause scars on berries.

**Economic losses :** In addition to sun scorch, presence of dark spots and blemishes spoil the uniform colour of berries. The initial loss of green colour is loosed due to loss of chlorophyll content. The basic composition of berry skins is also changed. Small dark spots caused on berries and



Fig. 19 : Scorching by thrips and sun scar



chemical scorching by wettable formulation of fungicides, irregular corky scars caused by incidence of thrips and blemishes on the berries that are caused of powdery mildew changes the appearance of berry and finally they are no more edible.

**Preventive measures :** Adequate plant-protection measures are to be taken to avoid the incidence of sun scars and scorching by thrips and powdery mildew on berries, and adequate care and caution are to be exercised while spraying fungicides to control the diseases taking into account the stage of berry development, the choice of fungicide and its concentration. Some tips and control measures are given below:

- i) The canopy management should be taken into consideration. There should be atleast 10-12 leaves maintained above the cluster and bunch.
- ii) The orientation of arm should be North South direction to avoid direct exposure to sunlight.
- iii) Avoid spraying of Bordeaux mixture, and fixed copper formulation, wettable sulphur or dinacop during the period commencing berry set to pea stage of berries to avoid formation of black specks of tender berries.
- iv) Spray wettable sulphur and dinacop only after pea stage of berries cautiously only at recommended concentrations, if needed.
- v) Avoid drenching of the bunches with spray solutions, particularly of wettable sulphur, copper fungicides or dinacop.
- vi) Do not allow the fungicides to settle in the tank or container while spraying to avoid chemical scorching of berries sprayed with the solution at bottom.

## 4. Herbicide related disorders

Herbicides, also commonly known as weedkillers, are pesticides used to kill unwanted plants. The risk of injury to non-target plants varies widely among herbicides; many can be used adjacent to sensitive plants with little risk of injury, whereas others pose a risk to adjacent areas whenever they are applied. Sometimes commercial herbicide use generally has negative impacts on plants and cause injuries. Herbicides are of various types according to their chemical properties.

### 4.1 Phenoxy herbicides

Perhaps as many as one hundred or more herbicide formulations contain a phenoxy-type active ingredient. Grapevines are extremely sensitive to herbicides containing phenoxy-type active ingredients. The growth regulators which are used as herbicides more commonly

contain phenoxy compounds. This group includes 2,4-D, MCPA, Weedone, Weedmaster, Crossbow, Banvel, Garlon, Grazon, Weed-B-Gone, and Brush Killer.

Growth regulator herbicides are of two major classes and most products are sold under a variety of tradenames and as assortment of combinations (Table 2). Using a combination of GR herbicides provides a broader spectrum of weed control and allows lower rates of individual products to be used.

**Table 2.** Examples of growth regulator herbicides

Phenoxy	Benzoic	Pyridine
2,4-D (many trade names)	dicamba (Banvel, Clarity, Distinct, Vanquish, Status, many others)	picloram (Tordon, Grazon P&D)
2,4,5-T (no longer marketed)		triclopyr (Garlon, Remedy)
MCPA		clopyralid (Stinger, Transline, Hornet)
2,4-DP (diclorprop)		aminopyralid (Milestone)

## 4.1.1 2,4-D injury

Grapevines mainly injured by 2,4-D and related phenoxy compounds at concentrations in parts per billion.

Aerial applications to field crops have injured grapevines several miles from the point of application. More often, ground application in an adjacent field or the use of so-called "weed and feed" products for lawn care adjacent to a vineyard are the sources of injury.



Fig. 20 : 2,4-D Injury

**Symptoms :** Grapevines will exhibit damage symptoms when exposed to only minute amounts carried by the wind. The symptoms of phenoxy herbicide damage are most dramatic on the youngest leaves and the tips of growing shoots, young leaves at the tips of shoots become small, narrow and misshapen, and have closely packed, thick veins that lack chlorophyll than usual (Fig. 21, 22 and 23).





Fig. 21 : New leaves and growing tips show the most severe damage. Affected leaves are small, narrow, and misshapen



Fig. 22 : Farther down the shoot, leaves have a fan-shape appearance. Leaves sometimes are cupped, and margins often end in sharp points

Further down the shoot, damage symptoms are progressively less severe; leaves have irregularly shaped, a distinctive fan-shape appearance with parallel, strap-like, clear veins and crystalline in texture. The leaves sometimes are cupped, and the leaf margins often terminate in sharp points. Small, puckered, interveinal spots retain some green chlorophyll.

During the active shoot growth period, phenoxy damage often causes growth to stop temporarily and to be retarded for several weeks. If the effects are not too severe, normal growth will resume the same or following year. Damaged flower clusters set very few or no berries.

**Economic losses :** Grapevines in close proximity to a sprayed area are at highest risk. However, even grapevines some distance from a phenoxy-treated area can be damaged under certain conditions. Flower clusters are particularly sensitive; exposure during bloom can greatly reduce fruit set. Injured vines also may have delayed fruit ripening. Severe injury can prevent complete maturation of the fruit. The delayed maturation effect may exist in a vine for 1 to 3 years before normal ripening resumes and vines may not recover for 2 years or more. Slight injury may have little or no effect upon fruit maturity.

**Preventive measures :** The most effective means of reducing the risk to your vineyard is to talk with your neighbours and commercial pesticide applicators in the area. Use this fact sheet to inform them of the high risk of damage to grapevines posed by phenoxy herbicide use. Encourage them to use herbicides with a different active ingredient.

Off-target drift can be minimized by careful application timing and methods. Wind speed and direction should be monitored closely and applications postponed until drift potential is very low. All label directions, restrictions and precautions should be read before using any pesticide. Spray-thickening agents (drift retardant) may help to reduce spray drift.

Finally, encourage a good neighbor relationship that will enable all parties involved to effectively conduct their operations.

## 4.2 Quaternary herbicides

These are one of the most widely used herbicides in the world. They are quick-acting, non-selective, and kills green plant tissue on contact. It is redistributed within the plant, but does not harm mature bark. They acts by inhibiting photosynthesis, mainly includes diquat, paraquat and difenzoquat etc. and are difficult to analyze.

### 4.2.1 Paraquat injury

Injury from the contact herbicide paraquat (Gramoxone Extra®) typically appears as rusty-orange spots or irregular-shaped blotches on leaves (Fig. 24). At times this injury may look similar to black rot infections on leaves, but paraquat injury lacks the dark pycnidia (fruiting bodies) and the cream-colored center that occurs with black rot. This injury typically results from spray drift, so the damage is most severe on leaves near the ground.



Fig. 23 : Paraquat injury

## 4.3 Phenylurea herbicides

These are the solid or liquid compounds absorbed on a dry carrier. Available in a wettable powder, granular, flowable, pelleted/tableted, liquid suspension, and soluble concentrate formulations. This group contains any of several related products (Diuron, Fenuron, Linuron, Monuron, Neburon, Siduron) formally derived from urea. They can react as acids by generating toxic gases and inhibiting photosynthesis. These are used as a herbicide to control a wide variety of annual and perennial broadleaf and grassy weeds on both crop and noncrop sites.

### 4.3.1 Diuron injury

Diuron herbicide injury causes leaf veins to appear yellow to cream-colored (Fig. 25). Severe cases can cause stunting of vines. This injury is often associated with light soils or areas where soil has eroded so that the vine roots are near the soil surface. Vines may need more than one year to outgrow this injury.



Fig. 24 : Leaves showing the typical yellow veinal pattern of diuron herbicide injury

## 4.4 Chlorotriazine herbicides

These are the selective and systemic herbicides; consisting of an s-triazine-ring which gives it a herbicidal property. These are used to treat weeds and broadleaf grass annually. They mainly act by inhibiting photosynthesis. This group mainly involves atrazine, simazine and terbuthylazine. They remain active in the soil for 2-7 months after application.



#### 4.4.1 Simazine injury

Injury from this herbicide appears as yellowing in the leaves between veins that remain green. In more advanced stages, portions or the entire leaf becomes brown. As with diuron, simazine injury tends to occur on light soils and sites where erosion has exposed roots near the soil surface.



Fig. 25 : Simazine herbicide injury showing the characteristic yellowing between green veins. As the injury becomes more severe, leaves become lighter, eventually becoming brown and falling from the vine

#### 4.5 Organophosphorus herbicides

These are the broad-spectrum systemic herbicide used to kill weeds, especially annual broadleaf weeds and grasses known to compete with crops grown widely. They are effective in killing all plant types including grasses, perennials and woody plants. Organophosphorus compounds contain probably phosphates. They mainly acts on various enzyme systems inhibiting certain proteins that are needed for growth. This group mainly involves Fosamine, Glyphosate, Piperophos, Amiprophos and many more.

##### 4.5.1 Glyphosate injury

Glyphosate (Roundup®) injury to grapevines has several characteristics. Young shoots injured early in the growing season will produce misshapen, stunted leaves from the point where the herbicide contacted the leaf to the end of the shoot.

**Symptoms :** Glyphosate (Roundup®) injury to grapevines has several characteristics. Young shoots injured early in the growing season will produce misshapen, stunted leaves from the point where the herbicide contacted the leaf to the end of the shoot. Leaves are roughly triangular and crinkled with cuplike depressions.



Fig. 26 : Glyphosate herbicide injury

Injury late in the growing season may stop shoot growth and result in off-green leaves. Late-season injury will be carried over to the next year. Multiple severely stunted shoots will emerge from nodes. This stunted growth will continue throughout the growing season or until the vine dies, presumably from lack of functional leaf area.

**Economic losses :** Late- season injury will be carried over to the next year. Multiple severely stunted shoots will emerge from nodes. The stunted growth also will continue throughout the growing season or until the vine dies, presumably from lack of functional leaf area.

#### 4.6 Pesticide spray injury

Injury may be caused by a known incompatibility between a specific variety or a specific crop growth stage and a particular pesticide (e.g., sulfur injury on several grape varieties). An unknown incompatibility may result from the variety being sprayed, the specific mix of pesticides, the equipment being used or the weather conditions during spraying. Sometimes, herbicides spray injury is also noticed due to herbicides drip to grapevines.

The drift is the movement of a spray solution from the intended target to a place where it is not wanted. In other words, drift is also the movement of spray droplets or pesticide vapors out of the sprayed area.

**Symptoms :** Pesticide sprays can cause brown spots on leaf tissues and fruit. This injury typically occurs on the youngest leaves at the end of shoots and often goes undetected until several days after the application. By that time, several new leaves may have emerged at the shoot tips so that the injury has a pattern of healthy leaves at the shoot tip with injured leaves farther back on the shoot.



Fig. 27 : Pesticide spray injury

When pesticides spray injury is caused on a young, emerging leaf at the end of a shoot. The injured leaf will continue to develop at an uneven rate, becoming crinkled and misshapen.

**Economic losses :** In particular, herbicide/pesticide spray drift, can damage shelterbelts, garden and ornamental plants, cause water pollution, and damage non-susceptible crops in



a vulnerable growth stage. Herbicide spray drift also can cause non-uniform application in a field, with possible crop damage and/or poor weed control. In addition, insecticide spray drift can damage beneficial insect populations especially bees and natural predators of agricultural pests. Drift is also costly from a financial standpoint. If only 50 percent of an applied solution makes it to the target, then you have wasted 50 percent of what you have applied. In all the above cases, the pesticide becomes an environmental pollutant, injuring susceptible plants, contaminating water, wildlife and even humans.

**Preventive measures :** Sadly, the majority of pesticide spray drift problems involve mistakes that could have been avoided by the applicator. Avoiding chemical trespass is the responsibility of each pesticide user. This requires intelligent management and great care. So care should be taken during pesticide applications.

### Using pesticide

- Low-volatile (LV) esters are not really low volatile. Indeed, they are less volatile than the old high-volatile ones (butyl esters), but the LV esters are still considerably more volatile than amines. LV esters are more susceptible to movement because gases can move farther than spray droplets, and can come off of previously sprayed plants or soil. Choose the amine form if there are susceptible plants in the area.
- Proper timing of herbicide application can help avoid damage to nearby plants.
- Use adequate amounts of carrier, drift-control adjuvant, such as Nalcotrol, may help reduce the production of small droplets, thereby reducing drift.
- Do not apply pesticide to dusty soil that might later be carried on winds to sensitive crops or aquatic areas.
- Do not apply pesticides to areas where treated soil is likely to be carried by water to where sensitive crops are grown.
- Use pesticides safely. Be cautious when you apply pesticides, read the pesticide label-even if you've used the pesticide before and follow closely the instructions on the label (and any other directions you have).

### Using Nozzle / Sprayer

All nozzles produce a range of droplet sizes, the small, drift-prone particles cannot be completely eliminated, but drift can be reduced and kept within reasonable limits with proper sprayer and nozzle.

- Keep spray droplets as large as practical. For most pesticide usage, especially with 2,4-D-type herbicides, a minimum size of 0.2 gal/min (for example, Spraying Systems 8002) flat fan nozzle tips and a maximum of 30 psi pressure are sufficient for good coverage.

- Use a drift-reducing nozzle where practical. They produce larger droplets and operate at lower pressure than the equivalent flat-fan nozzle.
- Avoid using smaller nozzle tips or high pressure. Smaller nozzle tips or higher pressures create fine droplets; too many "fines," or small droplets, which can easily move laterally to non-target areas. 40 PSI should be considered the maximum for conventional broadcast spraying. Some herbicide labels call for application at higher pressure. Apply these products with extra caution.
- Flood-type nozzles can reduce spray drift by producing larger droplets at low pressure. They produce a less precise pattern than flat fan nozzles, but in many situations they are satisfactory. Consider using a new generation of flat fan nozzles designed for lower pressures when the precision of the flat fan is required.
- Use wide angle nozzles and keep the boom stable and as close to the crop as possible.
- Many drift-reducing spray additives which can be used with regular spray equipment are available today.
- Use calibrated sprayers and nozzles.

### **General precautions**

- A windscreen may reduce drift. A windscreen around the boom and reaching near the sprayed surface may reduce drift.
- Always avoid drift, but in areas where grapes are grown, not spraying during sensitive stages may be the safest approach.
- To avoid a chimney effect, place windscreens above the boom. Because the spray pattern cannot be seen by the operator, sprayers can be equipped with tip monitors to detect plugged nozzle tips.
- The biggest single weather factor involved in drift is wind. Even relatively light breezes can carry small droplets a long distance. Generally, spraying early in the morning is preferable to afternoon or evening. If you are spraying near sensitive crops, limit your applications to times when winds do not exceed 5 mph. Spraying when slight winds are away from sensitive crops may be safer than spraying when the air is calm.
- Consider not spraying those areas nearest to sensitive crops. Leave a buffer zone.
- Spray when wind speeds are less than 10 mph and when wind direction is away from sensitive crops.



- Do not spray when the air is completely calm or when an inversion exists.
- Use a shielded spray boom when wind conditions exceed prime pesticide application conditions.

### 5. Non-specific disorders

#### 5.1 Rachis cracking

This abnormality was evidenced by the swelling of rachis which later cracked longitudinally. Varietal variation was observed in the incidence of this cracking. It is due to the death of cells and the subsequent oxidation of polyphenols in the dead cells. This condition is observed more often on very fertile soils in dry period following ample moisture. It is ascribed to magnesium deficiency.

**Preventive measures :** Spraying the clusters with magnesium sulphate (0.5 to 5.0%) reduced the incidence of necrosis considerably. According to Winkler et al. (1974), the sprays of calcium chloride or any other antioxidant can be more effective. On the other hand, magnesium and other nutrient contents of leaves on the shoots bearing bunches with cracked rachis suggested that this disorder was not associated with any nutrient deficiency (Arora et al., 1974).

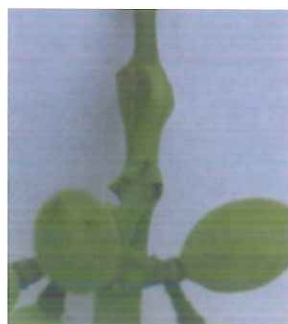


Fig. 28 : Rachis cracking

#### 5.2 Rachis swelling

Recently grape rachis exhibiting swelling disorder was reported from almost all the growing regions in Maharashtra. Initially the disorder was reported from table grape growing vineyard but now it is being reported in raisin grape growing vineyards also.

**Symptoms :** The abnormal swelling can be visibly noticed two to three weeks after fruit set depending on climatic conditions. Initially rachis swellings followed by cracking symptoms were observed. Few studies reported that the abnormal swollen rachis contains some granules.



Fig. 29 : Rachis swelling

**Economic Losses :** Grapevine trunk diseases are responsible for significant economic losses to the wine industry worldwide. Berry growth and quality, was affected by the malady. Berries grew normally in most of the cluster with swollen rachises but some of them failed to ripen fully.

**Preventive measures :** From all the studies, no particular cause reported for rachis swelling. But after survey, it was found that the early pruned (during September) vineyards were affected and other plots which were pruned (during late October and November) were not affected. This indicates that the vines which were pruned in September might have not got exposure of October heat which might have resulted in development of rachis swelling. Hence early pruning may be avoided and plant growth regulators sprays may be managed according to proper growth stages of vine.

## 6. Others

These are not disorders but are often confused with disorders, so are given for sake of knowledge.

### 6.1 Guttation

The appearance of drops of xylem sap on the tips or edges of leaves in some plants. Although guttation occurs at night, it should not be confused with dew, which condenses from the atmosphere, primarily onto the leaf blade.

It is caused by the buildup of water pressure in the plant beginning late in the evening and continuing until early morning. After daylight photosynthesis begins, the stomata open and a water deficit begin to occur in the plant. At that time the droplets may actually be drawn back into the plant through the pores called hydathodes at the margins of the leaf. More often they just evaporate or fall off the plant.



Fig. 30 : Water droplets and salt accumulation from guttation on the margin of grape leaf

Guttation takes place only on a heavy rainy day with very high relative humidity in the atmosphere. Under such conditions the roots absorb more water and develop root pressure. It is the root pressure that is responsible for pushing the water up and out of Hydathodes. Guttation is found only in those plants which also develop root pressure under favorable



conditions mentioned above. However, the amount of water lost by guttation is not that significant.

### 6.2 Pearl bodies

Pearl bodies are enlarged cells on the surface layer of grapevine cells. They are often mistaken for the insect eggs and cause no harm to the vine.



Fig. 31 : Pearl bodies

### 6.3 Bird damage

Birds damage grapes either by totally removing berries or by pecking the berry surface.

**Symptoms :** Birds often puncture berries. The resulting angular punctures often develop into depressions in the berry surface.



Fig. 32 : Bird damaging

**Economic losses :** All over the world, grape growers have problems with birds ruining grape crops and the extent of damage to crops, caused by birds of varying types is often significant. Birds damage grape crops by either pecking or consuming whole grapes from bunches.

In the table grapes, grape bunch appearance is an important feature of the produce and even minimal feeding by birds cause cosmetic damage, making the fruit unsuitable for the export market.

Bird damage also cause secondary infection, causes secondary spoilage as bacteria, moulds and insects attack the damaged berries, which may ruin an entire bunch.

**Preventive measures :** "How to prevent birds from damaging grapes?" is a big question. Till date there are no possible ways to prevent damage from bird. Studies showed that strategies to try and eliminate birds species, that damage grape crops have a poor record of success.



Fig. 33 : Cosmetic damage caused by birds

There are a few methods, The grape growers using are listed below :

**Bird Netting :** Some growers initially used net to prevent attacks from bird but were not found effective. Some grape growers stretch plastic strings over the vineyard and these

strings will vibrate in the wind and make a low irritation sound that could (notice I said “could”) repel unwanted birds.

**Visual Repellents :** Grape growers use shiny streamers and other shiny and fluttering objects like small mirrors hanging from strings, to repel birds, but as with the propane gas cannon, birds acclimate to these objects quickly.

The stretched plastic used previously in netting was also found repellent with low irritation sound.

**Chemical Repellents :** No proven chemical repellent has been successfully used in vineyards. Normally, the grapes are almost ready for harvest and applying chemicals to the grapes, could lead to artificial flavor to grapes and in the end to the wine and it could be dangerous to humans.





### Summary

In the present era of serious threats being experienced by variable biological processor involved in regulating the primary productivity of all kinds of crops and grapevine are not exceptional to it. To overcome all these remedies, a deep understanding of the symptoms and control measures are needed. It's imperative to have knowledge of the same. Hence the present publication is therefore designed to cater to the needs of all those who are engaged in grape research.

The book embodies scientific information of practical utility on grapevine improvement under various remedies, disorders under ecological, physiological and ecophysiological conditions. The ecological disorders like dead arm, barrenness of vines, sun scald and hail damage are direct effect of abiotic stresses of the climate or soil and causes distinct reduction in productivity. Physiological disorders have effect on production with water berries, shot berries, berry cracking and berry drop like symptoms, disorders.

The environmental conditions and physiological conditions also cause some disorders and are grouped under ecophysiological disorders. Due to intense sunlight and wrong canopy management the disorders like berry shrivel, sun scars and guttation are observed and have detrimental effect on quality and finally production.

Herbicide related disorders are also covered and categorized according to the chemical group contents of the herbicide.

Though some disorders like rachis cracking, rachis swelling which are newer and exact causes of it are yet to be unknown, no research done on it or are of unknown etiology are also given and grouped under heading non specific disorders.

Considering all these, economic losses due to disorder have been covered in some headings. Adequate weightage has been given also simplicity and control measures to overcome the disorders.

We are confident that this book will definitely helps farmers, scientists, scholar, teacher and students engaged in grapevine research and surely helps in increasing the economic status of viticulture research in India.





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