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Viticultural Factors Affecting Inflorescence Necrosis and Ammonia Metabolism

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Inflorescence Necrosis (IN) has been an unpredictable problem for grape growers in Oregon. The industry has seen significant losses due to this fruit set disorder in several out of the eight years since its first description in 1988, particularly in Pinot noir. Little is known of how to prevent the disorder, in fact, there is little known about its physiology.

Reported here are three groups of experiments that attempt to better characterize IN (effects of shade and defoliation, rootstock, and clone), investigate the physiology of the disorder, and determine if there is a link between the ammonium ion (NH_4^+) and IN in the field (which has already been established in more controlled environments).

The Oregon grape industry helped fund research that revealed associations between IN and shade, vigor, and NH_4^+ levels. Research has also suggested that one reason NH_4^+ builds up to damaging levels is a lack of enzymes to detoxify it, specifically in the flower cluster tissue. One of the key enzymes in NH_4^+ detoxification is ferredoxin glutamate synthase (Fd-GtS), so our studies have concentrated on demonstrating that this enzyme is present and active in flower tissues.

We have already reported the presence of Fd-GtS protein in grape tissues, as determined by Western blotting (OSU Winegrape Research Wine Advisory Board Progress Reports 1994-1995). Recently we developed a procedure to extract Fd-GtS and assay its activity from grape leaf tissue, which has not, to our knowledge, been reported in the literature before. Currently, characteristics of the enzyme are being investigated, and later the procedure will be used to determine Fd-GtS enzyme activity in petiole, rachis, flower, and pedicel tissues. Differences in activity between these tissues may point to possible reasons for the build up of NH_4^+ to toxic levels.

A three year study on the effect of pre-bloom shoot manipulations was completed in 1995. The effects of partial vine shade, leaf removal, and shoot tipping on flower cluster NH_4^+ levels, as well as IN symptoms were investigated on Pinot noir vines at a site with a history of IN.

For the defoliation treatments, leaves from the top-half of, lower-half of, or entire shoot were removed approximately one week before bloom. Additionally, individual shoots were shaded from budbreak (SSE) or beginning from one week before bloom (SSL). Flower clusters (in all treatments), leaves, and petioles (in all but defoliation treatments) were collected at bloom and analyzed for NH_4^+ . Symptoms of IN were visually surveyed after fruit set.

In 1994 overall NH_4^+ concentrations in flower clusters were lower than in 1993 and 1995. Relative to

controls, flower clusters from completely defoliated shoots had consistently higher NH₄⁺ concentrations. In the two years when individual shoots were shaded, shoot shade just for the week prior to bloom (SSL) had the greatest effect on increasing flower cluster NH₄⁺. Leaf and petiole NH₄⁺ levels were also affected by the treatments: shading shoots early or late raised leaf blade NH₄⁺ by almost two-fold over that for the controls, but only in SSE was petiole tissue NH₄⁺ raised. Tipping shoots one week prior to bloom, reported to decrease IN, had no effect on tissue NH₄⁺

There were no significant differences in IN severity between treatments in 1995, though overall IN severity at this vineyard was greater than seen in any of the rootstock trials surveyed.

Grape varieties show different susceptibilities to IN, with Pinot noir being one of the most affected. Some preliminary surveys in 1994 showed that rootstock and Pinot noir clone may have an effect on the severity of IN. In 1995 three cooperative rootstock trials in Oregon (two in the Willamette Valley, WV1 and WV2, and one in the Rogue River Valley, RRV) and the Pinot noir clonal trial at Woodhall III vineyard were surveyed for NH₄⁺ and IN severity to see 1) if there was a significant effect of rootstock/clone on IN, and 2) if NH₄⁺ in the flower cluster or petiole tissue could be an indicator of IN susceptibility.

In the rootstock trials, site was the factor having the greatest effect on tissue NH₄⁺ content. RRV had the highest NH₄⁺ in flower clusters and leaf petioles in both years surveyed. NH₄⁺ varied considerably between 1994 and 1995, suggesting weather plays a large part in NH₄⁺ levels in the vines. Data on IN severity were taken in 1995 only.

When overall NH₄⁺ levels were high at a site, significant differences were found between rootstock flower cluster and petiole NH₄⁺ levels. At RRV, rootstocks 420A and 44-53 were ranked among the lowest and 101-14 and Harmony the highest in flower cluster NH₄⁺ in 1994. This past year, 420A and 44-53 were again the lowest ranked, but on the high end were 3309 and own-rooted vines.

Compared to flower clusters, NH₄⁺ was much lower in petiole tissues. Significant differences in petiole NH₄⁺ between rootstocks were found at RRV and WV1 in 1994, but only at RRV in 1995. Petioles from 5C and 420A tended to have lower NH₄⁺ and 3309 and own-rooted higher NH₄⁺ concentrations. Petioles and flower clusters collected from the same node showed a significant ($p < 0.001$) relationship in NH₄⁺ level.

Significant differences in IN between rootstocks were found at all sites, with the most severe symptoms occurring at WV2 (Fig. 1). At this site, own rooted vines showed the least IN, while 420A and 3309 had higher visual ratings of severity. At WV1 4453 and 5C had lower and Harmony higher ratings. Scores for 420A and own rooted were the lowest at RRV, with 101-14 and 3309 having the higher ratings.

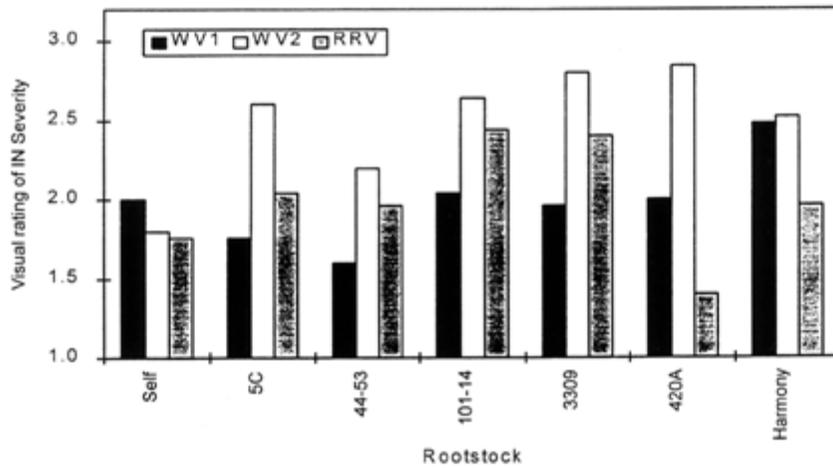


Fig. 1. Visual ratings of Inflorescence Necrosis (IN) in three replicated rootstock trials in Oregon - two in the Willamette Valley (WV1 & WV2) and one in the Rogue River Valley (RRV). Data were taken after fruit set in 1995 according to the following scale: 1= <5% (little or no); 2= 5-20% (moderate); 3=20-40% (significant); 4= 40-60% (severe); 5= >60% (very severe). Standard deviations: WV1=0.81, WV2=0.98, RRV=0.85

The collection of 20 own-rooted Pinot noir clones at Woodhall III vineyard yielded fewer significant differences in terms of NH4' and IN. There was a marginally significant (p=0.052) difference between clones in flower cluster NH4'1 with UCD23 and UCD32 being among the lowest. Most of the rest of the clones were clustered around 2.2mg NH4+/g dry wt., but UCD4 was the highest with 2.7mg/gdw. Petiole NH' was generally low, with notable exceptions for ESP374, DJN60, and DJN10/18. Again, as found in the rootstock survey, there was a significant correlation between flower and petiole NH4'

There were significant differences in IN severity between clones with DJN 115, UCD4, and UCD29 having lower ratings and UCD23, UCD33, and DJN10/18 having higher ratings (Fig. 2). There was no correlation between IN rating and flower cluster or petiole NH4''

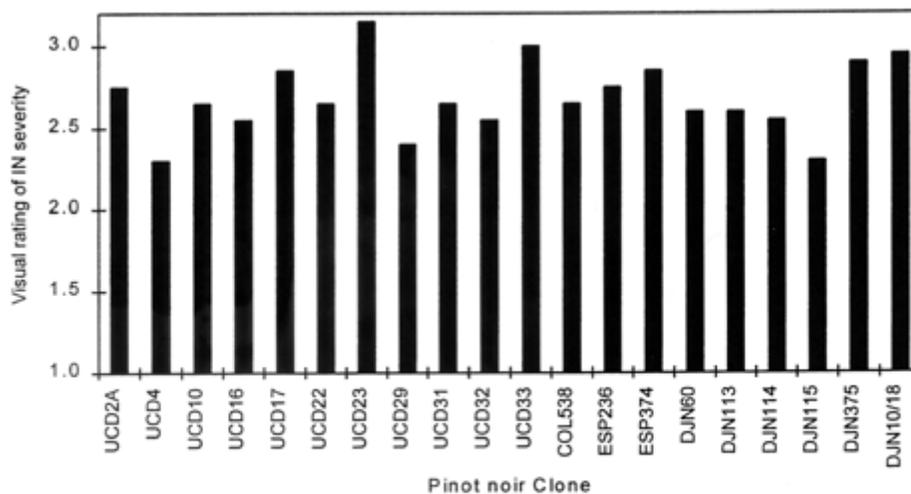


Fig. 2. Visual ratings of Inflorescence Necrosis (IN) in the Pinot noir clonal trial, Woodhall III vineyard, Alpine, Oregon. Data were taken after fruit set in 1995 according to the following scale: 1= <5% (little or no); 2= 5-20% (moderate); 3=20-40% (significant); 4= 40-60% (severe); 5= >60% (very severe). Standard deviation=0.67

OVERALL CONCLUSIONS

While our study on the physiology of IN has yet to be completed, shoot manipulations have shown that pre-bloom shading and defoliation can have an effect on shoot tissue NH_4^+ , if not IN symptoms.

We have also demonstrated that rootstock can have a significant effect on NH_4^+ in flower clusters and on IN. Rootstocks on 420A tended to have lower NH_4^+ in tissues while those on 3309 tended to have higher concentrations. In terms of IN symptoms, own-rooted vines tended to have fewer and 3309 more, but there was great variability between the sites surveyed.

Site, yearly variations in weather, and management practices may all have just as great an effect on IN and NH_4^+ as the rootstock. IN is most associated with vigorous growth and shade - rootstock, trellis, weather, and management can all affect how the vine grows and thus have an indirect effect on IN.

Variations in NH_4^+ and IN between clones are, not surprisingly (given their genetic similarity), small, suggesting that the well-described differences between clone cluster sizes and yield are due to factors other than IN. UCD4 ("Pommard") and DJN 115 had a tendency for less severe IN in 1995, while UCD23 ("Mariafeld") and UCD33 tended towards more severe IN.

While petiole and flower cluster NH_4^+ were significantly related, there was no relationship between these factors and observed IN symptoms (Fig. 3). There is a growing amount of evidence that the appearance of IN is determined not solely by NH_4^+ , but also by the availability of carbohydrates in the plant and possibly other factors. More thorough investigation into the physiology of the disorder will provide the information needed to, eventually, find a predictor of IN. Nevertheless, NH_4^+ within plant tissues is a common result of plant stress, so even if the relationship between NH_4^+ and IN is cloudy, management practices that raise it in vines should be avoided.

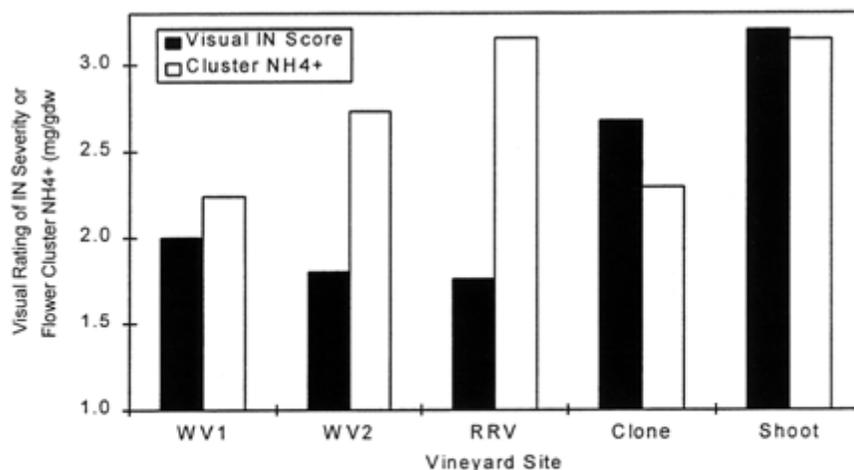


Fig. 3. Visual rating of IN severity and flower cluster NH_4^+ in vineyards surveyed in 1995. Rating scale used: 1= <5% (little or no); 2= 5-20% (moderate); 3=20-40% (significant); 4= 40-60% (severe); 5= >60% (very severe). Data from controls in the rootstock (own-rooted) and shoot experiment vineyards.