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Study of cold sensitivity of floral buds of sweet cherry cv Kordia in early phenological stages

From the earliest years of cultivation of cv Kordia in Trentino, its sensitivity to cold from the earliest phenological stages has been evident. The variety, introduced in the late 1990s, was already affected by severe frosts in the early 2000s.

Linked to the varietal weakness is the climatic aspect, which is inevitably affected by climate change: the last few seasons have been characterized by mild winters, which have caused an earlier vegetative recovery. This leads to an increase in the period of risk for flower organs, of encountering temperature drops that can damage them. Making an analysis of the last seven seasons (2017 to date), during five spring times there have been episodes of late frosts that have caused damage to production. These events often occur in the period from the last decade of March to the first decade of April, when most of the cherry orchards are in sensitive phenological stages (from bud break to pre-bloom).

To defend production, many farmers practice active defense: the techniques most widely used in Trentino are orchard heating with paraffine candles or pellet stoves and anti-frost irrigation. An essential information, to carry out active defense, is to know what the critical temperatures are, harmful to flower organs at different phenological stages. In the literature, the information refers to other varieties and is not specific to Kordia. Field experience, however, shows how extremely sensitive Kordia is, compared to other cultivars, especially during the early stages of development.

To get more information, a field data collection began in 2018: temperatures were monitored during frost events, phenological stages and cold damage were noted. However, this approach highlighted how complex the issue of frost is: in fact, it is influenced by many variables, some of them related to climatic aspects and others to the plant (phenological stage, physiological state, and nutrient content of buds). The initial information gathered was often unclear and sometimes even conflicting.

For this reason, we wanted to reduce the variables involved to focus on only a few factors. To do this, a laboratory trial was set up, with the aim of studying the effect of temperature on some early phenological stages. To limit the effect of other factors, plant material was sampled in the same plot and subjected to standardized, common frost curves for the different stages.

LABORATORY TEST

Materials and methods

The trial was conducted over two seasons, 2020 and 2021. Using a climate cell, hypothetical frost curves were reproduced. They were characterized by the same total duration of eight hours, the initial rate of temperature reduction of 1°C per hour, and the fast final rise to 0°C. Each phenological stage was subjected to frosts with minimum -2°C, -3°C, -4°C and -5°C. The average relative humidity was about 70%. The tested phenological stages concern the early stages of development, from swollen bud to pre-bloom. Sampling was done from about 40 trees of a cherry orchard located at 800 m a.s.l. in Valsugana valley, in an area usually little prone to frost.

The plant material was composed of branches with the presence of both single floral buds and spur buds and it was sampled when most of the them were at the required phenological stage. For each phenological stage, sampling was done on the same day. The collected branches were divided into bundles, consisting of 10-15 branches each: one sample was represented by one bundle. The bundles were stored in cold storage, preserving humidity, at 4-5°C, waiting for frost. During the following days, on four different moments, the frost curves were reproduced: to each frost were subjected some of the samples (each sample suffered only one frost). After freezing, the samples were kept soaking in a bucket of water, waiting for damage control. The control phase was carried out with the help of a stereomicroscope by etching the bud and counting the number of healthy and damaged floral buds. A flower was defined as damaged when it showed browning at the floral ovary. Of each sample, 150 flower buds were checked by randomly removing them from each branch of the sample.

The checked buds were divided according to the percentage of damaged ovaries, identifying different classes of severity: in figures 1 and 2, completely healthy buds are colored in green, buds with only one damaged ovary in yellow, buds with most damaged ovaries in orange, and completely damaged buds in brown.

Results

Figures 1 and 2 indicate the response of buds at different phenological stages to the minimum temperatures after eight hours of frost; the y-axis represents the percentage of the different damage classes. The blue line shows the percentage of completely healthy buds in the control sample. What is observed in the figures?

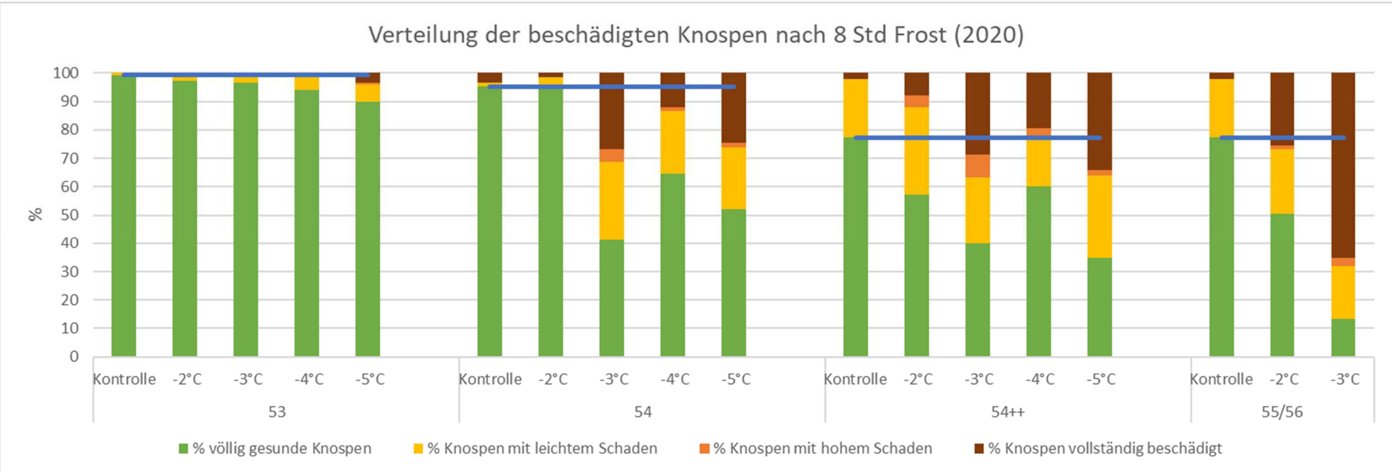

Fig.1: Percentage of different damage classes as a function of minimum temperature for some phenological stages (2020)

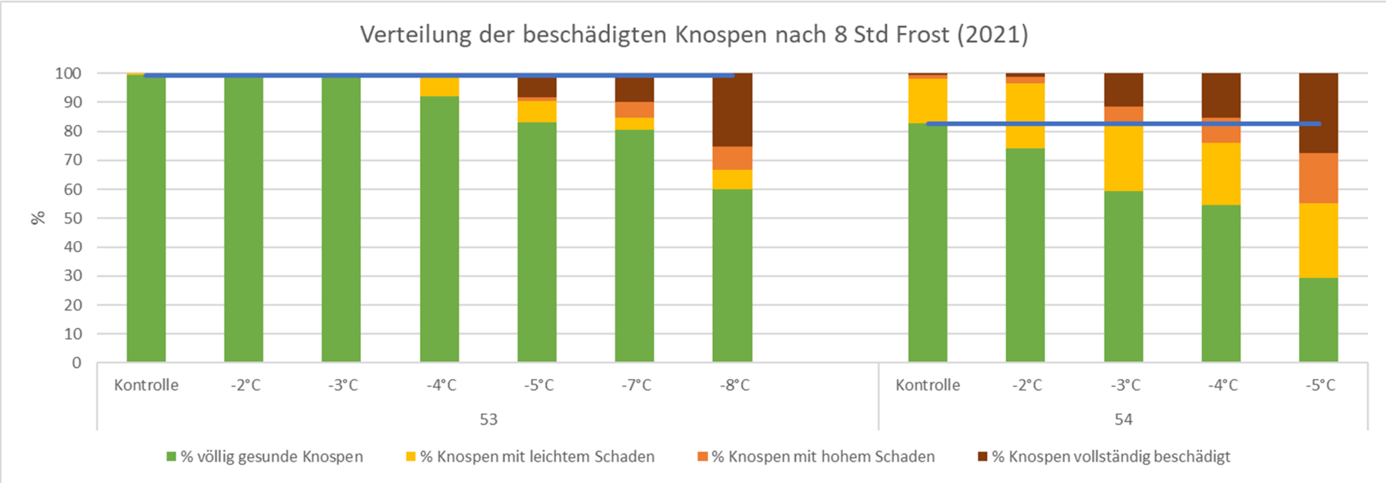

Fig.2: Percentage of different damage classes as a function of minimum temperature for some phenological stages (2021)

- The phenological stage of side green (BBCH 53) was quite resistant to all tested minimum temperatures. In 2020 (figure 1), even following minimum temperatures of -5°C, 90% of the buds were completely healthy. In 2021 (figure 2) the resistance of buds to significantly more severe temperatures, down to -8°C, was tested: at these temperatures the percentage of damaged buds increased but did not go beyond 40%.

- The phenological stage of green tips (BBCH 54) was much more sensitive. The results obtained highlight, at the same temperature, a different response of the buds during the two seasons. In 2020 the minimum temperature of -2°C caused no damage at all. In contrast, the frost with a minimum temperature of -3°C caused a high percentage (about 60%) of damaged buds. The frosts with minimum temperatures of -4°C and -5°C did not increase the damage. In 2021, the minimum temperature of -2°C was confirmed as not very dangerous. The -3°C temperature generated a lower percentage of damaged buds than in the previous year, but still significant due to the large percentage of fully damaged buds. The frost with a minimum of -4°C does not differ much from the effects of the -3°C frost, while a high increase in damaged buds is observed after the -5°C curve.

- The following phenological stages (BBCH 54++ and 55/56) are sensitive as early as the minimum temperature of -2°C; the minimum temperature of -3°C, however, causes the highest percentage of damaged buds. Testing of these stages was conducted only during 2020 season.

Another aspect analyzed was the effect of frost duration on final damage. For this purpose, different samples were subjected to the same frost curve, but some of them were removed before eight hours.

Figure 3 shows the effect of different duration at minimum temperature on bud damage, regarding the phenological stage BBCH 54. What emerges is that it could take only a few hours at the critical temperature to achieve significant damage; moreover, prolonging the duration of frost often does not result in increased damage. This concept was observed very clearly in 2020 and partially in 2021.

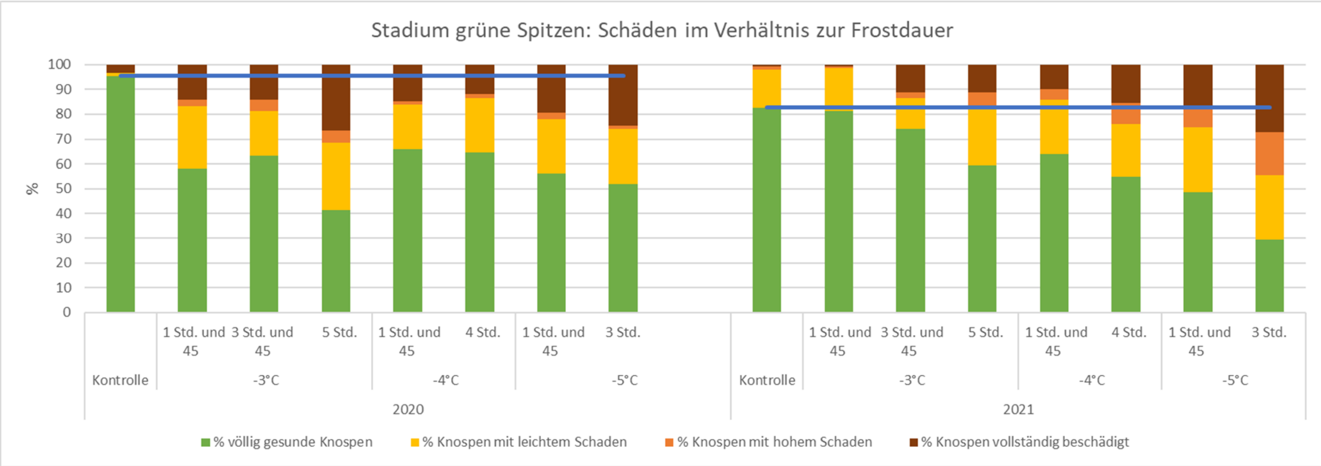

Fig.3: Percentage of different damage classes as a function of dwell time at minimum temperature for each phenological stage (2020 and 2021).

FIELD INVESTIGATION

Materials and methods

Beside the laboratory test, a field data collection was carried out. In anticipation of frost events, dataloggers were placed at some of the cherry orchards, to record temperature curves; then cold damage was monitored (both before and after frost) and the preponderant phenological stage in the plant was noted. In the case of consecutive frost events, a sample was collected after each night to unequivocally associate the damage with a specific temperature curve. In this way it was possible to assess the increase in damage contributed by each individual frost.

Sampling was done by taking about 60-70 floral buds, collected from the lower part of the canopy (1.5-2 m) and near the datalogger. Both one-year-shoot and spur buds were collected, taking care that the sample respected the phenological stage present in the field. The buds then were dissected, and the percentage of damage was noted. The damage was the percentage ratio of damaged ovaries to the total number of ovaries in the sample.

Results

Most of the data collected are mainly for the 2021 and 2023 seasons. Information collected for the green tip phase will be considered.

Figure 4 summarizes the results collected in the 2023 season: the minimum temperature recorded on the night of frost is related with the percentage of damaged ovaries, in the vertical axis. Each point on the graph represents what occurred in a plot on a single frost night. Looking at the scatter of the points, there is a great deal of variability. Going into detail, however, it is possible to group the samples into two populations. The plots that experienced frost for the first time (blue spots) are observed to be most damaged. The critical temperature in this case was around -2.5°C -3°C. In contrast, samples from subsequent frosts (orange spots) are found to have considerably less damage increase.

The analysis of the 2021 season (figure 5) provides other information: although the frosts were more severe, they resulted in significantly less severe damage. These results highlighted the enormous variability of the frost phenomenon, which cannot be explained solely by the relationship between temperature and phenological stage. Probably other aspects, which are difficult to quantify, come into play in an important way, e.g. sensitivity of buds may be influenced by the previous year's production and sugar content within them.

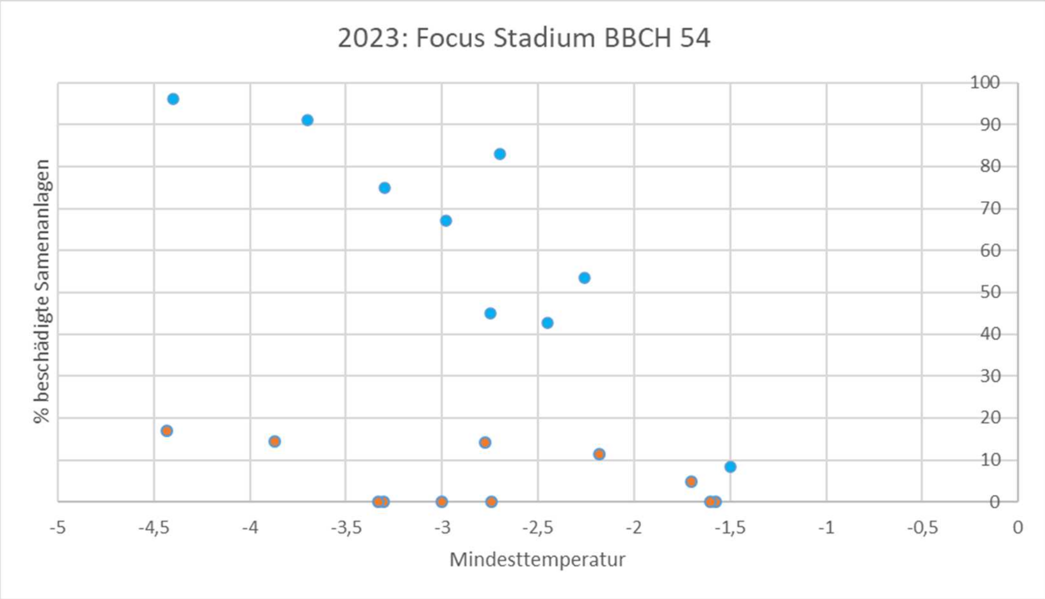

Fig.4: Relationship between minimum temperature monitored during frost and percentage of damaged ovaries in stage of green tip (2023).

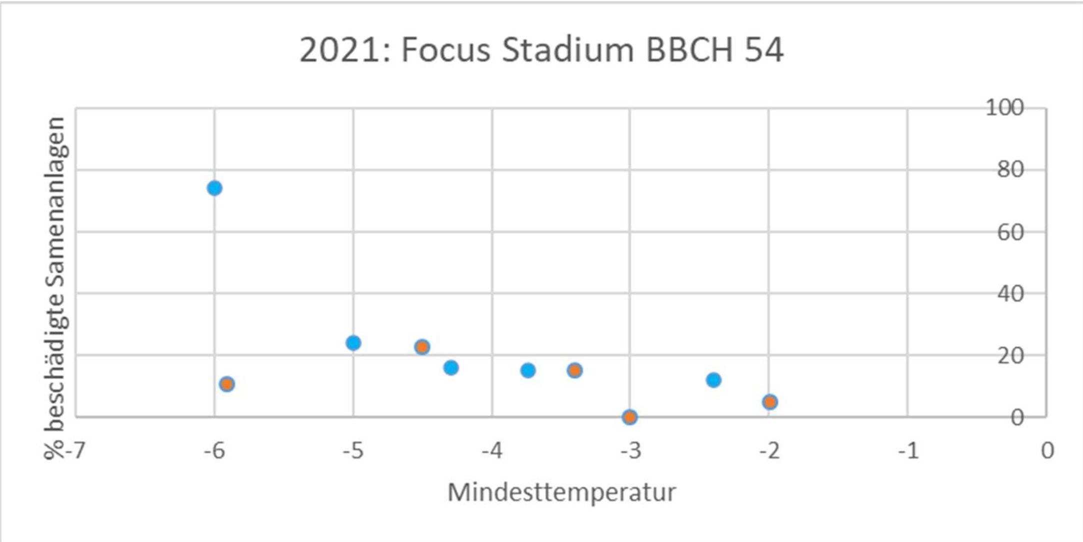

Fig.5: Relationship between minimum temperature monitored during frost and percentage of damaged ovaries in stage of green tip (2021).

Conclusions

The data collected in the field, while showing some variability, confirm some aspects that also emerged from lab tests:

- The phenological stage BBCH 53 tends to be resistant to severe minimum temperatures (-5°C, -7°C)

- The phenological stage BBCH 54 is confirmed to be a decidedly sensitive time for Kordia: the permanence of buds at -3°C, even for a short time, can generate significant damage

- The increase in the number of hours of cold is not always proportional to the percentage of damage

- In the case of consecutive frosts, the greatest damage tends to be caused by the first event, and subsequent events are less decisive.

The results obtained do not allow for a complete explanation of the frost phenomenon, which is the result of the complex iteration of many variables. However, they provide the first important insights into the behavior of Kordia, especially during green tip stage.
Future seasons may be an opportunity to validate and expand the information obtained and further investigate the impact of other variables, especially related to physiology and nutrition.

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