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Breeding and Selecting New Peach Cultivars for the Changing Mid-Latitude Michigan Climate

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Abstract

Climate change has increased potential problems for peach production in northern regions. Peach breeders will need to search available germplasm for promising combinations of parents to improve cold hardiness and disease resistance. Tools such as marker-assisted breeding and controlled temperature evaluation will be important to make rapid progress.

Successful commercial peach production is highly dependent upon favorable environmental conditions, made more challenging by climate change. In Michigan and other mid-latitude growing regions, the major constraint is cold temperature damage from fall to spring (Fig. 1). The west Michigan fruit belt usually benefits when westerly winds from Lake Michigan bring mild temperatures during cold weather and suffers when air flow misses the lake or stops. Cold damage to peach in Michigan can be traced to three distinct time periods: rapid temperature drops in late fall causing tree damage, mid-winter low temperatures damaging fruit buds and trees, and springtime cold events damaging fruit buds. Over the last two decades, peach crop losses in Michigan due to spring frost have been more common than fall or mid-winter cold events (Table 1), in part due to climate change.

The rise in annual air temperature association with increased atmospheric CO2 concentrations is not a direct cause of production problems in Michigan because peach is generally well-adapted for warm growing conditions. However, early spring rise in temperature accelerates plant development, which in turn sets the stage for cold injury. Climate change has brought about more extreme temperature fluctuations, increasing the chances for cold damage, and more rainfall, which favors both fungal and bacterial diseases.

Market forces also set the stage for cold weather challenges to the Michigan peach industry in the 1990s. Cultivars such as 'Redhaven' commonly used by Michigan had insufficient color to compete in the wholesale marketplace during the 1990s. This induced growers and local plant breeders to seek better-colored replacement cultivars, drawing upon germplasm, in some cases, with less cold tolerance and increased susceptibility to some diseases. This increased the need for strategies, including breeding to combat these challenges.

Alternatives to breeding

Cultural strategies have been devised over the years to counteract cold weather effects on peach and other tree fruit yields. Fall ethephon treatments delay spring fruit bud development, but our experience so far in Michigan has been that this method is not reliable and can cause damage to trees. Overhead mist systems in early spring cool

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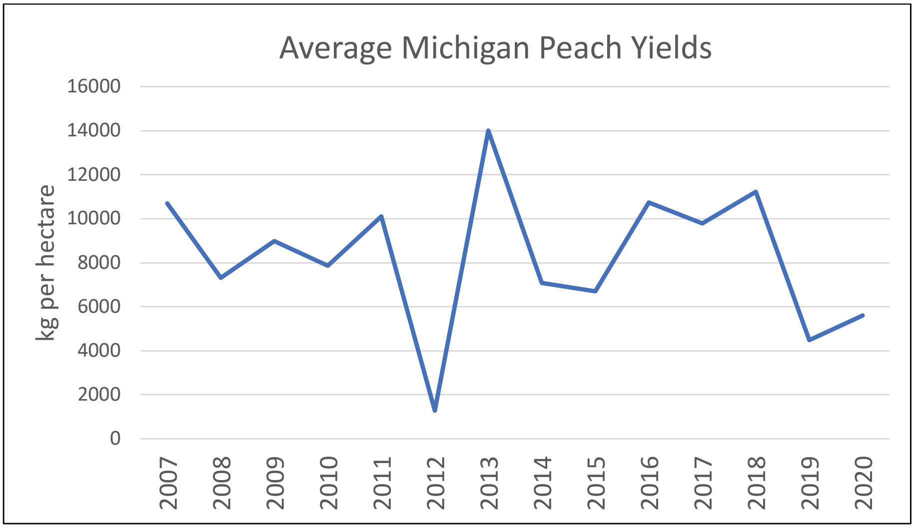

Figure 1. Fluctuations in average Michigan peach yields primarily due to cold weather events. Average Michigan peach yields from 2007 to 2020. Source: National Agricultural Statistics Service

the tree and delay plant development (Rijal, 2017), but has not been implemented for large-scale commercial fruit production mainly due to the difficulties of maintaining an over the tree sprinkler system. Wind machines are common in grape and apple commercial plantings in Michigan and are gradually being utilized for peach orchards. Wind machines are not helpful when winds eliminate warm air layers above the crop. Less commonly used for freeze protection are under-tree microsprinklers because the research has shown warming effect does not extend significantly into the upper canopy of a tree. Although these techniques can be helpful in specific cases, cultivar genomics is the foundation for peach productivity.

To obtain peach cultivars for the future in the Michigan climate we need to increase genetic based cold hardiness and disease resistance. Fortunately, genes for these traits are available in relatively high-quality cultivars so that improvement is feasible through breeding but finding the best improved seedling with the desired collection of traits can take many years.

Development of cold-tolerance peaches

The Michigan State University breeding program has emphasized mid-winter har-

Table 1. Cold damage events to southwest Michigan peach crops 2000 – 2021.

Time period	Freeze types	Dates of cold events
Fall	Quick drop to low teens (-10 to -12 C) in early December or before	Dec 2013, Dec 2014
Winter	Low temperature below -8 F (-22 C) in mid winter	Jan 2005, 2007, Jan 2014, Jan 2019, Feb 2021
Spring	Drop below 28 F (-2.2 C) in spring	Apr 2002, May 2002, May 2004, Apr 2006, Apr 2008, Apr 2010, Apr 2012, Mar 2017, May 2020, May 2020, Apr 2021, May 2021

diness to combat low temperatures in the northern region during January and February, and high chill requirements to delay fruit bud opening. Other regional breeding programs in New Jersey, North Carolina, South Carolina, and Georgia have produced peach cultivars of value to Michigan growers but testing of these is necessary to see if mid-winter cold tolerance is adequate.

Marker-assisted breeding (MAB) for peach has made good strides in helping to select progeny from crosses for traits such as red blush, acidity, soluble solids, ripening date and bacterial spot resistance. MAB has also proved useful to select for delayed flowering date but has yet to make much headway in breeding for dormant season fruit bud cold resistance. The time-honored way to develop new cold-tolerant peach cultivars has been to cross parents with promising horticultural and cold-tolerant traits and test the progeny under field conditions. At MSU, we shortcut the field evaluations by subjecting fruit buds collected throughout the winter to controlled temperatures in environmental chambers, followed by dissection to see browning by lethal temperatures. In recent years this process has become more efficient with the use of differential thermal analysis (DTA) (Liu, J., 2019) whereby freezing of fruit buds within the chamber is detected with thermoelectric modules (TEM), eliminating the need for time-consuming bud dissections.

Dealing with increased disease problems

Bacterial spot caused by *Xanthomonas arboricola pruni* (Xap) has become a persistent problem in sandy Michigan peach orchards and made more severe by increased precipitation associated with climate-change (GLISA, 2019). Proper use of bactericides such as copper and oxytetracycline helps to suppress this disease, but increased use raises the possibility of resistance as has been seen with a somewhat similar disease on walnuts (Buchner, R. P. et al, 2001). We have used marker-assisted breeding to good advantage for selecting progeny with promising fruit resistance to bacterial spot. Quantitative trait loci (QTL) Xap.Pp.OC-6.1 have been identified on peach linkage group (LG) 6 associated with Xap resistance in fruit (Yang, et al, 2013). Peach cultivars and seedlings homozygous for this trait displayed smaller fruit lesions in the field. Searches for markers for finding effective Xap resistance in leaves have been less successful. Better resistance is needed because nearby leaf infections by Xap can induce infections of adjacent fruit even if the cultivar is homozygous for Xap.Pp.OC-6.1 resistance to fruit infection, although lesions tend to be small.

Brown rot is a significant fungal problem for humid peach growing regions. In Michigan, careful selection and timing of fungicide sprays are sufficient for disease management most years. Development of peach resistance to brown rot has been a focus at Clemson University in South Carolina when relatively hot growing conditions can make disease management particularly tough. The specter of fungal resistance to the major classes of systemic fungicides is a major concern (Lesniak, et al, 2020) and may raise this problem to a higher priority for northern breeding programs.

Thinking ahead

A practical consideration for the use of techniques such as differential thermal analysis and marker-assisted breeding is deciding when to test the progeny from crosses for the desired trait (Wannemuehler et al, 2020). At MSU where nearby land for nurseries is plentiful, we have elected to use these techniques to help select elite peach lines after fruiting has been observed in the field. Other programs, especially those with adequate greenhouse space and access to automated testing equipment, may choose to test seedlings before planting in the field. The prospects are good for continued improvement of peach cultivars as additional useful markers for peach traits are identified.

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