20 years in, NAFTA finally sours the US sugar program

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Key Points

- Although the North American Free Trade Agreement (NAFTA) was signed 20 years ago, it only truly began affecting the US sugar industry over the past two years as world sugar production has increased and world prices have declined.

- Recent trade negotiations have complicated the US Department of Agriculture’s ability to control total US sugar supplies.

- The US sugar industry will need to reduce annual domestic production by 5 to 10 percent to meet US trade commitments and minimize taxpayer costs.

Introduction

The North American Free Trade Agreement (NAFTA) was signed in 1994, but US restrictions on sugar imports from Mexico were only slowly relaxed over the following 14 years. In 2008, however, all restrictions were removed. Until recently, this trade liberalization policy had only small effects on the US sugar industry, for four reasons.

First, Mexico was only slowly granted access to the US sugar market. Second, Mexico’s domestic sugar production remained relatively flat between 1994 and 2010. Third, Mexico’s sugar consumption also remained relatively stable until, over the past five years, high world sugar prices prompted many of Mexico’s food and soft-drink manufacturers to substitute high-fructose corn syrup (HFCS) for sugar. Fourth, world and US sugar prices were at record-high levels early in this decade because of poor weather conditions.
Over the past two years, however, world sugar production has increased and prices have declined, largely because of improved sugar-growing conditions in major production regions. The combination of unrestricted access to the US sugar market, increases in Mexican sugar production, and reductions in Mexican sugar consumption will result in Mexico being a major supplier of sugar to the United States. Hence, future US sugar production levels will need to account for this new trade environment if the US sugar program is to remain a “no cost to taxpayers” program.

**World Sugar Production**

World (and US) sugar prices have been volatile over the past eight years (especially since 2008), primarily because of substantial fluctuations in world sugar production. Between 2009 and 2012, US sugar prices were atypically high and world prices substantially exceeded the price at which the US government supports domestic sugar prices through processor marketing loans.¹

Sugar is produced in many countries around the world. In general, farmers raise sugar beets in regions with temperate climates (for example, the northern United States, Europe, Ukraine, and Russia) and the sugar beets are processed into refined sugar. In tropical climates (where most of the world’s sugar is produced), sugar is obtained from sugarcane. Sugar beets and sugarcane are bulky commodities with a limited post-harvest shelf life. Consequently, sugar refineries are located close to areas where sugar beets and sugarcane are grown.

Globally, more than 195 million tons of sugar were produced in fiscal year (FY) 2012–13.² World production has generally been increasing for several decades (see figure 1). Currently, Brazil, India, China, Thailand, and the United States are the largest producers (see figure 2). However, their combined output is only 56 percent of total world production.

US Sugar Production

US sugar production averaged about 8 million tons over the past 25 years. In FY 2012–13, however, production reached almost 9 million tons, primarily because of good growing conditions. Sugar obtained from sugar beets typically comprises about 55 percent of US sugar production, with sugarcane (produced in Louisiana, Florida, Texas, and Hawaii) making up the rest. In FY 2012–13, beet sugar production was just over 5 million tons while cane sugar production was almost 4 million tons (see figure 3).

Figure 3. US Sugar Production


World and US Sugar Prices

In the 2008–09 and 2009–10 marketing years, adverse weather conditions caused world sugar production to decline substantially. In response, world sugar prices increased. Globally, refined-sugar prices reached a record high of 34.5 cents per pound in 2011 and averaged 29 cents per
pound between the 2010 and 2012 calendar years (see figure 4). This level was far in excess of average prices (15 cents per pound) that occurred over the previous decade.

World sugar prices also caused US wholesale refined-sugar prices to reach a record of 59.5 cents per pound in August 2010 and average 50.94 cents per pound between 2011 and 2012, far in excess of the average US domestic support price of 24.09 cents per pound. World and US sugar production recovered in 2013, and both world and US sugar prices declined to their pre-2010 levels.

**Figure 4. World and US Monthly Wholesale Refined-Sugar Prices**

US Sugar Consumption

Total US sweetener consumption has been relatively stable at around 20 million tons (dry basis) for over a decade (see figure 5). Sugar represents 10.75 million tons while HFCS accounts for almost 7 million. Other sweeteners (for example, honey, glucose, dextrose, and syrups) provide the remaining 2 million. On a per-capita basis, total US sweetener consumption is about 130 pounds (dry basis), of which 68 pounds are sugar (see figure 6).

Figure 5. Total US Sweetener Consumption

US Sugar Exports

US domestic sugar prices are higher than world sugar prices because of US tariff-rate quotas (TRQs), nonrecourse marketing loans, domestic supply controls, and occasional government purchases of sugar that are subsequently sold at a discount to the ethanol industry (see figure 4). Consequently, US sugar exports are relatively small—only 269,000 tons in 2013 (see figure 7). These exports are primarily the result of a re-export program in which raw sugar is imported by US raw-sugar refiners, processed into refined sugar, and then exported.
US Sugar Imports

Total US sugar imports averaged about 2 million tons between FY 1990–91 and FY 2004–05 but substantially increased in FY 2005–06 to 3.4 million tons (see figure 8). After a decline to 2 million tons in FY 2006–07 as some countries increased inventories following two low production years, imports steadily increased to 3.7 million tons in FY 2010–11. By FY 2012–13, imports declined to 3.2 million tons (a 13.3 percent reduction from FY 2010–11). In FY 2012–13, imports represented 26 percent of total US sugar supplies.

Many countries, including the United States, protect their domestic sugar industries from global price movements. The United States uses TRQs to restrict sugar imports and support domestic sugar prices. TRQs establish a relatively low in-quota tariff of 0.625 cents per pound of raw sugar for amounts that do not exceed an individual country’s import allotment. However, sugar
that is imported in excess of the predetermined quota is charged an over-quota tariff of 15.36 cents per pound. Raw-sugar prices in the United States have averaged 23 cents per pound since 1990. Thus, for countries with TRQs, the over-quota tariff is an effective disincentive to export sugar to the United States in excess of TRQ allotments.

Figure 8. US Sugar Production and Imports

The United States has an obligation under its World Trade Organization (WTO) commitments to annually import 1.231 million tons of raw sugar and 25,954 tons of refined sugar from TRQ countries. The United States receives TRQ-restricted imports from 40 countries and unrestricted imports from several others. TRQ imports have averaged 1.51 million tons since FY 2000–01 (see figure 9). Each year, initial annual TRQ raw-sugar allotments are set near the minimum quota required by US trade commitments. However, TRQ allocations can be increased during a year in response to changing supply-and-demand conditions (see figure 10).
Figure 9. US Sugar Imports by Source


Figure 10. Initial and Final TRQ Raw Cane Sugar Allotments

Brazil, the Dominican Republic, and the Philippines are the top three TRQ sugar exporters to the United States, followed by Australia, Guatemala, and Argentina (see figure 11). US sugar imports from Brazil averaged 243,350 tons annually from FY 2009–10 to FY 2012–13.\(^6\) Imports from the Dominican Republic and Philippines averaged 212,762 tons and 177,904 tons, respectively, over the same period.

**Figure 11. US TRQ Sugar Imports by Country, FY 2012–13**


Typically, US domestic sugar prices have been much higher than world prices such that even after considering additional transportation and TRQ tariff costs, foreign countries have generally filled their US TRQ allocations (at an average of 90 percent). However, between 2010 and 2012, when world sugar prices exceeded the average US Commodity Credit Corporation (CCC) loan rate for refined beet sugar of 24.09 cents per pound, some countries did not fill their TRQs. Over this period, the difference between US and world prices was not large enough to offset
transportation costs and in-quota TRQ tariffs. Thus, only 54 percent of total TRQ allocations (a record low) were filled in 2012–13 (see figure 12).  

Figure 12. Percentages of US TRQ Allocations Filled


US Sugar Policy

The origins of US sugar policy can be traced to 1789, when the fledgling US government levied a tariff on imported sugar. The tariff was intended to raise money for the US Department of the Treasury rather than support a domestic industry, given that little sugar was produced in the United States at the time. The US sugar industry developed in the 19th and early 20th centuries. The 1934 Sugar Act established various sugar import tariffs and was the first federal program designed to support the industry.

The stated purpose of the 1934 act and its successors was to ensure an adequate supply of sugar and keep US sugar prices above world prices. Later, import quotas and domestic-processor marketing allotments were implemented to meet this dual mandate. Since 1934, the US program
has been continued through a series of acts, with a suspension of government intervention in the market occurring only once, in the early 1970s when world sugar prices spiked for a couple of years.  

Modern iterations of the US sugar program began with the 1977 farm bill. The bill identified sugar as a protected commodity and gave the US Department of Agriculture (USDA) the authority to purchase sugar and issue nonrecourse loans to keep domestic prices above world prices. Several other commodity marketing loan programs are available to crop producers. But the sugar marketing loan program is directed at processors because the bulkiness and short shelf life of sugar beets and sugarcane require that both be processed quickly into sugar for storage and trade. To qualify for such loans, processors agree to pay producers for sugar beets and sugarcane proportionally to the value of the marketing loan.  

The Food Security Act of 1985 introduced an additional objective for the sugar program: to operate as much as possible at “no cost” to US taxpayers. This objective has played an important role in policy discussions. To meet the no-cost policy stipulation, a combination of import restrictions and domestic supply controls are used to maintain domestic sugar prices above the CCC loan rate.  

While TRQs are used to restrict US sugar imports, domestic supply controls restrict domestic production, and CCC nonrecourse marketing loans establish a minimum price floor. The USDA estimates total sugar needs for each coming year by forecasting sugar consumption and export quantities. Hence, accurate estimates of US sugar use are essential for establishing import restrictions and domestic production targets. The USDA attempts to match estimates of total domestic supply with estimates of total domestic consumption to keep domestic sugar prices at or above CCC loan rates.  

Each domestic sugar processor is allocated a percentage of the domestic sugar market in exchange for the opportunity to participate in the CCC loan program using the Overall Allotment Quantity (OAQ) program. The OAQ establishes limits (marketing allotments) on the amount of sugar that can be sold by each domestic sugar processing company for that company to remain
be eligible for CCC loans. In the absence of production limits, domestic sugar production would increase and cause domestic prices to consistently fall below the CCC loan rates, resulting in government expenditures associated with loan forfeitures.

CCC loan rates are established by federal agricultural policies and have not changed appreciably over the past 20 years (see figure 13). The CCC nonrecourse marketing loan program essentially guarantees a minimum price for wholesale sugar.

![Figure 13. Average CCC Loan Rates](source)


Between 1996 and 2001, US sugar policy was the product of the Federal Agriculture Improvement and Reform Act (FAIR Act), which continued to allow sugar processors access to marketing loans from the CCC. These loans, however, were deemed nonrecourse if TRQ imports exceeded 1.5 million tons. Loans became recourse if TRQ imports were stipulated to be less than 1.5 million tons.

The rationale for the distinction was that if large TRQ imports occurred, then it was more likely that domestic sugar prices would decline. Hence, nonrecourse loans would provide a minimum wholesale sugar price for processors. However, the FAIR Act suspended domestic processor
marketing allotments. The termination of domestic supply controls (and concurrent lower prices of other agricultural commodities that were production substitutes, especially for sugar beets) resulted in a substantial increase in domestic sugar production. The subsequent reductions in sugar prices caused significant sugar loan forfeitures and costs to taxpayers.

The Food Security and Rural Investment (FSRI) Act of 2002 made several important changes to the 1996 FAIR Act, including reinstating processor marketing allotments to help restrict domestic production. Furthermore, marketing loans were deemed to be exclusively nonrecourse. The 2014 farm bill (the Agriculture Act) continues the FSRI sugar policies. The result of the post-1977 sugar programs is that US sugar prices stay well above world prices as long as world production is not adversely affected by weather events in major sugarcane-producing regions (see figure 14).

Figure 14. US and World Raw-Sugar Prices

Although the 2002 FSRI Act reinstated domestic sugar production restrictions, recent trade negotiations have complicated the USDA’s ability to control total US sugar supplies. NAFTA slowly relaxed restrictions on Mexico’s access to the US market. In 2008, Mexico’s domestic sugar industry was granted unrestricted access. Although the TRQs negotiated in the 1994 WTO agreement set soft but essentially binding limits on the amount of sugar imported from many countries, they have not applied to Mexico since 2008.

Recently, US sugar prices have been near or below CCC loan rates, which has led to sugar forfeitures. Forfeited sugar is generally sold at heavy discounts to ethanol plants.\(^\text{11}\) Because of transportation, storage, and price discounting, forfeited sugar represents a cost to taxpayers and violates the 1985 (and subsequent) “no-cost” component of US sugar policy.

**Mexico and US Sugar Imports**

Since their introduction in 1994, sugar TRQs have been effective US import control measures. Mexico’s unrestricted access to the US sugar market since 2008, however, has reduced the USDA’s ability to control US sugar supplies and maintain domestic sugar prices above CCC loan rates.

Although varying from year to year, US imports of Mexican sugar have been increasing on average since 2005–06 (see figure 15). In FY 2012–13, the United States imported a record amount of sugar from Mexico (1.925 million tons). Sugar imports from Mexico in FY 2013–14 are expected to be slightly lower than FY 2012–13 because of lower Mexican production.
In FY 2012–13, increases in Mexican sugar imports offset declines in TRQ sugar imports from other countries although, as discussed earlier, total US imports were 13.3 percent lower than in FY 2010–11 (see figure 9). However, Mexico’s share of those total imports increased to 68.9 percent in FY 2012–13.

Mexican sugar production has increased from about 6 million tons to just over 8 million tons over the past six years (see figure 16). This supply response was at least partially the result of increased access to the US sugar market, where policy-driven prices are generally well above world levels. Furthermore, Mexico’s sugar imports have been relatively flat. Hence, the source of expanded Mexican exports to the United States does not appear to be transshipments of sugar that Mexico imports from other countries.

Mexico’s domestic sugar consumption has declined by about 1 million tons since 2008–09 and Mexico’s exports have increased by about that same amount. Mexico’s sugar consumption has declined as Mexican food processors’ use of HFCS has increased. Some of the impetus for this
substitution has been recent increases in sugar prices that, in part, were driven by Mexico’s expanded access to the US sugar market (see figure 17). Approximately 28 percent of Mexico’s HFCS is produced domestically, and between 80 and 90 percent of the corn (about 2 million tons) needed to produce it is imported from the United States. The remaining 72 percent of Mexico’s HFCS is also imported, primarily from the United States.

**Figure 16. Mexico’s Sugar Production, Imports, Exports, and Consumption**

Technological Change in the US Sugar Industry

In the United States, the area planted to sugarcane has been relatively constant at around 900,000 acres over the past 25 years (see figure 18). Although somewhat variable, sugarcane yields have averaged about 35 tons per acre over that period (see figure 19). In contrast, sugar beet yields have increased substantially over the past 15 years because of technological change (see figure 19). Thus, the amount of sugar produced by an acre of sugar beets has increased about 25 percent (from about 3 to 4 tons per acre) over the past 15 years (see figure 20). However, the amount of sugar obtained from an acre of sugarcane has remained relatively flat at about 4 tons per acre. As the amount of sugar produced in each acre of sugar beets has increased, acreage
devoted to sugar beet production has declined because of domestic sugar-supply control mandates prescribed by successive farm bills (see figure 18).

Figure 18. US Sugar Beet and Sugarcane Acreage

Figure 19. Sugar Beet and Sugarcane Yields per Acre


Figure 20. US Sugar Production per Acre

NAFTA and US Sugar Imports

Before the implementation of NAFTA, Mexico’s US export allotment was approximately 9,000 tons. Although the agreement was signed in 1994, as emphasized earlier, Mexico was allowed belated access to the US market. Between 1994 and 2001, Mexico was permitted to export 27,500 tons of duty-free sugar to the United States. However, duty-free exports in excess of 9,000 tons were limited to that obtained from Mexico’s net sugar surplus, which was defined as the difference between Mexico’s domestic sugar production and its consumption. This stipulation was intended to deter the transshipment of sugar from other countries through Mexico and to the United States. A side agreement included a provision that HFCS use would be counted on the consumption side of the net surplus equation, but that Mexican HFCS production would be ignored when calculating Mexico’s domestic sugar production.

In 2001, NAFTA increased Mexico’s duty-free access to the United States to 165,000 tons, with the caveat that exports above 9,000 tons could only occur if Mexico experienced a net sugar surplus. However, Mexico would be allowed unlimited access to the US sugar market if Mexico became a net sugar exporter for two successive years. The unlimited-access provision was later eliminated by another side agreement.

For the first 10 years following NAFTA, however, Mexico exported less than 200,000 tons of sugar annually to the United States as Mexico’s domestic production and consumption increased slowly and concurrently. Mexico’s sugar exports did not exceed this level until FY 2005–06.

Beginning in 2008, Mexico was allowed unrestricted access to the US sugar market and to sugar prices that, as discussed earlier, were much higher than world prices. Since then, annual US sugar imports from Mexico have ranged from 800,000 to 1.9 million tons. This increase was largely unimportant to the US sugar industry between 2010 and 2012 because US and world sugar prices were at record-high levels, a direct result of relatively low world sugar production. However, world production has since increased and world and US sugar prices have substantially declined.
The relatively large increase in Mexico’s sugar exports to the United States, coupled with much lower world sugar prices in 2012 and 2013, prompted the American Sugar Coalition to file antidumping and countervailing duty petitions with the US International Trade Commission in March 2014. The petitions allege that the Mexican sugar industry receives substantial subsidies from Mexico’s federal and state governments. Furthermore, the petitioners argue that US sugar producers have been materially harmed by US imports of Mexican sugar. The petitions also note that 20 percent of Mexico’s sugar-processing sector is owned by the Mexican government.

Although the US sugar industry was concerned about NAFTA’s potential effects on the US market when the agreement was signed in 1994 (as evidenced by numerous side agreements), the industry was largely insulated from its effects between 1994 and 2008. In addition, Mexico’s production was relatively flat until FY 2011–12. But Mexico’s increased use of HFCS and concurrent reductions in sugar consumption have created additional sugar supplies for export. Finally, record-high sugar prices during the first part of this decade offset many of the potential impacts of NAFTA on the US sugar industry.

Déjà Vu All Over Again?

The US sugar industry’s recent trade actions are somewhat analogous to the experience of the US cattle industry following the implementation of the Canadian–United States Free Trade Agreement (CUSTA) in 1989, which reduced a variety of cattle and beef trade impediments. Furthermore, in 1995, the Canadian government repealed the Western Grain Transportation Act, which eliminated Canadian grain transportation subsidies. Consequently, the value of feed grains in Alberta and Saskatchewan declined.

The combination of lower feed grain prices and CUSTA stimulated the Canadian beef (and hog) production sectors. Although it took several years for the industry to expand, Canadian cattle and beef exports to the United States increased from 500 million pounds in 1988 to 1.7 billion pounds in 1996. Concurrently, US domestic beef production increased from 22.8 billion pounds to 24.1 billion pounds.
By 1996, US cattle prices had declined substantially from record levels that occurred in the early 1990s. Some of this decline was the result of growth in the Canadian cattle industry. But most was the result of declining consumer beef demand and increases in US beef production. A US producer group (R-CALF) filed an antidumping suit against Canada, claiming material damages from the sale of Canadian cattle to US feedlots and beef processors at prices that were below production costs.

Although it took several years, the suit was eventually dismissed. Interestingly, in 2013, total US beef and cattle imports from Canada and the rest of the world were almost identical to their levels in 1996. Yet US (and Canadian) cattle prices have been at record-high levels over the past several years because world beef production has declined while world beef demand has increased.

**Future US Sugar Industry Challenges**

NAFTA has limited the US ability to control supplies of sugar in its domestic market. Because of good weather and technological innovations, record US sugar production occurred in FY 2013–14. Although US sugar production from sugarcane may decline a little in FY 2014–15, sugar produced from sugar beets will be similar to the amount produced in FY 2013–14. Weather conditions in Mexico and Brazil may cause some declines in world sugar production. But such declines will probably not substantially reduce downward pressure on world sugar prices.

If 2014–15 world sugar prices are appreciably lower than US CCC loan rates, then it is likely that TRQ countries will come close to filling their US TRQ quotas to historical levels (approximately 90 percent). Because this year’s initial TRQ allocations are consistent with previous years (1.231 million tons), a 90 percent TRQ fill rate would increase the amount of sugar supplied to the US domestic market by at least 500,000 tons over the preceding year. Furthermore, Mexico is likely to export only a slightly smaller amount of sugar to the United States this year relative to last year.
Given that US sugar prices are currently near CCC loan rates and that some sugar nonrecourse loan forfeitures have already occurred in 2014, it is possible that low US sugar prices will cause relatively large nonrecourse loan forfeitures in the coming year. Such forfeitures represent losses to the US Department of the Treasury and, therefore, violate the “no-cost” (to the federal government) provision of the US sugar program. Consequently, domestic or import supply quantities would have to be reduced to avoid these monetary outlays.  

**Conclusion**

US sugar policies have traditionally established a minimum domestic wholesale sugar price and insulated US prices from world sugar price variations. The program has caused US sugar prices to exceed world prices. However, recent high world prices were caused by world production shortfalls. These high world prices substantially increased US domestic prices because US processors have the option to export sugar to other countries.

Over the past two years, however, world sugar production has recovered and world prices have declined. The US sugar program supports sugar prices through a combination of sugar import restrictions, domestic supply controls, and nonrecourse CCC loans. The ability to limit sugar imports has been reduced by the NAFTA agreement, which since 2008 has allowed Mexico unrestricted access to the US sugar market. Mexico has increased sugar production and reduced sugar consumption as food processors continue to substitute HFCS for granulated sugar (which happened in the United States more than 30 years ago).

The combination of increasing US sugar beet productivity and sugar imports from Mexico has expanded US sugar supplies. In addition, low world prices may cause other sugar exporting countries to fill their US TRQ import allocations over the next several years. If so, domestic prices will decline to levels near CCC loan rates, and sugar processors will likely forfeit sugar placed under marketing loans. Such forfeitures could cause substantial US treasury monetary outlays. Given that the United States produced about 9 million tons of sugar last year, it appears that domestic sugar production will have to be reduced by 5 to 10 percent in future years to
accommodate the expansion of Mexican sugar imports that has occurred since 2008 and the likely return to a 90 percent TRQ fill rate by other countries.

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Notes

1. Processors can obtain marketing loans from the US government at a value stipulated by the Commodity Credit Corporation (CCC) for refined or raw sugar. Although loan rates vary by region and state, refined beet sugar and raw cane sugar loan rates averaged 24.09 cents and 18.75 cents per pound, respectively, in recent years. If the domestic price of sugar is above the loan rate, processors sell sugar in the domestic market and the marketing loan is repaid along with accumulated interest. This type of loan is a typical recourse loan. However, the loans are considered nonrecourse if domestic wholesale prices are lower than the CCC loan rate loan. If so, processors can forfeit the loan collateral (for example, refined or raw sugar) to the CCC in lieu of repaying the loan. Essentially, nonrecourse loans create a price floor at the CCC loan rate for US wholesale sugar prices.
2. Unless otherwise noted, all quantities in this paper are in short tons, raw value (STRV). A short ton is a US measure representing 2,000 pounds. One short ton equals 0.907 metric tons or, conversely, one metric ton equals 1.102 short tons. Raw value refers to the weight of raw sugar. Sugarcane is processed into a raw component (brown crystals) before being refined into white sugar. Typically, raw-sugar weight is 107 percent of refined-sugar weight.
3. Dry basis is used in this context so that quantities of sugar can be compared to quantities of high-fructose corn syrup and other liquid sweeteners.
4. Allotments are announced for raw cane sugar, but an additional 25,954 tons of refined sugar is also part of the US commitment.
5. The final allocation for FY 2013–14 has not yet been determined. The initial allocation was 1.231 million tons of raw sugar.
6. FY 2103–14 is not included in this average because the marketing year has not ended.
10. The decision as to whether loans would be recourse or nonrecourse was actually fait accompli. US trade agreements stipulate that TRQ imports could be no less than 1.491 million tons (in other words, the sum of 1.231 million tons of cane sugar and 25,954 tons of refined sugar). This value was almost identical to the FAIR Act’s 1.5 million tons needed to trigger nonrecourse loans.
11. The Feedstock Flexibility Program for Bioenergy Producers is used to sell CCC loan–forfeited sugar to non–food users (primarily ethanol plants).
12. “Nonprogram” sugar imports are those that are sourced from non–TRQ countries. “Other program” sugar imports are those sourced under various smaller programs that do not fall under the general TRQ, such as the re–export program and the Dominican Republic–Central American Free Trade Agreement.
13. The introduction of glyphosate-resistant sugar beet seed varieties in 2008 increased per–acre tonnage and extractable sugar contents. The new technology has eliminated the use of nonselective herbicides. Although nonselective herbicides reduced (but did not eliminate) weed infestations, they also tended to stunt sugar beet plant growth. Reduced weed pressure has also boosted yields because competition for sunlight and soil nutrients has been greatly reduced. And glyphosate-resistant technologies have reduced mechanical cultivation and soil compaction. Mechanical cultivation often harmed sugar beet plants, and reductions in soil compaction encourage plant growth,
especially for root crops. Furthermore, weed reductions have reduced sugar beet pile losses because residual foliage generates heat that increases sugar beet spoilage during storage.