

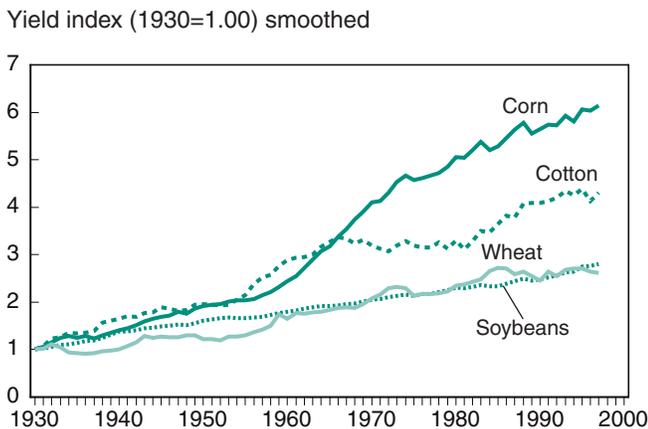
Improved Seed Is a Major Contributor to Crop Yield Gains and Agricultural Productivity

Over the past 70 years, there has been a remarkable increase in the yields of all major field crops in the United States, and more than half of the yield gains are attributed to genetic improvements achieved by plant breeders.

Among the four major field crops examined in this report, yield increases have been most significant for corn; the next highest increases were for cotton, soybeans, and wheat (fig. 4). Average per acre yields for corn in the United States rose from 20 bushels in 1930 to about 70 bushels in 1970 and reached 140 bushels by the mid-1990s (fig. 5). Soybean yields have also increased substantially since the 1930s (fig. 6). Overall per acre yields for soybeans increased from about 13 bushels in 1930 to nearly 40 bushels in the mid-1990s.

Cotton yields stagnated from 1866 to 1935. Yields grew rapidly from 1935 to 1960 as higher yielding cultivars were introduced together with synthetic fertilizers and pesticides (fig. 7) (Meredith and Bridge, 1984). After reaching a plateau during the 1960s and early 1970s, cotton yields resumed their rapid growth. Overall, cotton yields rose nearly fourfold during 1930-98 (figs. 4, 7). Wheat breeding has relied heavily on genetic improvement of self-pollinating varieties. Though wheat yields have grown steadily since 1950, the rate of growth has not been as high as that of corn and cotton (fig. 8). Still, overall wheat yields increased 2.5-fold during the period.

Figure 4
Yields for major crops



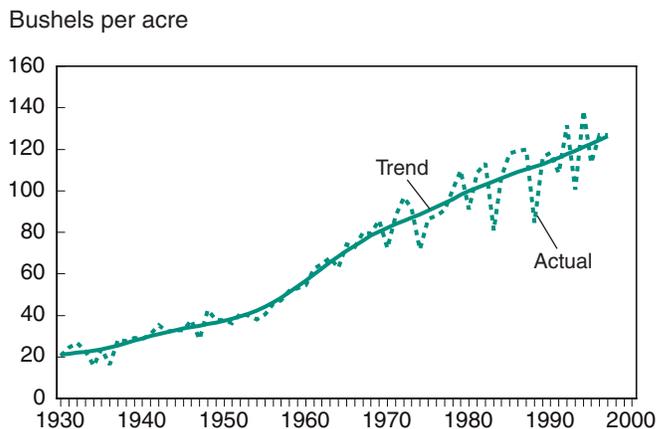
Source: *Agricultural Statistics*, NASS, USDA, various years.

Contribution of Plant Breeding

Crop yields have benefited from genetic improvements through plant breeding as well as from improved pest management, mechanization, and fertilizer use. Still, extensive evidence suggests that crop yields have benefited the most from plant breeding, which includes the use of improved hybrids and varieties. Studies of the determinants of increased crop yields for corn, soybeans, and wheat conclude that 50 percent or more of the overall yield gain for each crop can be attributed to genetic improvements of plant varieties. For the same crops, the annual rate of yield gain due to plant breeding improvements is 1-3 percent per year (Duvick, 1992, p. 291).

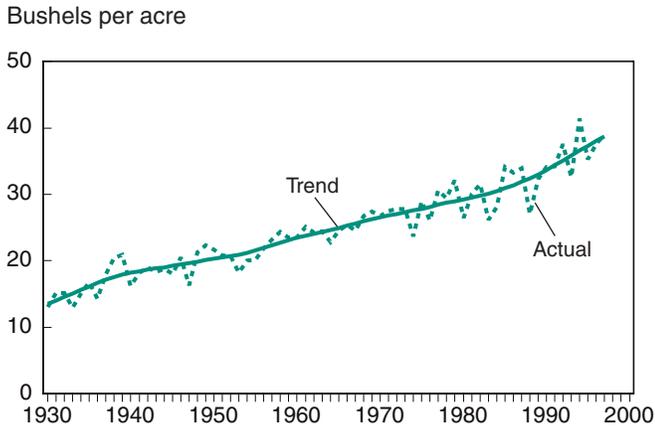
Different estimates of plant breeding's contribution to crop yield gains reflect differences in the period covered and the complex nature of the research. Thirtle (1985, in Fuglie et al., 1996, p. 44) concludes that between 1939 and 1978, biological inputs (improved seed varieties and changes in agronomic practices) increased average annual yields by 1.7 percent for corn, 1.1 percent for soybeans, 0.5 percent for cotton, and 1.5 percent for wheat. Over the entire period, biological inputs contributed to 50 percent of the yield growth in corn, 85 percent for soybeans, 24 percent for cotton, and 75 percent for wheat. Fehr (1984, in Fuglie et al., 1996, p. 44) estimates that genetic improvements accounted for 89 percent of the

Figure 5
Corn yields



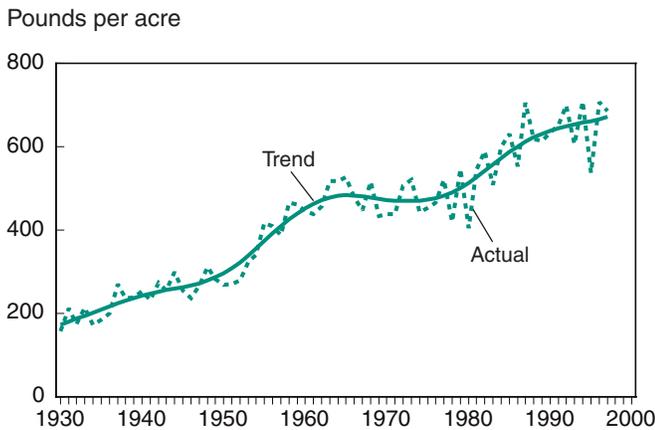
Source: *Agricultural Statistics*, NASS, USDA, various years.

Figure 6
Soybean yields



Source: *Agricultural Statistics*, NASS, USDA, various years.

Figure 7
Cotton yields

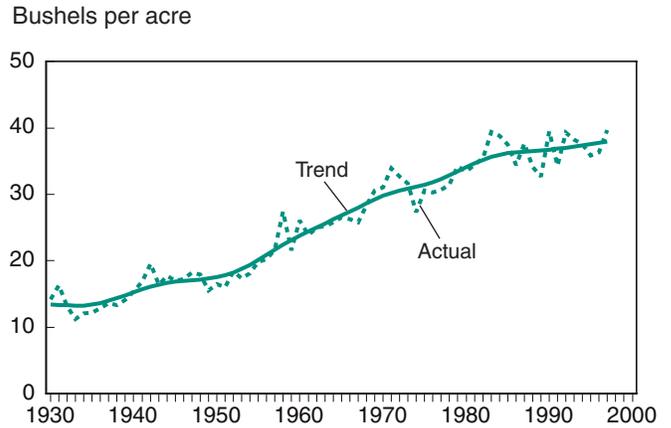


Source: *Agricultural Statistics*, NASS, USDA, various years.

gain in corn yields between 1930 and 1980, a 90-percent gain in soybean yields between 1902 and 1997, 67 percent of the gain for cotton yields between 1936 and 1960, and a 50-percent gain for wheat yields between 1958 and 1980.

The effects of other contributing factors to crop yield gains—fertilizers, pesticides, machinery, and labor—vary widely. For example, Cardwell (1982, reported in

Figure 8
Wheat yields



Source: *Agricultural Statistics*, NASS, USDA, various years.

Duvick, 1992, p. 29) concludes that, since 1930, better weed control has accounted for 23 percent of corn yield gains in Minnesota, synthetic nitrogen fertilizer has accounted for 19 percent, and plant breeding has accounted for 59 percent (16 percent for the shift from open-pollinated to hybrid seeds, and 43 percent for other breeding improvements).

The remarkable yield gains over the past 50 years are observed not only in crops cultivated under ideal conditions, where complementary inputs, such as soil fertility and water supply, are optimal, but also in crops cultivated under less ideal conditions, where yield-improving inputs are not optimized due to such conditions as drought or pests. Many new varieties possess genetic qualities that improve seed productivity in both favorable and unfavorable environments. For example, the improved root strength in newer hybrid corn varieties increased the plant's ability to resist stalk-rot fungi, heat, drought, limited nitrogen nutrition, and pests, such as the European corn borer (Duvick, 1992, pp. 292-293). Still, despite the improved plant varieties, crop yields have been subject to periods of stagnation or slow growth. Cotton yields, for example, stagnated between 1960 and 1980 before increasing again in the 1980s (Fuglie et al., 1996, p. 44).