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Biotechnology and U.S. Crop Yield Trends

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Introduction

Biotechnology varieties first became available for commercial use in the U.S. in 1996. By 2011, they accounted for 88%, 90%, and 94% of the acres planted to corn, upland cotton, and soybeans, respectively (U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS), *Acreage*, http://www.nass.usda.gov/Publications/index.asp, 6/30/11). For other crops, adoption of biotech varieties has been limited or nonexistent. Given that 15 years have passed, this article compares the trend in U.S. average yield since 1995 with the trend that existed from 1940 through 1995, a period that predates commercial biotech varieties. The year 1940 approximates when the average yield of most U.S. crops began increasing, due in part to traditional breeding methods.

Analytical Methods

Yields per harvested acre were obtained for corn, all cotton, soybeans, and 11 crops for which adoption of biotechnology varieties is limited or non-existent. Source of the data is USDA, NASS, http://www.nass.usda.gov/Data_and_Statistics/, 11/2011. Linear yield trends were estimated for 1940-1995 and 1996-2011 using regression analysis. The estimated yield trends are tested statistically to determine if they exceed zero at the 95% confidence level. Also, the 1996-2011 yield trend is compared against the upper value of the 95% confidence range around the pre-1996 trend. This test provides an indication of whether the trend is statistically higher since 1995.

Findings

The yield trend is estimated in the crop's quantity unit per harvested acre. For example, the estimated yield trends for corn are 1.86 bushels per harvested acre for the earlier 1940-1995 period and 2.02 bushels per harvested acre for the later 1996-2011 period (see Table 1 below).

For 13 of the 14 crops, the yield trend estimated for 1940-1995 exceeds zero with 95% statistical confidence. The exception is sugar cane. The time-trend R^2 exceeds 0.78 for each of the 13 crops, implying that the time trend explains at least 78% of the variation in yield over time. This is a high degree of explanation for a single variable. For 1996-2011, 9 of the 14 yield trends exceed zero with 95% statistical confidence. A lower number is expected because the number of observation years is smaller.

For the same reason, it is not surprising that R^2 also is lower.

For only 7 of the crops analyzed in this study is the estimated yield trend higher during 1996-2011 than 1940-1995. The 7 crops are barley, corn, cotton, peanuts, rice, soybeans and sugar beets. For each of these 7 crops, the 1996-2011 yield trend exceeds the high end of the 95% confidence range for the 1940-1995 yield trend (see Table 2 below). This finding suggests that, for these 7 crops, the 1996-2011 yield trend exceeds the 1940-1995 yield trend with 95% statistical confidence.

Table 1. Yield Trends for Selected Crops, 1940-1995 and 1996-2011 Periods, U.S.

	1940-1995			1996-2011		
Crop (unit/harvested acre)	Yield Trend	R^2	95% Confident Yield Trend > 0	Yield Trend	R^2	95% Confident Yield Trend > 0
Corn (bushels/acre)	1.86	0.92	Yes	2.02	0.68	Yes
Cotton (bales/acre)	7.44	0.83	Yes	14.35	0.60	Yes
Soybeans (bushels/acre)	0.33	0.87	Yes	0.39	0.43	Yes
Alfalfa (tons/acre)	0.03	0.86	Yes	0.00	0.01	No
Barley (bushels/acre)	0.68	0.91	Yes	0.86	0.53	Yes
Oats (bushels/acre)	0.53	0.78	Yes	0.23	0.12	No
Peanuts (pounds/acre)	42.13	0.84	Yes	57.84	0.71	Yes
Potatoes (cwt[A]/acre)	4.42	0.98	Yes	4.27	0.82	Yes
Rice (pounds/acre)	76.18	0.95	Yes	88.18	0.76	Yes
Rye (bushels/acre)	0.37	0.85	Yes	0.01	0.00	No
Sorghum (bushels/acre)	1.05	0.86	Yes	-0.03	0.00	No
Sugar Beets (tons/acre)	0.16	0.81	Yes	0.40	0.63	Yes
Sugar Cane(tons/acre)[B]	-0.01	0.00	No	-0.24	0.26	No
Wheat (bushels/acre)	0.46	0.91	Yes	0.34	0.27	Yes

Table 2. Comparison of Yield Trends before and after 1995, Selected Crops, U.S.

Crop (unit / harvested acre)	95% Confidence Range on 1940-1995 Yield Trend	1996-2011 Yield Trend > 1940–1995 Upper Confidence Value
Corn (bushels/acre)	1.70 – 2.01	Yes
Cotton (bales/acre)	6.52 – 8.35	Yes
Soybeans (bushels/acre)	0.29 – 0.36	Yes
Alfalfa (tons/acre)	0.02 – 0.03	No
Barley (bushels/acre)	0.63 – 0.74	Yes
Oats (bushels/acre)	0.45 – 0.61	No
Peanuts (pounds/acre)	37.05 – 47.21	Yes
Potatoes (cwt[A]/acre)	4.24 – 4.60	No
Rice (pounds/acre)	71.21 – 81.15	Yes
Rye (bushels/acre)	0.33 – 0.41	No
Sorghum (bushels/acre)	0.94 – 1.17	No
Sugar Beets (tons/acre)	0.14 – 0.18	Yes
Sugar Cane (tons/acre)[B]	-0.07 – 0.05	No
Wheat (bushels/acre)	0.42 – 0.50	No

NOTES for tables: A. cwt. = hundredweight (100 pounds). B. Sugar cane yield is not available for 2011.

SOURCE for tables: original calculations using data from U.S. Department of Agriculture referenced in article

Implications

This analysis finds that, while the yield trend increased for all 3 biotech crops after 1996, the yield trend increased for less than half of the crops (4 of 11) for which biotech varieties are of limited importance. *This finding does not prove that biotechnology is the reason for the higher yield trend for corn, cotton, and soybeans. It only reveals that the evidence on linear yield trends is not inconsistent with such a*

conclusion.

Over 10 years, the higher yield trend translates into a harvest yield that is 1.6 bushels, 0.6 bushels, and 69.1 pounds higher for corn, soybeans, and cotton, respectively. This addition to yield is 1.0%, 1.4%, and 7.9% of the highest harvest yield observed for corn, soybeans, and cotton, respectively. *Thus, for corn and soybeans, the increase in yield trend since 1995 is not large.*

These implications are subject to change with more years of data. Also, the analysis does not address what the yield trend would have been for corn, cotton, and soybeans if biotech varieties had not been introduced.?

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