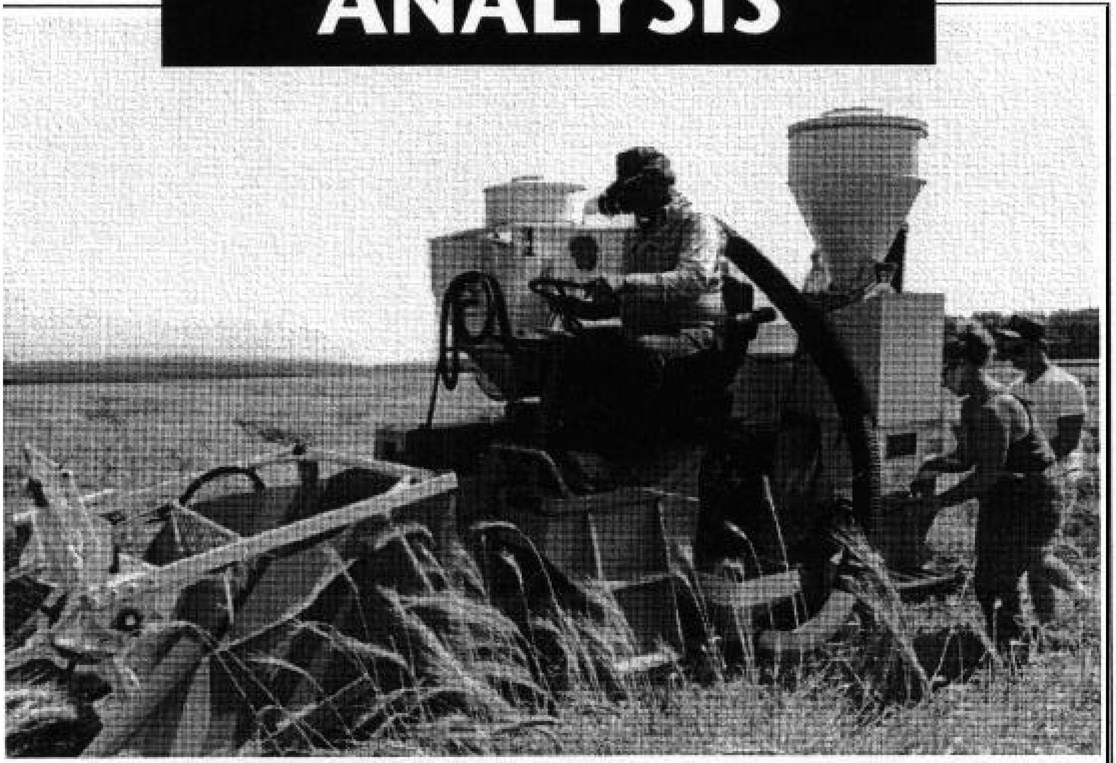
KANSAS WHEAT BREEDING

AN ECONOMIC ANALYSIS



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KANSAS WHEAT BREEDING: AN ECONOMIC ANALYSIS[1]

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ABSTRACT

This study measured the economic impact of the adoption of semidwarf varieties, the first of which for Kansas producers was Newton, released by K-State in 1977. Since then, K-State has released Cheney (1978), Arkan (1982), Norkan (1986), Karl (1988), Karl 92 (1992), Ike (1993), and Jagger (1994). Special consideration was given to the timing of genetic improvement: development of a new variety can require as long as 17 years between the initial cross and release. Additionally, several years are needed for growers to adopt and plant new varieties. The economic analysis accounted for these long development and adoption periods, because the costs of breeding a new variety are incurred many years before the benefits of enhanced wheat yields are realized. The comprehensive costs of the K-State wheat-breeding program for the period 1979 to 1994 averaged $3.8 million per year, including all research costs and overhead. During the same period, the new semidwarf varieties resulted in increased wheat production of more than 1% per year. As a result, the economic benefits to wheat producers averaged $52.7 million per year. The benefit-to-cost ratio was 11.95 for the KAES wheat breeding program over the period 1979 to 1994. In other words, for each $1 invested in varietal improvement, nearly $12 was earned by Kansas wheat producers. The internal rate of return (the most comprehensive measure of returns) was over 39% for the same period. Although not included in this analysis, enhancement of Kansas wheat varieties and the spillover of Kansas varieties into neighboring states provided further benefits.

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Introduction

Public research in wheat breeding has resulted in higher yields for Kansas wheat producers over the past several decades. Wheat breeding research at the Kansas Agricultural Experiment Station (KAES) currently is funded at approximately $4 million per year. This study addressed the question, "What are the economic impacts of this research effort?" More specifically, empirical evidence was gathered to determine whether the public investment in Kansas wheat breeding has resulted in a socially worthwhile use of public funds, and how the economic benefits of the research program are distributed across consumers and producers in Kansas and other regions. The results of this study are particularly important in an era of declining taxpayer support for public agricultural research (Fuglie et al., 1996; USDA Cooperative State Research Service, 1993). Careful measurement of the economic rate of return of the investment in wheat-breeding research provides crucial information to administrators and policy makers, whose decisions on the allocation of research funding will determine the future size and scope of publicly funded agricultural research.

The agronomic contribution of the Kansas wheat-breeding research program was measured by quantifying the increase in yields attributable to genetic enhancements in wheat for the period 1979 to 1994. Yield gains were measured for all semidwarf varieties released by KAES, beginning with Newton in 1977. This increase in wheat yields represents an increase in the supply of wheat produced in Kansas and is the foundation of the economic impacts of the wheat-breeding program.

An economic model of the world wheat market was developed and used to measure the impact of the KAES wheat-breeding program on: (1) Kansas wheat producers; (2) Kansas consumers of wheat (flour millers); (3) wheat producers outside of Kansas, including foreign producers such as Argentina and Australia; (4) all wheat consumers outside of Kansas, including importers such as China and Japan. Annual benefits to each group resulting from the increased wheat yields were measured and analyzed. Several measures of the outcome of the investment in wheat breeding were calculated and assessed, and policy implications for the future of Kansas wheat breeding are presented.

Funding of Kansas Wheat-Breeding Research

Research in wheat genetics is funded by a variety of sources, as can be seen in Figure 1. All nominal dollar values were deflated by the personal consumption expenditure (PCE) index (US Department of Commerce); therefore, all values reported are in constant 1995 dollars. The major sources of funds for public wheat breeding in Kansas are the State of Kansas and other nonfederal sources, such as grants from the Kansas Wheat Commission. The federal component of funding is relatively small, averaging approximately $250,000 per year from 1970 to 1995. Public wheat breeding in Kansas is a cooperative effort between the KAES and the USDA Agricultural Research Service (USDA/ARS), as can be seen by the ARS funds (which include overhead) in Figure 1. Funds from ARS averaged $740,000 per year.

Annual state-level appropriations and other nonfederal sources resulted in an increase in total research funding from $1.8 million in 1970 to over $6 million in 1988. Since 1988, however, state and other nonfederal funds have declined, causing total funding to decline to approximately $3.2 million in 1995. The importance of state-level funding, coupled with the current political climate of decreasing public sector support (Acker, 1993), result in a situation where continuation of public funding of the wheat-breeding research program is dependent on how well the program is serving the public. Empirical evidence on the economic consequences of the breeding program provides evaluation of the program, together with assessment of the likely consequences of changes in the level of funding for public wheat breeding in Kansas.

Measurement of the Social Benefits of Kansas Wheat Breeding

The methodology used to calculate the economic consequences of the Kansas wheat-breeding program followed a rich literature on the welfare economics of agricultural research, initiated by Schultz (1953) and further developed by Ayer and Schuh (1972) and Akino and Hayami (1975). More recently, the economic evaluation of agricultural research has been summarized by Huffman and Evenson (1993) and Alston et al. (1995). Previous evaluations of wheat breeding programs were conducted by Blakeslee and Sargent (1982); Zentner and Peterson (1984); Brennan (1984, 1989a, and 1989b); and Byerlee and Traxler (1995).

The first step in evaluating the economic impact of the Kansas wheat-breeding program was to measure the increase in yields from the genetic improvement of wheat, holding all other production parameters constant. This was accomplished by applying the methodology of Feyerherm et al. (1984) to calculate the relative yields for each variety with data from KAES performance tests with wheat varieties (KAES). Use of relative yield performance data from nurseries implicitly assumes that actual producer yields are equivalent to test plot yields in KAES experiments. Although a gap between experimental and actual yields may exist, Brennan (1984) wrote, “The only reliable sources of relative yields are variety trials” (p. 182).

Salmon (1951) reported that tests over many location-years are necessary to detect differences in cultivar yields. Yield data were aggregated over all locations and years to develop a yield ratio for each variety. Following Feyerherm et al. (1984), relative yield ratios were derived by calculating the mean yield ratio over all location-years where each wheat variety was grown together with the control (Turkey). Yield ratios for all varieties grown in Kansas performance tests (191l-1995) were calculated (see Appendix); the yield ratios for the eight semidwarf varieties released by KAES are shown in Table 1. Following the recommended methods of Brennan (1984) and Zentner and Peterson (1984), an index of varietal improvement was used to calculate annual shifts in the aggregate wheat production function attributable to Kansas wheat-breeding research. The index was constructed by calculating the average yield increases of the eight KAES semidwarf varieties relative to Turkey’s yield, weighted by the percentage of Kansas acres planted to each variety. The index of varietal improvement included two sources of change: higher yields and different percentages of acres planted to a variety. The annual shift in Kansas wheat production is the annual change in the index of varietal improvement. Both of these factors are reported in Table 2, together with the percentage of acres planted to each of the KAES semidwarf varieties.

The annual shift in wheat production is the foundation for analysis of the economic impacts of wheat-breeding research. Previous work by Echeverria et al. (1989) also used experimental yields to measure research-induced shifts in the industry supply curve for rice in Uruguay. Alston et al. (1995) demonstrated how to convert an annual shift in the quantity of wheat produced into a percentage shift in cost savings.

An Economic Model of the Impacts of Kansas Wheat-Breeding Research

Edwards and Freebairn (1984) pioneered an economic model to measure the impact of productivity gains from research on a tradable commodity such as wheat. Alston et al. (1995) reported explicit formulas for the calculation of changes in economic surpluses to producers and consumers in two countries. This simple two-country model of supply and demand was adopted in this study to estimate the impact of the research-induced supply shift on producer and consumer surpluses in (1) Kansas and (2) the rest of the world (ROW, defined as all areas outside of Kansas). The supply and demand of wheat in Kansas and the ROW were assumed to be linear functions of the world price of wheat. To simplify the model, no transportation costs were assumed, resulting in a constant price in both regions, and a system of five equations was used to solve for world price of wheat, supply and demand in Kansas, and supply and demand in ROW. The solution to this system of equations gave the welfare changes for producers and consumers in Kansas and ROW.

To solve this simple model, price and quantity data, elasticity estimates of supply and demand, and a measure of research-induced productivity change were necessary. A recent study of changes in Kansas crop acreage provided an estimate of 0.4 for the supply elasticity of wheat in Kansas (Lin and Barkley, 1997). For simplicity, I assumed that this elasticity also applies to ROW. The demand elasticity of -0.1 was taken from Huang (1985). The price of wheat was the season average price received by farmers (USDA *Agricultural Outlook)* deflated by the PCE (US Department of Commerce). The quantity of wheat supplied in Kansas was taken from *Kansas Farm Facts* (Kansas Department of Agriculture), and the Kansas quantity demanded was the number of bushels of wheat ground into flour and feed (Kansas Department of Agriculture). Wheat production in ROW was found by subtracting Kansas production from the world wheat production reported in USDA *Agricultural Outlook.* A market-clearing equation was used to calculate ROW demand.

Model Results: Research-Induced Changes in Economic Surpluses of Wheat

The results of the model appear in Table 3. Kansas wheat producers gained an average of $52.7 million dollars per year from 1979 to 1994 from growing semidwarf wheat varieties developed and released by KAES. Not all producers benefited; only those who adopted the high-yielding varieties earned higher levels of economic surplus. Although the average change in economic surplus to Kansas producers was positive and large, the changes in producer surplus were volatile, fluctuating from a low of $900,000 in 1986 to a high of $280.7 million in 1993. Losses ranging from $2.9 to $84.9 million occurred in several years, when wheat varieties other than KAES varieties were grown. Consumers of wheat in Kansas benefited by an average of $190,000 per year. This relatively small benefit resulted from the research-induced shift in the world supply of wheat being quite small, because Kansas produced only about 2% of the world's wheat. This fact allowed for large producer gains with only a limited drop in the world price of wheat.

Wheat producers outside of Kansas were worse off because of the decrease in the price of wheat, having average annual losses of $40.7 million. Some benefit of research on KAES varieties spills over into neighboring states, particularly Oklahoma, but these spillovers were not accounted for in this analysis. Non-Kansas consumers benefited from the research-induced shift in the supply of wheat by an annual average of $41.4 million. The ROW producer losses were approximately equal to the ROW consumer gains. This result, together with large gains to Kansas wheat producers and small losses to Kansas consumers, yielded an annual average change in total economic surplus of $53.6 million. This annual benefit is large relative to the annual average costs of roughly $4 million for the research program.

Economic Rate of Return to Kansas Wheat Breeding

The final step in the evaluation of the impacts of the Kansas wheat-breeding program was to calculate the rate of return to the public investment in the genetic improvement of what varieties. Proper measurement of the rate of returns required careful consideration of the timing of varietal development and the discounting procedure. Input from KAES agronomists led to the assumption of 17 years as the time required to develop a new variety from the initial cross to the release date. Because the economic benefits of KAES semidwarf varieties began in 1979, all research costs from the period of 1962 to 1994 were included in the analysis (1962 is 17 years prior to 1979). Cost data were not available from KAES records prior to 1970, so annual costs of $2 million were assumed for the period 1962 to 1969. The total economic surpluses reported in Table 3 were used for the period 1979 to 1994. After 1994, the 5-year average benefit level from 1990 to 1994 ($69.0 million) was assumed to decrease at 10%, until all research-program benefits were depleted in 2005. These values were used to calculate the benefit-cost ratio as a measure of gross research benefits. The net present value of the program also was calculated, taking into account the discount rate. A third measure of economic performance, the internal rate of return, was computed as the discount rate that results in a value of zero for the net present value.

The benefit-cost ratio for KAES semidwarf wheat varieties was 11.96; that is, for each dollar of public funds invested in wheat breeding research, almost $12 of benefits resulted, most of which accrued to Kansas wheat producers. The net present value of the program for the period 1962 to 2004, with an assumed discount rate of 5%, was $446.3 million (1995 dollars). The internal rate of return for the wheat-breeding program was 39%. These three measures provided evidence that the economic rate of return to Kansas wheat breeding is high, although assessing them further is difficult without comparable values for other public investments.

Conclusions and Policy Implications

Results of the two-region economic model of research-induced increases in the supply of wheat in Kansas provide empirical evidence that wheat producers who adopt the new varieties are the major beneficiaries of the technological advance. Kansas consumers (wheat millers) also are made better off, but by only a small percentage (0.04%) of the value of wheat purchased. A transfer of economic surplus from non-Kansas producers to ROW consumers of approximately $41 million occurs annually, because of the decrease in the world price of wheat induced by the enhanced yields of KAES wheat varieties.

The traditional sources of research funding for the wheat program are the State of Kansas and the federal government. If political realities cause these sources to reduce their support of the program, society would lose the economic benefits of the research. Two alternative funding procedures are possible. First, a 14 per bushel "tax" or "checkoff program" would raise roughly $3.8 million each year (on average, 380 million bushels of wheat are produced in Kansas), which would allow continuation of the research at approximately the current size and scope. One attribute of this method is that the major beneficiaries of the program, the Kansas wheat producers, also would be the funding sources of the program. One difficulty with this approach is that the economic benefits might not be obvious to all wheat producers, causing problems in raising the funds. A second possibility is to raise the price of the released foundation wheat seed to a level high enough to cover the costs of research and development. This strategy would "internalize" the large, positive externality associated with public wheat breeding. The higher price also could lead to increased competition from private breeders, who have difficulty competing with the currently subsidized KAES varieties.

One implication for wheat breeders can be derived from this research; any decrease in the long development time (17 years) of a variety would result in large economic benefits to society. An example of this is greenhouse breeding, which allows for two generations of winter wheat to be grown in 1 year. The major implication of this research is that more resources could be allocated advantageously to the wheat-breeding program. The major tent of economics is to "allocate resources to the highest return." Although the Kansas wheat-breeding program has distributional consequences, the economic rate of return to the investment is high. Given this large economic benefit, an increase in funding is an appropriate use of scarce resources.

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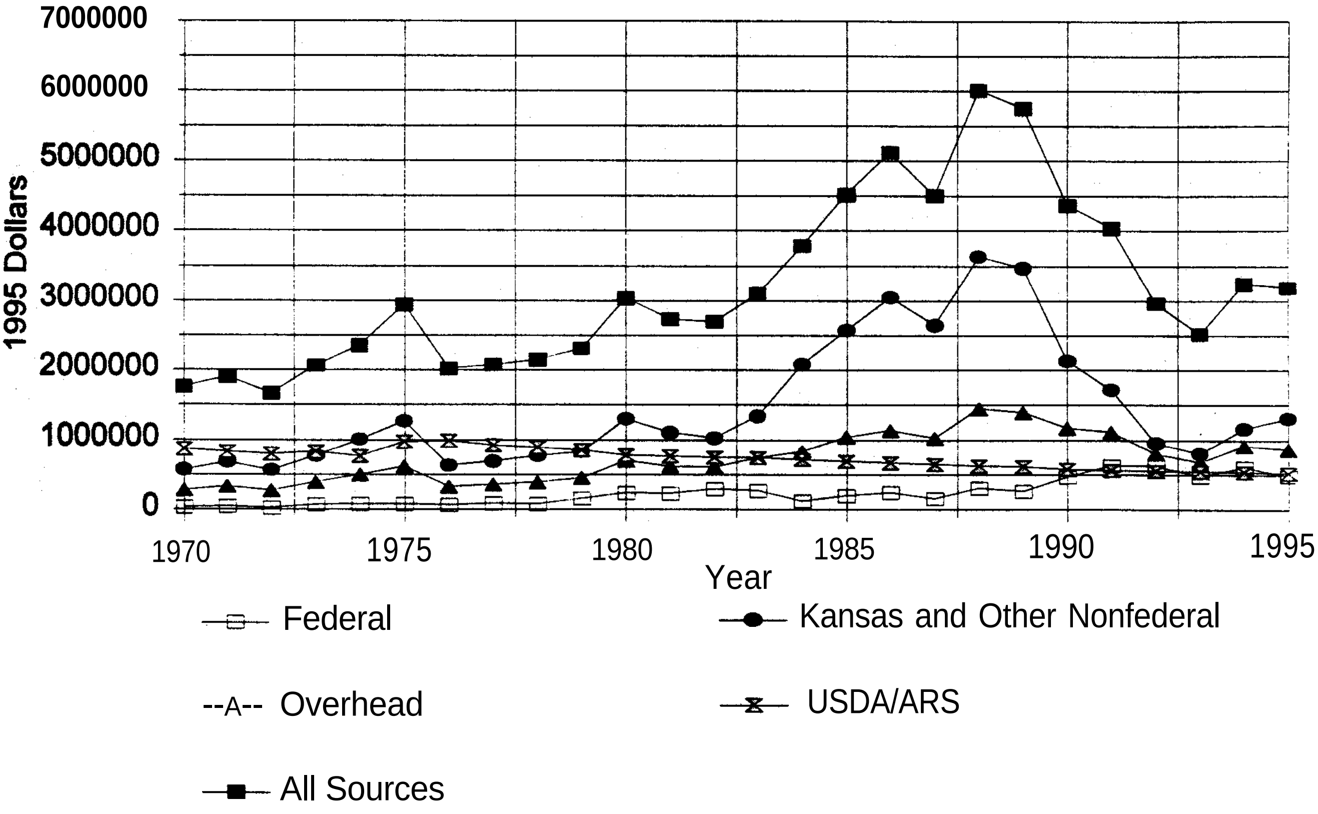

Figure 1. Funding Sources for Kansas Wheat Breeding, 1970-1995.

Table 1. Yield Advantages of KAES Semidwarf Wheat Varieties.

KAES Variety	Year Released	Yield Ratio[a]
Newton	1977	1.253
Cheney	1978	1.251
Arkan	1982	1.315
Norkan	1986	1.297
Karl	1988	1.609
Karl92	1992	1.712
Ike	1993	1.646
Jagger	1994	2.345

[a]Mean values of the ratio of the yield of each variety to the yield of the control variety (Turkey) for all location-years. A higher value indicates higher yields of the variety relative to the control variety.

Table 2. Percent Acres Planted and Production Increase of KAES Semidwarf Varieties.

	Variety									
Year	Newton	Cheney	Arkan	Norkan	Karl	Karl 92	Ike	Jagger	VI[b]	WP[c]
	(% of acres)									
1978	0.1	0	0	0	0	0	0	0	0.0003	0
1979	2.8	0	0	0	0	0	0	0	0.007	0.007
1980	17.5	0	0	0	0	0	0	0	0.044	0.037
1981	34.2	0	0	0	0	0	0	0	0.087	0.042
1982	41.1	0.1	0	0	0	0	0	0	0.104	0.018
1983	38.5	0	0	0	0	0	0	0	0.097	-0.007
1984	30.9	0	0.9	0	0	0	0	0	0.081	-0.016
1985	25.7	0	6.3	0	0	0	0	0	0.085	0.004
1986	21.1	0	10.1	0	0	0	0	0	0.085	0.0003
1987[a]	17.3	0	12.5	0.4	0	0	0	0	0.084	-0.001
1988	13.4	0	14.9	0.8	0	0	0	0	0.083	-0.001
1989	11.6	0	11.9	1.3	0	0	0	0	0.071	-0.013
1990	8.3	0	6.8	0.8	0.7	0	0	0	0.049	-0.022
1991	7.6	0	3.2	0.2	5.9	0	0	0	0.066	0.017
1992	5.8	0	2.2	0	11.5	0	0	0	0.092	0.026
1993	3.1	0	0.8	0	0	23.0	0	0	0.174	0.083
1994	2.5	0	0.4	0	0	23.6	0	0	0.176	0.002
1995	1.6	0	0.1	0	0	22.4	0.9	0	0.170	-0.006
1996	1.3	0	0	0	0	20.9	7.2	0.1	0.212	0.042

[a]Data on acres planted to each variety were not collected in 1987 (KAES); therefore, values for 1987 are the means of values for 1986 and 1988.
[b]Index of varietal improvement (a higher value indicates higher use and/or higher yields of KAES varieties).
[c]Annual shift in the index of varietal improvement (a higher value indicates a larger annual increase in the index of varietal improvement, and a negative value indicates a decrease in the use and/or yields of KAES varieties).

Table 3. Research-Induced Changes in Economic Surpluses, 1979 to 1994.

Year	Wheat Produced Kansas	Wheat Produced ROW	Wheat Price[a]	Kansas Producer Surplus	Kansas Consumer Surplus	ROW Producer Surplus	ROW Consumer Surplus	Total Surplus
	----(mil.	bu.)----	($/bu)	----------------(million	1995 dollars)------------------			
1979	410.4	15,535	7.66	52.8	0.22	-41.8	42.8	53.9
1980	420.0	16,266	7.06	274.8	0.98	-214.7	219.5	280.6
1981	302.5	16,483	6.44	207.0	0.74	-161.6	163.9	210.1
1982	458.5	17,586	5.53	110.1	0.38	-86.9	88.8	112.5
1983	448.2	17,986	5.26	-38.6	-0.14	30.9	-31.5	-39.4
1984	431.2	17,979	4.94	-84.9	-0.27	68.2	-69.6	-86.6
1985	433.2	18,809	4.09	16.8	0.06	-13.4	13.6	17.1
1986	336.6	18,376	3.12	0.9	0.003	-0.7	0.7	0.9
1987	366.3	19,257	3.24	-2.9	-0.01	2.3	-2.3	-2.9
1988	323.0	18,225	4.58	-3.6	-0.02	2.9	-2.9	-3.7
1989	213.6	18,188	4.56	-30.0	-0.12	24.1	-24.3	-30.3
1990	472.0	19,584	2.91	-72.1	-0.28	58.1	-59.2	-73.6
1991	363.0	21,605	3.12	47.3	0.15	-37.4	37.9	48.0
1992	363.8	19,919	3.37	78.9	0.28	-62.1	62.9	80.0
1993	388.5	20,643	3.42	280.7	0.97	-214.9	218.2	285.0
1994	433.2	20,551	3.48	5.5	0.02	-4.4	4.5	5.6
Mean(1979-94)	376.9	18,562	4.55	52.7	0.19	-40.7	41.4	53.6

[a]Price is in constant 1995 dollars.

APPENDIX
Yield Ratios of Wheat Varieties Grown in Kansas Performance Tests, 1911-1995

	Variety Name	Ratio[a]	Release	Source[b]	Company Name
1.	Abilene	1.451	1986	PC	Agripro
2.	AGSECO 7805	1.369	1988	PC	AGSECO
3.	AGSECO 7837	1.344	1985	PC	AGSECO
4.	AGSECO 7846	1.434	1986	PC	AGSECO
5.	AGSECO 7853	1.687	1988	PC	AGSECO
6.	Apache	1.206	1949	NM	
7.	Arapahoe	1.543	1988	NE	
8.	Archer	1.266	1980	PC	Agripro
9.	Arkan	1.315	1982	KS***	
10.	Baca	1.315	1973	CO	
11.	Bennett	1.190	1978	NE	
12.	Bison	1.200	1956	KS***	
13.	Blackhull	1.111	1917	PC	Clark
14.	Blue Jacket	1.150	1946	PC	Clark
15.	Bounty 100	1.410	1981	PC	Bounty
16.	Bounty 122	1.477	1985	PC	Bounty
17.	Bounty 200	1.285	1981	PC	Bounty
18.	Bounty 201	1.496	1982	PC	Bounty
19.	Bounty 202	1.438	1982	PC	Bounty
20.	Bounty 203	1.559	1983	PC	Bounty
21.	Bounty 205	1.550	1984	PC	Bounty
22.	Bounty 301	1.527	1984	PC	Bounty
23.	Bounty 310	1.480	1982	PC	Bounty
24.	Brule	1.333	1981	NE	
25.	Buckskin	1.263	1973	NE	
26.	Caldwell	1.628	1981	IN	(Soft)
27.	Centurk	1.361	1971	NE	
28.	Century II/2148	1.018	1986	PC	Greenbush Seed
29.	Chanute	1.241	1969	PC	DeKalb
30.	Cheney	1.251	1978	KS***	
31.	Cheyenne	1.103	1933	NE	
32.	Chief Kan	1.274	1935	PC	Clark
33.	Chisholm	1.357	1983	OK	
34.	Clarkan	1.154	1934	PC	Clark
35.	Cloud	1.296	1973	KS***	
36.	Colt	1.327	1983	NE	
37.	Comanche	1.206	1943	KS***	
38.	Concho	1.216	1953	OK	
39.	Danne	1.298	1970	OK	
40.	E. Blackhull	1.175	1928	PC	Haeberle

(continued)

Yield Ratios of Wheat Varieties Grown in Kansas Performance Tests. 1911-1995 (Cont'd)

	Variety Name	Ratio[a]	Release	Source[b]	Company Name
41.	Eagle	1.268	1970	KS***	
42.	Gage	1.302	1963	NE	
43.	Golden 50	1.200	1963	PC	Clark
44.	Golden Acres 522	1.128	1984	PC	Golden Acres
45.	Hart	1.405	1976	MO	(Soft)
46.	Hawk	1.328	1982	PC	Agripro
47.	Homestead	1.243	1973	NE	
48.	HR48	1.425	1984	PC	Garst
49.	HR53	1.266	1984	PC	Garst
50.	HR64	1.323	1984	PC	Garst
51.	HW 1010	1.371	1981	PC	Hybrex
52.	HW 1018	1.270	1982	PC	Hybrex
53.	HW 1019	1.294	1983	PC	Hybrex
54.	HW 1020	1.173	1982	PC	Hybrex
55.	HW 1030	1.311	1983	PC	Hybrex
56.	Ike	1.646	1993	KS***	
57.	Kanred	1.133	1917	KS***	
58.	Karl	1.609	1988	KS***	
59.	Karl 92	1.712	1992	KS***	
60.	Kaw	1.179	1960	KS***	
61.	Kawvale	1.266	1927	KS***	
62.	Kiowa	1.198	1950	KS***	
63.	Kirwin	1.243	1973	KS***	
64.	Lamar	1.290	1988	CO	
65.	Lancer	1.461	1963	NE	
66.	Lancota	1.258	1975	NE	
67.	Laredo	1.401	1990	PC	Agripro
68.	Larned	1.237	1976	KS***	
69.	Lindon	1.347	1975	CO	
70.	Longhorn	1.255	1990	PC	Agripro
71.	McNair 1003	1.517	1982	PC	Northrup King
72.	Mesa	1.429	1986	PC	Agripro
73.	Mustang	1.337	1984	PC	Agripro
74.	Nebred	1.137	1938	NE	
75.	Newton	1.253	1977	KS***	
76.	NK 817	1.323	1980	PC	Northrup King
77.	NK 830	1.341	1981	PC	Northrup King
78.	NK 835	1.325	1980	PC	Northrup King
79.	Norkan	1.297	1986	KS***	
80.	Ogalalla	1.474	1992	PC	Agripro

(continued)

Yield Ratios of Wheat Varieties Grown in Kansas Performance Tests. 1911-1995

	Variety Name	Ratio[a]	Release	Source[b]	Company Name
81.	Omaha	1.129	1960	NE	
82.	Ottawa	1.257	1960	KS***	
83.	Parker	1.288	1966	KS***	
84.	Parker 76	1.293	1976	KS***	
85.	Pawnee	1.220	1943	NE	
86.	Pecos	1.834	1992	PC	Agripro
87.	Pioneer 2154	1.199	1987	PC	Pioneer
88.	Pioneer 2157	1.285	1983	PC	Pioneer
89.	Pioneer 2163	1.761	1989	PC	Pioneer
90.	Pioneer 2172	1.549	1985	PC	Pioneer
91.	Pioneer 2180	1.709	1988	PC	Pioneer
92.	Pioneer 2551	1.697	1987	PC	Pioneer (Soft)
93.	PL145	1.224	1981	PC	Pioneer
94.	Ponca	1.156	1951	KS***	
95.	Pronto	1.161	1970	PC	DeKalb
96.	Ram	1.265	1983	PC	Agripro
97.	Red Chief	1.145	1940	PC	Clark
98.	Redland	1.392	1986	NE	
99.	Rocky	1.272	1977	PC	Agripro
100.	Rodco	1.282	1957	PC	Rodney
101.	Sage	1.265	1973	KS***	
102.	Sandy	1.460	1980	CO	
103.	Satanta	1.252	1968	PC	DeKalb
104.	Scout	1.289	1963	NE	
105.	Scout 66	1.223	1967	NE	
106.	Shawnee	1.226	1967	KS***	
107.	Sierra	1.462	1988	PC	Agripro
108.	Siouxland	1.356	1984	NE	
109.	Stallion	1.424	1985	PC	Agripro
110.	Sturdy	1.165	1967	TX	
111.	Tam 101	1.208	1972	TX	
112.	Tam 105	1.337	1979	TX	
113.	Tam 107	1.428	1984	TX	
114.	Tam 108	1.403	1984	TX	
115.	Tam 200	1.466	1987	TX	
116.	Tam 202	1.273	1992	TX	
117.	Tascosa	1.210	1959	TX	
118.	Tenmarq	1.160	1932	KS***	
119.	Thunderbird	1.453	1984	PC	Agripro
120.	Tomahawk	1.524	1990	PC	Agripro

(continued)

Yield Ratios of Wheat Varieties Grown in Kansas Performance Tests, 1911-1995

	Variety Name	Ratio[a]	Release	Source[b]	Company Name
121.	Trison	1.221	1973	KS***	
122.	Triumph	1.133	1940	PC	Danne
123.	Triumph-Imp.	1.192	1959	PC	Danne
124.	Triumph 64	1.201	1967	OK	
125.	Turkey (control)	1.000***	1873	RUSSIA	
126.	Tut	1.306	1982	PC	Pharoah
127.	Victory	1.472	1985	PC	Agripro
128.	Vista	1.591	1992	NE	
129.	Vona	1.366	1976	CO	
130.	Warrier	1.296	1960	NE	
131.	Wichita	1.204	1944	KS***	
132.	Wings	1.338	1977	PC	Agripro
133.	Wrangler	1.484	1983	PC	Agripro
134.	Hickok	1.703	1993	PC	Agripro
135.	Ponderosa	1.314	1992	PC	Agripro
136.	Jagger	2.345	1994	KS***	

[a]Mean values of the ratio of the yield of each variety to the yield of the control variety (Turkey) for all location years. A higher value indicates a higher yield relative to the control variety.
[b]PC = private company; asterisks indicate the control variety and the semidwarf KAES varieties used in the economic analysis.

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