The U.S./Mexico Water Dispute: Impacts of Increased Irrigation in Chihuahua, Mexico

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Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Mobile, Alabama, February 1-5, 2003

 The authors acknowledge Frank Daniello and Jose Pena for their contributions to this project.

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Mexico accumulated a water debt of 1.5 million acre feet to the United States while increasing its use of irrigation water by fourteen percent in Chihuahua. This paper documents recent trends in irrigated production of major crops grown in Chihuahua, estimates irrigation water use in Chihuahua, and offers policy alternatives. Irrigated crop production in Chihuahua increased 236 percent since 1980, from 1.0 million metric tons (mmt) to 3.5 mmt in 2001. Irrigated harvested area increased 44 percent over the same period from 554,613 acres to 797,627 acres while estimated irrigation water use increased from 2.0 maf to 3.5 maf.

Key word: U.S.-Mexico water dispute, irrigation water use, 1944 U.S.-Mexico Water Treaty, NAFTA, Chihuahua crop production, estimated irrigation requirements

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Introduction

Since 1944, the United States and Mexico have shared the waters of the Rio Grande and Rio Conchos River basins under treaty provisions. Under Article 4 of the Treaty, Mexico agreed to provide the United States with one-third of the flows reaching the main channel of the Rio Grande (Rio Bravo) from the Conchos, San Diego, San Rodrigo, Escondido, and Salado Rivers and the Las Vacas Arroyo in cycles of five consecutive years or a minimum of 350,000 acre-feet annually. The balance of waters from the Rio Grande and 1.5 million acre-feet (maf) from the Colorado River were assigned to Mexico under the Treaty.

Priorities for joint use of international water were established under Article 3 of the Treaty. Domestic and municipal uses are first priority. This is followed by agriculture and stockraising. Electrical power, industrial uses, navigation, fishing and hunting, and all other uses represent lower priorities of water use.

After two periods of drought (1988-91 and 1993-1997), Mexico began to withhold water deliveries to the United States. Mexico's accumulated water debt with the United States reached 1.5 maf in May 2002 and as of October 2, 2002, extended across two five-year accounting periods. In addition, trade growth and increased agricultural production spurred by NAFTA, and an increasing population and industrial base on both sides of the U.S.-Mexico border, have placed greater pressure on the Rio Conchos/Rio Grande water system. Over this same time period, crop irrigation and production have continued in Chihuahua, Mexico which contains the Rio Conchos basin, the major Mexican water source of the Rio Grande River.

The purpose of this study is two-fold:

1. To document recent trends in irrigated production of major crops grown in the Mexican state of Chihuahua, focusing on the drought period and the continuing time of water deficit, 1994-2001, and
2. To estimate the amount of irrigation water used in Chihuahua to sustain crop production under semi-arid conditions in the region.

Background on Chihuahua and the Rio Conchos

Chihuahua is a diverse agricultural production region. Although historically known for production of apples, peaches, and pecans, more recently there has been increased production of peanuts, alfalfa, cantaloupe, and watermelon. Crops are grown under semi-arid conditions. Rainfall averages from 13.8-16.7 inches per year, with two-thirds occurring from May-October, and peak rainfall from July to September (CROPOWAT 7.0). October-January is relatively dry with less than 1.0 inch falling in most months. Since 1960, temperatures at the Chihuahua, Chihuahua weather station have averaged from a low of 50 degrees Fahrenheit in late November through January to a high 80.6 degrees in early June (USDA, FAS, PECAD).

It has been documented that annual inflows to La Boquilla, Chihuahua's largest reservoir, were 33 percent lower during the period 1994-99, 699,000 acre-feet (af), compared to the long-term historical average, 1.043 maf (Kelly and Comision Nacional del Agua-CNA). The major irrigation districts in the Rio Conchos basin reduced water use between 42 percent to 15 percent during the drought period (1994-99, Kelly). The Texas Center for Policy Studies report noted that as surface water availability has declined, the use of wells for irrigation has increased. This led to high extraction rates for some of Chihuahua's major aquifers, with use exceeding recharge by 19 to 127 percent. It is not clear that overuse of these aquifers has reduced water flows into the Rio Conchos and its tributaries, but concerns have been raised about this possibility. Some analysts believe that drought in Mexico and Texas, coupled with increased water use from wells in Chihuahua, likely exacerbated the water problem, leading to

reduced water availability for irrigation in the LRGV of Texas and in the Mexican state of Tamaulipas. It was estimated that annual average rainfall in the Rio Conchos basin was 47 percent of normal in 1994 and 69 percent of normal in 1995. For 1993, 1996, and 1997 rainfall was estimated at about 80 percent of normal levels (Brandes).

Surface water represents about 20 percent of the available irrigation water supply in Delicias, the largest irrigation district, with the major sources being the La Boquilla and Francisco Madero reservoirs (Kelly). Together, these two reservoirs account for 77 percent of storage capacity in the Rio Conchos basin (Center for North American Studies-CNAS estimate). The San Gabriel and Pico de Aguila supply the Rio Florido irrigation district, which uses primarily surface water for irrigation. The Bajo Rio Conchos district relies primarily on the Luis L. Leon reservoir. CNA estimates indicate that water use efficiency in the Rio Conchos basin is about 40 percent (Kelly). It is likely that these high rates of water loss represent system delivery inefficiencies due to seepage and evaporation in canals as well as irrigation losses due to runoff, wind, evaporation, and improper irrigation water application. It is uncertain exactly what proportion of total irrigation water is represented by surface sources and groundwater throughout the Rio Conchos basin.

Crop Production Trends

Irrigated crop production in the Mexican state of Chihuahua has increased 236 percent since 1980, from 1.0 million metric tons (mmt) to 3.5 mmt in 2001 (table 1). Irrigated harvested area increased 44 percent over the same period from 554,613 acres to 797,627 acres. Yields for all irrigated crops increased 133 percent to 4.38 mt/acre. For 2001, forages accounted for 44 percent of irrigated production in Chihuahua, followed by vegetables (26 percent), grains, soybeans, and cotton (20 percent) and tree nuts, fruits, and peanuts (10 percent). It is estimated that irrigated production represents about 82 percent of total agricultural production in the state, but this varies widely by crop.

The peak in irrigated acreage and production in Chihuahua was 1997 when 1,105,026 acres were harvested to produce 4.26 mmt of output (table 1). Since then, irrigated acreage has fallen 28 percent,

production is down 18 percent, but irrigated crop yields have increased 13 percent. Irrigated corn, alfalfa, cotton, pecans, dry beans, and apples represented 66 percent of total irrigated crop acreage in Chihuahua for 2001.

Grains, Soybeans, and Cotton

Since 1995 irrigated corn acreage has increased 18 percent, from 123,861 acres to 145,553 acres (table 1). Production of irrigated corn increased 70 percent, while yields were up by 45 percent. Peak irrigated corn production occurred in 1992 at 725,446 mt. Irrigated corn acreage, however, peaked in 1993 at 327,845, with yields peaking in 2001 at 3.05 mt/acre, or about 120 bushels/acre.

Irrigated cotton acreage has declined 13 percent since 1995 and peaked at 157,929 acres in 1997. Irrigated production was only off by one percent, but yields increased 13 percent.

Irrigated acreage of soybeans, grain sorghum, rye grass and wheat have all declined over the period 1990-99. In 2001 there were only 2,036 acres of rye grass and 96 acres of soybeans harvested in the state.

Forages

Alfalfa is the number one irrigated forage crop produced in Chihuahua accounting for 54 percent of acreage and 51 percent of irrigated forage production in 2001 (table 1). Oats, corn, sorghum, and wheat account for a majority of the remaining output. Alfalfa acreage has increased 37 percent since 1995 and 54 percent since 1986. Alfalfa data was not reported in any significant amount before 1986. Alfalfa production has expanded 89 percent since 1995, while yields have increased 38 percent over the same period. Corn and sorghum forages have both increased in terms of harvested area and production from 1995-2001. However, oat forage has declined in acreage and production over the same time period.

Melons and Vegetables

Irrigated vegetable and melon acreage has increased 31 percent since 1995 and 196 percent since 1990, while production is up 54 and 286 percent, respectively, for the same periods (table 1). Peak acreage and production occurred in 1997, with total acreage falling 25 percent and production off nine

percent since then. Irrigated dry beans, green peppers, and onions accounted for 71 percent of total irrigated reported vegetable acreage and 56 percent of irrigated vegetable production. Potatoes, dry peppers, watermelon, cantaloupe, and tomatoes represent the other major vegetable crops grown in the region. All other vegetable crops reported declines in acreage and production, but accounted for only approximately 400 harvested acres.

The largest proportional increases in vegetable and melon acreage were for watermelon, bell peppers, potatoes, cantaloupe and onions. Acreage increases for 1995-2001 ranged from six percent for dry beans to 302 percent for watermelon. Increases in irrigated production ranged from 469 percent for watermelon, 169 percent for cantaloupe, and 157 percent for potatoes to 17 percent for onions, seven percent for bell peppers, and two percent for dry beans during the same time period. Irrigated production of tomatoes experienced declines of 43 percent from 1997 to 2001 with harvested area decreasing by 22 percent. During this same time period, dry pepper irrigated acreage increased 77 percent while production increased by only two percent. Tomato data was not reported from 1990-1996 and dry pepper data was not reported 1986-1996.

Over the 1990-2001 period irrigated watermelon acreage was up 1,200 percent, followed by tomatoes (342 percent), dry beans (215 percent), cantaloupe (141 percent), bell peppers (94 percent), potatoes (60 percent), and onions (35 percent). Production increases over the same period were 1,608 percent for watermelon, 608 percent for cantaloupe, 467 percent for tomatoes, 255 percent for dry beans, 178 percent for bell peppers, and 141 percent for potatoes. Note that the data reported for tomatoes and potatoes are for the 1989-2001 period as neither reported for 1990.

Tree Nuts, Tree Fruits and Peanuts

Irrigated apples and pecans accounted for 84 percent of tree fruit, tree nut, and peanut acreage in 2001 (table 1). Apple acreage was down 14 percent since 1995, but increased by three percent since 1990, while pecan acreage increased by 25 and 59 percent, respectively, over the same two periods. Irrigated apple output increased 10 percent since 1995, while pecan production was up 70 percent.

Peanuts, the next most important irrigated crop of this category with 17,507 harvested acres in 2001, were up 251 percent in acreage and 266 percent in production since 1995. Peanut acreage also increased four percent from 1990-2001, while output was up 68 percent over the same period. Peanut yields have greatly increased since 1990.

Summary

From 1995-2001, producers in Chihuahua have reduced harvested area for the grains, soybean, and cotton crop category by 38,100 acres. Forages, vegetables, melons, fruits, and nuts, however, account for an increase of 108,082 irrigated acres, leading to a net gain of 69,982 acres under irrigation, an increase of ten percent. This change in irrigated crop mix was likely profit driven as producers switched from crops with relatively low prices, such as grain sorghum and soybeans, to those with higher prices, such as alfalfa, cantaloupe, peanuts, peppers, potatoes, and watermelon. It should be noted that many of these alternative crops are more water-intensive than crops previously produced in Chihuahua.

Estimated Irrigation Water Use

Irrigation water use estimates were calculated for each crop using the Penman-Monteith (PM) equation. The PM equation uses a base estimation of evapotranspiration (ET_o) multiplied by a crop coefficient for each crop. The outcome of this equation, ET_c is an estimated water use requirement for that crop. Subtracting rainfall data from this requirement calculates an estimated irrigation requirement for the crop. CROPWAT model version 7 developed by the Food and Agriculture Organization of the United Nations provided monthly ET_o estimates for the Chihuahua region as well as average monthly rainfall data. The monthly ET_o was averaged over the months of the growing season then multiplied by the seasonal crop coefficient. Average monthly rainfall was summed over the months of the growing season and that number subtracted from the ET_c, yields the irrigation water use estimate for the crop. The estimate which is based on a single acre, was multiplied by the total number of irrigated acres to determine the total amount of irrigation water used for each growing year. It has been documented that irrigation efficiency is on average only 40 percent in Chihuahua, Mexico; therefore, this is the level of

efficiency we assume in this study. Data were lacking for four crops, potatoes, cucumbers, other fruits, and other vegetables, so the estimates in this report reflect a lower bound for the actual irrigation water used in the state.

Total estimated irrigation water use in Chihuahua has nearly doubled since 1980 from 2.0 maf to a peak usage of 4.5 maf in 1997 (table 2). Since 1980, average annual irrigation water use increased by five percent each year up to the peak usage. The single largest year-to-year increase in the use of water for irrigation occurred from 1996 to 1997 when usage expanded by 45 percent, likely due to worsening drought conditions in the Rio Conchos basin. Since 1997, irrigation water use has fallen to 3.5 maf in 2001, a drop of 21 percent. Between 1995-2001 irrigation water use increased 14 percent, indicating that while reservoirs in the Chihuahua may have fallen due to drought, producers switched to underground water sources for irrigation.

Five crops used 2.6 maf of irrigation water in 2001 and accounted for 73 percent of irrigation water use. In order of importance, these were: alfalfa (1,033 thousand acre feet-taf), corn (568 taf), pecans (377 taf), apples (317 maf), and cotton (298 taf) (table 2). Among these top five crops, water use per acre ranged from a low of 3.85 af for cotton to a high of 7.5 af for alfalfa. Due to relatively low water delivery efficiency in most of the region and to low water use efficiency on farm, these per acre usage figures could increase as this analysis is refined to more accurately reflect the actual efficiency of water use in the region. It has been estimated that 90 percent of the alfalfa and most of the pecan orchards in the region are flood irrigated, leading to relatively high rates of water loss due to runoff and evaporation (Kelly and Personal interview, Julie Watson Associated Press 5/1/02).

Bell peppers, dry beans, wheat, and oats together used 486 taf of irrigation water in 2001 (table 2). Other major crops using irrigation water were grain sorghum, onions, peanuts, and watermelon, which together used an estimated 178 taf of irrigation water in 2001. Dry peppers, tomatoes, peaches, rye grass, and cantaloupe accounted for most of the remaining irrigation water use. Among these crops,

peaches is the most water intensive on a per acre basis (7.02 af), followed by cantaloupe (4.23 af), dry peppers (3.65 af), tomatoes (3.38 af), and rye grass (2.15 af).

Policy Options

Mexico's failure to deliver water under Treaty has exacerbated the impacts of drought that has existed in South Texas since the mid-1990s. Robinson estimated losses to the Lower Rio Grande Valley economy to be about $135 million. Repayment of the existing water debt and timely delivery of future water commitments from the Rio Conchos into the Rio Grande is crucial to the viability of Lower Rio Grande Valley agriculture and the infrastructure it supports. Industry representatives and policy makers have been debating policy options to mitigate at least some of the negative impacts associated with water shortage and prolonged drought. Most of these options assume that water exists with which the current debt could be paid.

Direct producer compensation is one option. Congress appropriated $10 million to partially compensation producers for losses in FY 2003. Although payments will be made soon, this solution is only a short-term remedy and will not impact future treaty compliance by Mexico. In addition, some South Texas representatives have introduced legislation authorizing $100 million to improve existing irrigation systems, but prospects for approval by Congress are uncertain.

Some industry representatives advocate curtailing and even eliminating water releases from the Colorado River until Mexico repays its water debt. Others favor redirecting the Colorado River waters to the LRGV for use by south Texas producers. This option would not be popular with producers in California and may be prohibitively expensive, and would not be a long-term solution.

Some U.S. policy makers have discussed retaliatory duties on U.S. imports of agricultural products from Mexico. The United States is the largest export market for Mexican feeder cattle and fresh winter produce. This option could have major negative implications for U.S.-Mexico relations and would most likely result in counter-retaliation by Mexico. Most agricultural exporters in Mexico would be impacted by this policy, not only producers in Chihuahua, giving the policy wide ranging impacts.

Also, any such duties would most likely conflict with NAFTA and WTO obligations, making them difficult to enact and possibly resulting in calls by Mexico to renegotiate NAFTA.

Another option is to apply political pressure on Mexico by establishing linkage between water treaty compliance and favorable drug certification compliance under the U.S. Foreign Assistance Act. The President must certify annually that Mexico cooperates fully in U.S. drug control efforts. Lacking this certification, foreign assistance and financing of sales are suspended, U.S. representatives are required to vote against loans in multilateral development banks, and trade sanctions, including tariffs and denial of preferential trade benefits may be applied. U.S. imports from Mexico would be significantly reduced if the harshest of these measures were applied to Mexico. This policy option will have broad economic ramifications beyond the agricultural sector. Any action on this scale, or even the threat, would likely result in diplomatic challenge by Mexico and would quickly be deferred for diplomatic resolution. It would also be a highly questionable policy in view of recent attempts by the United States to strengthen the U.S. border against further terrorist threat.

Water treaty compliance and water repayment also could be linked to immigration reform and day-worker and seasonal worker entry. President Fox desires the easing of restrictions on movement of seasonal Mexican laborers across the U.S.-Mexican border. The promise of constructive, open discussions on immigration reform might result in Mexican compliance with the water treaty and repayment of the current debt, assuming that water is available.

There are also negotiations underway with the North American Development Bank that would allow the United States and Mexico each to receive up to $40 million for irrigation system improvements, including increasing the efficiency of water delivery and application. This too, is a long-term option that would do little to remedy the water shortage in the near-term.

It is likely that no one option will solve the problem. The immediate need is for water to irrigate crops. The longer-term need is to improve the efficiency of delivery and application of irrigation water on both sides of the border. A combination of options, administered by a binational institution, would

most likely result in the most effective long-term solution.

Conclusions

Despite prolonged drought, irrigation and agricultural production have continued in Chihuahua, Mexico. While total irrigated acreage has declined 28 percent from the peak in 1997, it increased 10 percent from 1995 to 2001, while irrigated production rose 28 percent. Producers have switched from relatively low profitability crops to alternatives that are more profitable and more water-intensive. As a result, irrigation water use, while down from its peak of 4.5 maf in 1997, increased five percent from 1995-01, with the largest increase, 44 percent, between 1996 and 1997, followed by an eight percent increase from 1999 to 2001.

It is uncertain what proportion of total irrigation water is from surface and groundwater sources. The largest irrigation district, Delicias, has been estimated to rely on groundwater for 80 percent of irrigation water supplies. Increased use of aquifers in the Rio Conchos basin will most likely lower the water table in the region, leading to lower runoff and less surface water availability downstream in the Rio Grande River. Should this occur, it is likely that producers in the Lower Rio Grande Valley of Texas will face additional water shortages, higher water costs, and declining competitiveness.

Major policy options under consideration to mitigate the negative impacts of chronic water shortages and treaty compliance have been many and varied. Among the most widely discussed are direct government compensation to producers, the imposition of retaliatory tariffs, linking treaty compliance to Mexican drug certification and/or immigration reform, withholding water deliveries to Mexico from the Colorado River, and funding from NADBank to improve irrigation water delivery and efficiency in both countries. It is likely that other options will be considered if this issue remains unresolved.

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Table 1. Harvested Acres, Production and Yields for Irrigated Crops in Chihuahua, Mexico
1980-2001

Crop	1980	1985	1990	1995	1996	1997	1998	1999	2000	2001
Grains, Soybean and Cotton										
GRAIN CORN										
Harvested Acres	61,520	80,920	126,268	123,861	146,370	228,577	176,264	152,614	169,160	145,553
Production MT (metr	54,773	89,697	255,861	260,377	319,915	566,938	436,310	424,770	438,859	442,618
Yield MT/Acre	0.89	1.11	2.03	2.10	2.19	2.48	2.48	2.78	2.76	3.05
GRAIN WHEAT										
Harvested Acres	118,195	140,978	98,828	39,165	41,550	79,556	36,069	20,603	30,419	31,214
Production MT	170,340	230,276	167,201	63,225	71,428	182,815	67,900	38,580	52,553	59,931
Yield MT/Acre	1.44	1.63	1.69	1.61	1.72	2.30	1.88	1.87	1.73	1.92
GRAIN OATS										
Harvested Acres	6,627	7,324	21,814	13,203	12,244	12,422	9,486	17,826	7,949	20,215
Production MT	9,384	9,684	26,134	18,275	16,220	17,732	11,633	22,692	10,389	22,954
Yield MT/Acre	1.42	1.32	1.20	1.38	1.32	1.43	1.23	1.27	1.31	1.14
SOYBEANS										
Harvested Acres	45,269	57,784	24,992	1,594	74	17,668	4,584	314	689	96
Production MT	40,833	40,660	21,309	1,154	73	17,525	2,987	316	684	79
Yield MT/Acre	0.90	0.70	0.85	0.72	0.98	0.99	0.65	1.01	0.99	0.82
GRAIN SORGUM										
Harvested Acres	42,701	86,922	63,436	29,143	39,563	57,107	33,376	28,518	35,571	16,101
Production MT	60,953	151,032	126,044	58,352	83,654	121,936	78,656	59,707	76,161	35,587
Yield MT/Acre	1.43	1.74	1.99	2.00	2.11	2.14	2.36	2.09	2.14	2.21
RYE GRASS										
Harvested Acres	-	-	-	37,609	27,260	3,286	3,551	7,203	5,787	2,036
Production MT	-	-	-	407,744	463,786	65,888	68,771	127,332	111,763	35,652
Yield MT/Acre	0.00	0.00	0.00	10.84	17.01	20.05	19.37	17.68	19.31	17.51
COTTON										
Harvested Acres	93,977	71,731	82,163	88,627	123,767	157,929	138,838	80,078	76,078	77,529
Production MT	81,523	64,571	76,352	85,831	135,095	170,139	149,862	77,645	73,855	85,021
Yield MT/Acre	0.87	0.90	0.93	0.97	1.09	1.08	1.08	0.97	0.97	1.10
GRAIN BARLEY										
Harvested Acres	8,631	8,130	12,745	5,424	5,068	7,962	3,039	1,651	3,064	7,781
Production MT	7,120	13,494	21,214	9,667	9,246	15,096	5,883	2,453	4,776	7,719
Yield MT/Acre	0.82	1.66	1.66	1.78	1.82	1.90	1.93	1.49	1.56	0.99
Total Grains, Soybean and Cotton										
Harvested Acres	376,921	453,789	430,246	338,626	395,896	564,507	405,207	308,806	328,718	300,526
Production MT	424,926	599,414	694,115	904,625	1,099,417	1,158,069	822,002	753,495	769,037	689,561
Yield MT/Acre	1.13	1.32	1.61	2.67	2.78	2.05	2.03	2.44	2.34	2.29

Source: Secretary of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA)

Table 1. Harvested Acres, Production and Yields for Irrigated Crops in Chihuahua, Mexico
1980-2001

Crop	1980	1985	1990	1995	1996	1997	1998	1999	2000	2001
Forages										
CORN FORAGE										
Harvested Acres	12,913	20,208	18,192	20,667	13,217	48,726	21,063	13,336	22,207	31,577
Production MT	131,660	229,944	236,470	258,749	531,469	773,714	316,321	193,486	328,299	443,704
Yield MT/Acre	10.20	11.38	13.00	12.52	40.21	15.88	15.02	14.51	14.78	14.05
SORGHUM FORAGE										
Harvested Acres	6,051	9,461	6,869	13,776	14,720	6,966	11,157	12,852	17,141	20,754
Production MT	78,368	143,970	103,304	187,487	188,460	57,665	115,280	119,690	198,400	238,957
Yield MT/Acre	12.95	15.22	15.04	13.61	12.80	8.28	10.33	9.31	11.57	11.51
BARLEY FORAGE										
Harvested Acres	3,798	-	867	-	-	541	82	25	-	74
Production MT	1,550	-	1,959	-	-	1,637	197	80	-	109
Yield MT/Acre	0.41	0.00	2.26	0.00	0.00	3.03	2.42	3.24	0.00	1.47
OATS FORAGE										
Harvested Acres	5,379	12,896	19,637	34,863	3,005	1,742	2,666	6,160	8,902	-
Production MT	52,084	67,508	95,893	79,505	5,397	3,395	4,924	13,990	33,461	-
Yield MT/Acre	9.68	5.23	4.88	2.28	1.80	1.95	1.85	2.27	3.76	0.00
ALFALFA										
Harvested Acres	-	-	113,629	100,533	82,225	128,275	109,008	114,877	132,329	137,677
Production MT	-	-	520,801	416,776	432,312	681,422	635,822	684,231	783,908	789,163
Yield MT/Acre	0.00	0.00	4.58	4.15	5.26	5.31	5.83	5.96	5.92	5.73
CUT OATS										
Harvested Acres	-	-	-	-	22,832	21,920	17,134	18,231	16,551	35,147
Production MT	-	-	-	-	42,926	64,632	56,969	53,933	34,598	68,922
Yield MT/Acre	0.00	0.00	0.00	0.00	1.88	2.95	3.33	2.96	2.09	1.96
WHEAT FORAGE										
Harvested Acres	5,268	1,935	630	-	-	425	534	1,505	954	755
Production MT	7,277	4,265	2,550	-	-	1,739	3,167	10,094	10,265	6,808
Yield MT/Acre	1.38	2.20	4.05	0.00	0.00	4.09	5.93	6.71	10.76	9.02
Total Forage										
Harvested Acres	33,410	44,500	159,824	169,839	135,999	208,594	161,643	166,985	198,084	225,985
Production MT	270,939	445,687	960,977	942,517	1,200,564	1,584,204	1,132,680	1,075,504	1,388,930	1,547,663
Yield MT/Acre	8.11	10.02	6.01	5.55	8.83	7.59	7.01	6.44	7.01	6.85

Source: Secretary of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA)

Table 1. Harvested Acres, Production and Yields for Irrigated Crops in Chihuahua, Mexico
1980-2001

Crop	1980	1985	1990	1995	1996	1997	1998	1999	2000	2001
Vegetables and Melons										
GREEN PEPPERS										
Harvested Acres	14,226	13,464	17,964	31,382	31,295	64,310	50,117	39,457	43,133	34,892
Production MT	68,964	120,260	120,076	310,881	268,875	533,914	432,672	338,001	382,952	333,866
Yield MT/Acre	4.85	8.93	6.68	9.91	8.59	8.30	8.63	8.57	8.88	9.57
ONIONS										
Harvested Acres	5,024	9,815	8,495	10,010	8,105	10,583	12,955	13,707	8,562	11,475
Production MT	66,803	133,046	84,319	131,644	105,169	162,587	174,260	188,258	115,580	153,531
Yield MT/Acre	13.30	13.56	9.93	13.15	12.98	15.36	13.45	13.74	13.50	13.38
BEANS										
Harvested Acres	15,231	14,972	15,992	47,416	32,486	75,440	43,032	40,090	34,983	50,302
Production MT	7,171	5,535	6,819	23,790	16,598	23,561	20,242	17,701	14,440	24,231
Yield MT/Acre	0.47	0.37	0.43	0.50	0.51	0.31	0.47	0.44	0.41	0.48
CANTALOUPE										
Harvested Acres	773	516	1,465	2,965	2,288	2,718	2,958	3,393	2,721	3,527
Production MT	5,160	5,291	6,256	16,463	16,562	29,203	32,134	34,552	36,731	44,308
Yield MT/Acre	6.67	10.25	4.27	5.55	7.24	10.74	10.87	10.19	13.50	12.56
RED TOMATOES										
Harvested Acres	1,109	-	-	-	-	3,543	2,686	3,842	2,296	2,754
Production MT	3,249	-	-	-	-	41,964	27,918	28,757	22,837	23,906
Yield MT/Acre	2.93	0.00	0.00	0.00	0.00	11.84	10.39	7.48	9.95	8.68
POTATOES										
Harvested Acres	2,214	6,385	-	6,733	6,528	9,125	6,766	11,883	12,676	12,713
Production MT	17,142	63,092	-	71,305	77,776	94,527	80,256	139,458	163,246	183,581
Yield MT/Acre	7.74	9.88	0.00	10.59	11.91	10.36	11.86	11.74	12.88	14.44
OTHER VEGETABLES										
Harvested Acres	-	-	1,364	1,878	2,301	1,307	1,433	1,117	450	235
Production MT	-	-	11,939	12,071	13,285	7,113	7,464	5,000	3,318	1,489
Yield MT/Acre	0.00	0.00	8.75	6.43	5.77	5.44	5.21	4.48	7.38	6.34
CUCUMBERS										
Harvested Acres	12	-	-	850	759	1,661	783	497	383	148
Production MT	150	-	-	6,786	6,198	9,095	4,309	2,815	3,422	1,068
Yield MT/Acre	12.14	0.00	0.00	7.98	8.17	5.48	5.50	5.67	8.94	7.20
WATERMELON										
Harvested Acres	625	44	1,018	3,296	3,524	8,812	5,266	7,109	10,111	13,238
Production MT	2,410	299	8,585	25,771	36,464	107,035	59,594	85,058	144,031	146,637
Yield MT/Acre	3.86	6.72	8.43	7.82	10.35	12.15	11.32	11.97	14.25	11.08
DRY PEPPERS										
Harvested Acres	912	781	-	-	-	4,401	4,277	7,171	6,065	7,776
Production MT	147	215	-	-	-	6,691	3,414	5,975	5,391	6,834
Yield MT/Acre	0.16	0.28	0.00	0.00	0.00	1.52	0.80	0.83	0.89	0.88
Total Vegetables and Melons										
Harvested Acres	40,127	45,978	46,299	104,531	87,286	181,900	130,274	128,265	121,379	137,061
Production MT	171,196	327,738	237,994	598,711	540,927	1,015,690	842,263	845,575	891,948	919,451
Yield MT/Acre	4.27	7.13	5.14	5.73	6.20	5.58	6.47	6.59	7.35	6.71

Source: Secretary of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA)

Table 1. Harvested Acres, Production and Yields for Irrigated Crops in Chihuahua, Mexico
1980-2001

Crop	1980	1985	1990	1995	1996	1997	1998	1999	2000	2001
Tree Fruits, Tree Nuts, and Peanuts										
APPLES										
Harvested Acres	56,628	42,743	43,769	52,689	48,469	57,834	44,265	57,416	44,633	45,172
Production MT	134,491	206,076	256,977	230,355	234,172	406,216	199,353	269,894	189,179	252,681
Yield MT/Acre	2.38	4.82	5.87	4.37	4.83	7.03	4.50	4.70	4.24	5.59
PEACHES										
Harvested Acres	9,429	4,458	3,425	1,989	2,602	2,701	2,147	2,812	2,763	3,081
Production MT	18,091	16,735	23,344	12,479	16,327	26,381	9,945	21,460	20,698	23,812
Yield MT/Acre	1.92	3.75	6.82	6.27	6.27	9.77	4.63	7.63	7.49	7.73
PECANS										
Harvested Acres	20,616	30,868	42,667	54,253	56,423	54,972	60,992	65,484	65,431	67,891
Production MT	3,466	12,669	21,308	23,560	24,000	27,325	30,515	36,381	34,091	40,091
Yield MT/Acre	0.17	0.41	0.50	0.43	0.43	0.50	0.50	0.55	0.52	0.59
PEANUTS										
Harvested Acres	16,533	27,295	16,830	4,986	5,481	34,087	27,065	20,119	28,882	17,507
Production MT	14,953	20,312	10,982	5,033	5,856	41,387	19,823	20,807	29,041	18,410
Yield MT/Acre	0.90	0.74	0.65	1.01	1.07	1.21	0.73	1.04	1.01	1.05
VARIOUS FRUIT TREES										
Harvested Acres	-	-	2,014	220	-	47	-	99	-	-
Production MT	-	-	6,643	692	-	19	-	20	-	-
Yield MT/Acre	0.00	0.00	8.15	7.78	0.00	1.00	0.00	0.50	0.00	0.00
PEARS										
Harvested Acres	949	914	-	511	156	383	447	445	403	404
Production MT	2,310	1,742	-	1,716	1,241	2,069	1,891	1,562	1,400	1,696
Yield MT/Acre	2.43	1.91	0.00	3.35	7.97	5.40	4.23	3.51	3.48	4.20
Total Tree Fruits, Tree Nuts and Peanuts										
Harvested Acres	104,155	106,278	108,704	114,649	113,130	150,024	134,917	146,375	142,112	134,055
Production MT	173,311	257,534	319,254	273,835	281,596	503,397	261,527	350,124	274,409	336,690
Yield MT/Acre	1.66	2.42	2.94	2.39	2.49	3.36	1.94	2.39	1.93	2.51
Total All										
Harvested Acres	**554,613**	**650,545**	**745,073**	**727,645**	**732,311**	**1,105,026**	**832,040**	**750,430**	**790,293**	**797,627**
Production MT	**1,040,372**	**1,630,373**	**2,212,340**	**2,719,688**	**3,122,504**	**4,261,360**	**3,058,472**	**3,024,698**	**3,324,324**	**3,493,364**
Yield MT/Acre	**1.88**	**2.51**	**2.97**	**3.74**	**4.26**	**3.86**	**3.68**	**4.03**	**4.21**	**4.38**

Source: Secretary of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA)

Table 2. Estimated Irrigation Water Use for Selected Crops in Chihuahua, Mexico
1980-2001

Crop	Acre Feet per Acre	1980	1985	1990	1995	1996	1997	1998	1999	2000	2001
		Acre Feet									
Alfalfa	7.50	-	-	852,752	754,468	617,075	962,663	818,074	862,117	993,094	1,033,228
Apples	7.02	397,305	299,890	307,085	369,670	340,059	405,765	310,570	402,835	313,151	316,932
Peaches	7.02	66,157	31,275	24,029	13,956	18,256	18,949	15,066	19,729	19,382	21,619
Pears	7.02	6,657	6,415	-	3,589	1,092	2,687	3,138	3,121	2,826	2,835
Pecans	5.55	114,371	171,248	236,706	300,986	313,022	304,975	338,369	363,291	362,995	376,642
Onions	4.36	21,895	42,778	37,027	43,629	35,325	46,127	56,466	59,741	37,318	50,015
Cantaloupe	4.23	3,268	2,182	6,192	12,530	9,669	11,486	12,499	14,337	11,496	14,906
Grain Corn	3.90	240,092	315,802	492,778	483,385	571,227	892,053	687,893	595,596	660,168	568,040
Cotton	3.85	361,799	276,153	316,317	341,203	476,487	608,005	534,507	308,288	292,890	298,476
Watermelon	3.73	2,331	166	3,796	12,290	13,138	32,854	19,633	26,506	37,700	49,359
Grain Wheat	3.71	438,434	522,944	366,591	145,280	154,125	295,106	133,795	76,425	112,837	115,784
Wheat Forrage	3.71	19,542	7,177	2,337	-	-	1,577	1,980	5,582	3,538	2,800
Dry Peppers	3.65	3,331	2,853	-	-	-	16,078	15,627	26,198	22,158	28,410
Oats Grain	3.43	22,729	25,119	74,816	45,281	41,993	42,603	32,535	61,137	27,263	69,332
Tomato	3.38	3,754	-	-	-	-	11,988	9,087	12,999	7,766	9,317
Corn Forrage	3.19	41,203	64,477	58,044	65,944	42,173	155,469	67,205	42,551	70,855	100,752
Barley Grain	3.16	27,300	25,713	40,313	17,155	16,030	25,182	9,613	5,221	9,691	24,611
Green Peppers	2.92	41,512	39,291	52,421	91,575	91,323	187,664	146,246	115,139	125,865	101,818
Sorghum Forrag	2.83	17,154	26,820	19,473	39,050	41,726	19,746	31,625	36,431	48,590	58,833
Grain Sorghum	2.83	121,045	246,398	179,820	82,611	112,150	161,882	94,610	80,839	100,834	45,642
Oats Cut	2.53	-	-	-	-	57,668	55,365	43,276	-	41,803	88,772
Oats Forage	2.53	13,587	32,573	49,598	88,056	7,589	4,400	6,734	15,559	22,484	-
Dry Beans	2.20	33,443	32,874	35,114	104,112	71,330	165,643	94,487	88,025	76,813	110,449
Rye Grass	2.15	-	-	-	80,930	58,661	7,072	7,641	15,500	12,453	4,381
Peanuts	1.90	31,352	51,759	31,915	9,456	10,393	64,640	51,323	38,151	54,769	33,199
Barley Forrage	1.88	7,129	-	1,628	-	-	1,016	153	46	-	139
Soybeans	1.12	7,442	8,225	24,497	14,826	13,750	13,949	10,653	20,018	8,927	22,701
Total		**2,042,832**	**2,232,131**	**3,213,248**	**3,119,982**	**3,114,259**	**4,514,943**	**3,552,805**	**3,295,383**	**3,477,668**	**3,548,992**