WP 90/02

[International Maize and Wheat Improvement Center]
CIMMYT Economics program.

CIMMYT Economics Working Paper 90/02

Economic Losses from Karnal Bunt of Wheat in Mexico

John P. Brennan and Elizabeth J. Warham,
with Julio Hernández, Derek Byerlee, and Francisco Coronel*

CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIGO
INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER
Lisboa 27 Apartado Postal 6-641 06600 México, D.F. México

CIMMYT Economics Working Paper 90/02

Economic Losses from Karnal Bunt of Wheat in Mexico

John P. Brennan and Elizabeth J. Warham,
with Julio Hernández, Derek Byerlee, and Francisco Coronel*

* *John P. Brennan, Ag. Economist, Agricultural Research Institute, Wagga Wagga, NSW, Australia, and Formerly Visiting Research Fellow, CIMMYT, Mexico; Elizabeth Warham, Consultant, CIMMYT, Mexico; Julio Hernández, Director, Centro de Economía, Colegio de Postgraduados, Mexico; Derek Byerlee, Director, Economics Program, CIMMYT, Mexico; Francisco Coronel, Economist, INIFAP, CIAPAN, Culiacán, Sinaloa, Mexico.*

The views expressed in this paper are those of the authors and are not to be attributed to their respective organizations.

Contents

Appendices

Tables

Acronyms

SARH	Secretaría de Agricultura y Recursos Hidráulicos
SNICS	Servicio Nacional de Inspección y Certificación de Semillas
PRONASE	Productora Nacional de Semillas
CONASUPO	Compañía Nacional de Subsistencias Populares
ANAGSA	Aseguradora Nacional Agrícola y Ganadera, S.A.
INIFAP	Instituto Nacional de Investigación Forestal, Agrícola y Pecuaria
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CEB	Campo Experimental del Bajío
CEAJ	Campo Experimental Altos de Jalisco
CCRI	Cereal Crops Research Institute, Pakistan
NWFP	North West Frontier Province, Pakistan
CIANO	Centro de Investigaciones Agrícolas del Noroeste

Aknowledgements

In compiling this report, we contacted representatives of several organizations to obtain data and information on KB. Those contacts are listed in Appendix A.

Executive Summary

Introduction

There has been concern in Mexico in recent years about the impact of the disease Karnal bunt (KB) on the wheat industry; however, to date no comprehensive information has been available on the economic impact of the disease. Karnal bunt first appeared in Mexico in 1970, but caused little economic loss until the early 1980s, when the level of infestation increased sharply in some years. Initially found in southern Sonora, by 1983 the disease had spread south into the neighboring state of Sinaloa. It has now spread to Baja California Sur (BCS), although not to northern Sonora or to Baja California Norte.

The purpose of this report is to estimate the costs to Mexico associated with KB in northwestern Mexico in an average year, based on the experience of recent years. The estimated costs can then be used for assessing: 1) the priority that should be given to KB in allocating wheat research resources, and 2) the appropriate level of investment in measures to prevent its spread to other wheat-growing areas of Mexico.

The economic costs caused by KB can be divided into direct and indirect costs. Direct costs include yield and quality losses and the loss of seed export markets following the presence of KB in Mexico. Indirect costs are those associated with measures aimed to prevent the spread of KB and to reduce its severity.

The estimates prepared in this study represent the first attempt to quantify the economic costs of KB. As such, they are based on often inadequate information and would benefit from more precise data. However, the data used are the best available, considering the paucity of information on many aspects of KB.

Costs of Karnal Bunt in Northwestern Mexico

Direct costs--Direct costs result from yield losses, quality losses, and seed export losses. Karnal bunt has a relatively minor effect on yield: the only yield loss is caused by the weight loss in infected grains. The estimated average loss of yield in the areas of northwestern Mexico affected by KB (southern Sonora, Sinaloa, and BCS) was 0.12% per year, and the value of the yield loss was 1,085 million Mexican pesos ($MN) per year.

The price farmers receive for grain infected with KB depends upon the percentage of infected grains found. Growers receive a 1% price discount for each 1% of infected grain up to 3%. These discounts are a cost to farmers but do not necessarily reflect the true cost to Mexico of infected grain, since grain with less than 3% infection can be easily and cheaply blended with sound wheat without any penalty in end use. Loads with greater than 3% of infected grain are accepted at the price of grain for livestock feed, with a discount of 20% from the price for food wheat.

For the purposes of this report, the estimated losses to Mexico are taken as those losses relating to heavily infected grain (>3%), and we assume that grain with less than 3% infection can be processed without affecting the quality of the end product. On this basis, an average total discount in northwestern Mexico of $MN 6,103 million (0.69% of the value of the crop in infected areas) accrued to grain with more than 3% infection.

Prior to the outbreak of KB in 1982, southern Sonora exported wheat seed to a number of countries. Following the KB infestation in northwestern Mexico, wheat seed exports from Sonora fell sharply. Since 1984, seed exports from southern Sonora have remained at zero, although some seed was exported from northern Sonora in 1987 and 1988. The estimated loss of seed exports is highly uncertain, because of major changes in the world supply and demand for wheat seed. For the estimates of losses in this report, the volume of lost seed exports is estimated at 12,000 t/yr. On the basis of a value added by seed exports of $MN 220,000/t, the average annual value of losses in seed export sales is an estimated $MN 2,640 million (0.30% of the value of production). This loss will not necessarily continue as a long-term loss to Mexico, provided that other areas free from KB take up the role of exporting seed.

Indirect costs--Various measures have been taken to prevent the spread or to reduce the severity of KB. These include quarantine restrictions on planting in KB-infected areas, grain fumigation, and restrictions on the use of KB-infected seed. It is not known to what extent these measures lead to savings in subsequent harvests.

Quarantine restrictions on planting were imposed on farmers' fields in southern Sonora in 1983/84, following the heavy infestation of KB in 1982/83. If grain delivered to receival depots has an infection level of more than 2%, the farmer is restricted from growing wheat for the following three years. If the level of infection is 1-2%, the farmer can sow only durum wheat, while if the level is less than 1% there is no restriction. When farmers are prevented from sowing bread wheat, they suffer a loss of income as bread wheat is more profitable than the alternatives. Between 1984 and 1989 in southern Sonora, an annual average of 7,357 ha were restricted to "no wheat," and 38,601 ha were restricted to "durum only."

Although quarantine regulations have been in existence in Sinaloa since 1986, they have been largely ineffective and are assumed to have caused no losses to date. The total estimated losses for farmers from the quarantine restrictions are based on 1) data from the relative losses from producing durum wheat or other crops rather than bread wheat and 2) data on the areas affected. The annual losses in southern Sonora have averaged $MN 4,826 million (0.96% of the value of production). Most of the loss came from land on which farmers were restricted from growing wheat.

Sanidad Vegetal has incurred additional costs associated with sampling and testing for KB and with meetings held in relation to KB. The total additional costs for Sanidad Vegetal are estimated at $MN 409 million in southern Sonora and Sinaloa, representing 0.05% of the value of production. The estimated costs are higher in Sinaloa because sampling for KB is done in farmers' fields rather than at the grain receival depot.

Since KB can be spread by infected seed, the acceptance of infected seed for certified seed is regulated. Farmers incur losses when wheat seed crops that have received extra inputs are rejected as unsuitable. The average value of the losses incurred in southern Sonora and Sinaloa by seed producers whose crops are rejected because of KB is $MN 108 million (0.01% of the value of production).

To ensure a supply of KB-free seed, seed production has also shifted away from the KB-infected areas since KB became a problem in northwestern Mexico. The shift of seed production to other areas has resulted in extra costs in transporting seed to the KB-infected areas. In southern Sonora and Sinaloa, these costs are estimated at $MN 1,377 million (0.17% of the value of production) per year.

Although seed treatment is only partly effective against KB, seed from the quarantined areas of northwestern Mexico has been treated with the fungicide PCNB since 1983 to give some control of the level of KB spread in the seed. The use of PCNB is more costly than the seed treatment that would have been used in the absence of KB. In southern Sonora and Sinaloa, the average annual additional costs were $MN 143 million, or 0.02% of the value of production.

Thus the total costs (direct and indirect) of KB in northwestern Mexico are estimated to average $MN 16,852 million ($US 7.02 million) per year (see Table). The major components of costs are the loss in quality of infected crops (37% of total costs), the losses from restrictions on planting (29%), the loss of wheat seed exports (16%), the additional costs of transporting seed (8%), and yield losses (6%). In terms of the distribution between states, 61% of the total losses are incurred in Sonora, 38% in Sinaloa, and 1% in BCS. The estimated total costs represent 2.1% of the value of production in southern Sonora, 2.0% in Sinaloa, and 0.3% in BCS.

Summary of costs of Karnal bunt in northwestern Mexico

State	Costs		
	Direct	Indirect	Total
		($MN million)	
Sonora	4,664	5,663	10,327
Sinaloa	5,162	1,200	6,362
BCS	2	161	163
Total	**9,828**	**7,024**	**16,852**

It is important in interpreting these estimates to consider whether the experience of recent years in northwestern Mexico is a reasonable representation of the future experience. Although rainfall is only one of many factors affecting the incidence of KB, a comparison of recent rainfall with expected average rainfall can provide an indication of the representativeness of recent years. On the basis of a comparison of rainfall data in the period since 1982 with the long-term averages, rainfall frequencies for January-March from 1982 to 1989 seem representative of the expected average over the long term in southern Sonora and northern Sinaloa. Hence, losses to KB estimated for the years 1982 to 1989 are believed to be representative of long-term averages.

Conclusions

The estimated economic losses caused by KB in northwestern Mexico are $MN 16,852 million per year, 2% of the value of the average crop in the infected areas, so that effective measures to control the disease could result in considerable savings. Indeed, the cost of the disease warrants considerable expenditure on research and other measures to effect its control.

At present, few options are available to further reduce costs in northwestern Mexico, given that KB is already widespread in farmers' fields. Possible future options include improved seed treatment, more economic fungicides, and the development of appropriate varietal resistance to KB, but these alternatives are likely to take time to develop. However, costs are associated with the extra resources employed in KB research. Extra work on KB is likely to have an opportunity cost in terms of slower progress in improving yield potential or in achieving other objectives in wheat research.

Although the losses from KB are substantial, they should be considered in the context of the total value of production and the costs of other diseases and production constraints. The average annual cost attributable to KB--approximately

2% of the value of wheat production--is less than the expected economic cost of some other diseases, such as leaf rust. Average annual losses from leaf rust have been low in recent years, because of the level of resistance in the varieties grown and the greater mix of varieties. However, the potential for increased losses from leaf rust emphasizes the need for caution in transferring research resources from leaf rust to KB, and indicates the need for new, additional funds to be used for KB research.

In determining the appropriate policy response to KB, it is important to consider what level of risk should be accepted in attempting to control the disease. The current policies in relation to KB are virtually "no risk" policies. However, a "no-risk" policy has costs as well as benefits, and the costs merit examination. It is apparent from the estimates presented in this report that measures to control KB, such as the planting restrictions in southern Sonora, often have high costs. In addition, the embargo on the movement of seed from infected areas has a high cost in terms of the reduced benefits flowing from the breeding programs in those areas in the future. Therefore, before implementing policies in relation to KB, the costs imposed by the policies need to be considered in the context of their economic benefits.

The estimates of the economic losses from KB, which are presented for the first time in this report, are necessarily tentative, given the hidden nature of many of the costs, the conceptual issues involved in identifying the losses caused by the disease, and the paucity of data available. The results emphasize the economic importance of KB and the need to research and develop effective measures of control. In addition, the high costs of some of the control measures are identified, which makes it possible to evaluate the merits of some of these measures in relation to their costs.

Chapter 1

Introduction

The effects of the disease Karnal bunt (KB) on Mexico's wheat industry have become a serious concern in recent years, but to date there has been no comprehensive information available on the economic impact of the disease.

Karnal bunt is caused by Tilletia indica Mitra (syn. Neovossia indica [Mitra] Mundkur), which partially infects seed of wheat and triticale. Teliospores of KB are transmitted on the seed and also survive in the soil. In addition, stubble burning disseminates teliospores over long distances (Matsumoto 1986). When KB was first reported on wheat in India during the early 1930s (Mitra 1931), it appeared to be limited in its distribution and to be unimportant. Since then, KB has spread to other similar environments in northern India, northern Pakistan, southern Nepal, and parts of Iraq and Mexico (Warham 1986).

In India KB has gradually increased its incidence and spread since the mid-1970s, notably in the major production regions of Punjab and Haryana (Singh 1986). However, no comprehensive estimate of the economic losses from KB in India is available. Karnal bunt first appeared in Mexico in 1970, but caused little economic loss until the early 1980s, when the level of infestation in some years increased sharply. Initially found in Sonora, the disease spread south into the neighboring state of Sinaloa, and to BCS.

The purpose of this report is to estimate the direct and indirect costs to Mexico associated with KB, as a basis for assessing: 1) the priority that should be given to KB in allocation of wheat research resources, and 2) the appropriate level of investment in measures to prevent its spread to other wheat-growing areas of Mexico.

Estimating the losses associated with KB is more complex than estimating losses for other diseases, mainly because KB reduces quality rather than yield and also because it is a seed-borne disease and indirect costs are incurred in preventing its spread. Further, there is some ambiguity as to which of the costs represent real costs to Mexico and which represent losses for one sector and gains to another.

The economic costs caused by KB can be divided into direct and indirect costs (Table 1.1). Direct costs include yield losses, quality losses (including the cost of handling and marketing infected grain), and the loss of seed export markets in view of restrictions imposed after KB was found in Mexico. Indirect costs are associated with preventing the spread of KB or reducing its severity. These preventive measures affect commercial grain production, commercial grain shipment, and seed production.

The various direct and indirect costs may be paid by different participants in the wheat industry, from farmers to consumers, as well as by taxpayers, who pay for enforcement measures. Since this report is primarily concerned with costs to Mexico and not their distribution between different entities, we express prices in terms of opportunity values or costs whenever possible.

Table 1.1. Costs associated with Karnal bunt

Direct costs
Value of yield loss
Loss of value of infected grain (quality loss)
Loss of seed exports
Indirect costs
Losses associated with planting restrictions
Costs for regulating authorities
Fumigation costs associated with grain shipments
Rejection losses to seed producers
Loss of efficiency in seed production
Seed treatment cost

Estimates of these costs can serve two main purposes. First, direct losses can be compared to potential losses from other diseases as a basis for assigning research resources to breeding for disease resistance and higher yield. Investment in research to reduce KB losses implies a tradeoff with other opportunities in wheat research, such as increasing yield potential or developing resistance to other diseases. Second, estimated costs of preventive measures can be compared to the potential losses that would be incurred if KB were to become more severe in areas already infested, or if it were to spread to new areas. For example, what would be the cost if KB were to spread to other wheat-growing areas of Mexico? How much investment in quarantine measures can be justified in trying to prevent such spread, and at what risk?

Basis of Valuation of Wheat Losses

The real cost to Mexico of resources lost through KB and resources used to reduce losses from KB is determined by the income that those resources could have generated if they were used elsewhere. We use the concept of "opportunity value" in determining prices and values in this report, where possible, rather than using the official prices paid to farmers in Mexico (Appendix C). To value the production of wheat and alternative crops, we use the estimated CIF (cost, insurance, and freight) import price for imported commodities such as bread wheat, and the estimated FOB (free on board) export return, adjusted for transport costs, for exportable commodities such as wheat seed. Similarly, in predicting likely average losses, a long-term trend price is more appropriate than a price in a specific market at a particular time, which may be affected by short-term factors.

The real long-term CIF trend price (in 1989 dollars) for bread wheat is estimated at US$ 190/t, or MN$ 456,000/t at a 1989 exchange rate of MN$ 2,400/US$ 1 (Table 1.2 and Appendix C).[1] Since durum wheat in Mexico is used for pasta, bread, and livestock feed, the average value of durum wheat produced in Mexico is a weighted average of prices for these uses, estimated at MN$ 407,000/t (a discount of 11% from bread wheat) (Appendix C). Prices for other commodities used in this study are also calculated in Appendix C (Table 1.2).

Table 1.2. Crop prices used in this study[a]

	MN$/t	US$/t[a]
Bread wheat	456,000	190
Durum wheat	407,000	170
Feed wheat	365,000	152
Barley (malting)	388,000	162
Safflower	549,000	229

Source: Appendix C.
a Prices and exchange rates as of April, 1989.
b At exchange rate of MN$ 2,400 = US$ 1.00.

Since the wheat prices used in this study are higher than the 1989 farmer prices in Mexico, the use of real, long-term trend prices leads to higher estimates for some of the costs than would have been obtained with current farm prices.

Organization of This Report

This report is organized as follows. The next chapter contains estimates of the direct costs of KB in northwestern Mexico, and Chapter 3 presents estimates of the indirect costs. The total costs are derived in Chapter 4, followed by an examination of research costs in Chapter 5. Chapter 6 presents the conclusions of the study, with their attendant qualifications.

1 MN = Mexican pesos (*moneda nacional*).

Chapter 2

Estimated Direct Costs of Karnal Bunt in Northwestern Mexico

Yield Losses in Sonora

Indian scientists have found a weight loss (and hence a yield loss) in KB-infected grain (Singh 1986, Warham 1986). An average weight loss in infected grain is about 25%, so that for each 1% of infected grain there is a 0.25% weight loss. In southern Sonora, loads of wheat are tested for the level of KB infection as they are delivered to grain receival depots. The various levels of infected grain in wheat samples tested from 1981/82 to 1988/89 are shown in Table 2.1.

Table 2.1. Percentage of samples by level of infected grain (%), southern Sonora, Mexico

	Percent of infected grain					
Year	0	0.1-0.5	0.5-1	1-2	2-3[a]	>3[a]
1981/82	94.2	5.4	0.3	0.1	0.0	0.0
1982/83	35.6	48.6	8.6	3.3	1.6	2.3
1983/84	82.4	15.7	0.9	0.5	0.3	0.2
1984/85	31.7	44.7	8.2	6.4	3.1	5.9
1985/86	51.3	39.3	4.3	2.5	1.3	1.3
1986/87	97.5	2.4	0.1	0.0	0.0	0.0
1987/88	97.0	2.9	0.1	0.0	0.0	0.0
1988/89	38.9	45.6	4.9	4.3	1.6	4.7

Source: Appendix D.

a After examining the original data, the subdivision of the "*muy fuerte*" classification (>2% infected grain) in Appendix D was divided into two categories: 2-3% and >3%.

In a season with severe disease infection such as 1984/85, 68.3% of loads delivered to depots had KB infection; of these, 5.9% had greater than 3% infection. In a season such as 1987/88 when disease incidence was low, 3% of the loads tested had some infected grain, but none had more than 2% infection. On average over the eight years to 1988/89, 33.2% of the loads tested had some infected grain, of which 1.8% had levels of infected grain higher than 3%.

Assuming that the samples tested were representative of the wheat production, on average a total of 350,000 t of infected grain were produced each year (Table 2.2). Of this, 19,000 t were infected at greater than 3%, the level at which CONASUPO designates infected wheat for feed. In contrast, an average of 682,000 t of uninfected grain were produced each year.

Table 2.2. Estimates of wheat production (000 t) by level of infected grain (%), southern Sonora, Mexico

Year	Percent of infected grain					
	0.1-0.5	0.5-1	1-2	2-3	>3	Total
1981/82	62	3	1	0	0	67
1982/83	472	83	32	16	22	627
1983/84	169	10	5	3	2	190
1984/85	507	93	73	35	67	775
1985/86	415	45	26	14	14	514
1986/87	23	0	0	0	0	24
1987/88	27	0	0	0	0	28
1988/89	428	51	44	34	34	592
Mean, 1982-89	**263**	**36**	**23**	**13**	**17**	**352**

To estimate total yield losses, the midpoint of the range was used for all wheat in the given ranges of infected grains. For loads with greater than 3% infection, the level of infection was found to average 6.6%. On this basis, with average production in southern Sonora of 1.03 million tons, the average loss of production was 687 t, or 0.07% per year (Table 2.3). At a price of MN$ 456,000/t, the average value of the yield loss was MN$ 313 million per year. Since there is no KB in northern Sonora, this figure represents the estimated average annual value of yield loss from KB in Sonora State.

Table 2.3. Estimates of production losses (t) through lower yields, southern Sonora, Mexico

Year	Percent of infected grain					
	0.1-0.5	0.5-1	1-2	2-3	>3	Total
1981/82	39	6	4	0	0	49
1982/83	295	157	121	100	446	1,118
1983/84	106	18	20	20	43	207
1984/85	317	175	272	216	1,346	2,326
1985/86	259	85	99	86	274	803
1986/87	15	1	0	1	0	16
1987/88	17	1	1	0	0	19
1988/89	271	87	153	95	737	1,343
Mean, 1982-89	**165**	66	84	65	**308**	687

Quality Losses in Sonora

The price farmers receive for grain infected with KB depends upon the percentage of infected grain found. Since 1984, a 1% price discount for each 1% of infected grain has been in effect, beginning at 0.1% and continuing to 3%. Loads with greater than 3% of infected grain have been accepted by CONASUPO at the price of grain for livestock feed.

These discounts are a cost to farmers, but it is unclear whether the discounts reflect the true cost to Mexico of the infected grain. Grain lots with less than 3% infection can be milled without penalty, and those with more than 3% infection can be blended with sound wheat to lower the infection percentage. Alternatively, if the infected grain is washed and cleaned first, millers can use grain with higher levels of infection before the taste and quality of processed wheat products are affected, although the levels of infected grain that can be used have not been clearly established. Sekhon et al. (1981) found that samples with 5% infected grain could produce satisfactory products if they were washed first, whereas samples with 10% infected grain could be used if they were first washed and steeped. However, Medina (1985) found that, even with washing and steeping, 7% infection affected bread-making characteristics. The extent to which infected grain is blended and washed will affect the costs to Mexico of KB. However, it has not been possible in this study to determine the extent of blending and/or washing of grain in Mexico, although it appears that, even in the absence of KB, washing grain is a standard procedure in many flour mills.

As noted earlier, grain with more than 3% infection is sold by CONASUPO as feed. Therefore, for the purposes of this report, the estimated losses to Mexico are taken as those losses relating to heavily infected grain (>3%). We assume that grain with less than 3% infection is easily and cheaply blended with sound wheat without any penalty in end use.

In estimating total price discounts, wheat loads with greater than 3% infection were assumed to be sold for livestock feed with a discount of 20% from the price for food wheat (Table 2.4). On this basis, with average production in southern Sonora of 1.03 million tons and a world price of MN$ 456,000/t, the average total discount was MN$ 2,404 million per year.

Table 2.4. Price discounts for each infection category, Mexico

Percent of infected grain	Average discount (%)	(MN$/t)[b]
0.1 - 0.5	0.25[a]	1,140
0.6 - 1	0.75[a]	3,420
1.1 - 2	1.50[a]	6,840
2.1 - 3	2.50[a]	11,400
> 3	20.00	91,200

a For midpoint of the range.
b Based on price of MN$ 456,000/t.

Of the total discount, MN$ 1,711 million accrued to grain with more than 3% infection (Table 2.5), and this is taken as the true cost to Mexico of the reduction in quality due to KB.

Table 2.5. Estimated value of quality losses in southern Sonora, Mexico[a]

Year	Quality losses (MN$ million)
1981/82	0
1982/83	2,032
1983/84	196
1984/85	6,138
1985/86	1,251
1986/87	0
1987/88	0
1988/89	4,072
Mean, 1982/89	**1,711**

a Valued at price of MN$ 456,000/t.

Yield Losses in Sinaloa

In Sinaloa wheat is tested for KB at harvest from trucks in farmers' fields. It is uncertain how much effect the different sampling procedures in Sinaloa and Sonora have on the levels of infection detected, since some farmers in Sinaloa have opportunities to mix infected grain with cleaner grain to lower the level of infection before testing. Thus it is possible that the levels of infection in grain delivered to the receival depots in Sinaloa are lower than the levels indicated by the samples taken on the farms. The possibility of mixing before delivery depends on whether the farmer has an alternative source of clean grain, which is less likely for smaller than for larger growers. The extent of mixing is unknown, and therefore this report assumes that the levels of infection detected in the field samples are the same as if the samples were taken at the grain receival depot. To the extent that grain is mixed in Sinaloa before delivery, this assumption will lead to an overestimate of the amounts of highly infected grain received for processing.

Table 2.6. Percentage of samples by level of infected grain (%), Sinaloa, Mexico

Location and year	Percent of infected grain 0	0.1-0.5	0.5-1	1-2	2-3	>3
Northern Sinaloa						
1983/84	92.9	7.1	0.0	0.0	0.0	0.0
1984/85	49.1	36.2	3.6	4.9	1.8	4.4
1985/86	15.9	34.1	9.5	9.5	5.1	25.9
1986/87	71.2	24.9	1.6	0.9	0.9	0.5
1987/88	85.6	14.4	0.0	0.0	0.0	0.0
1988/89[a]	14.4	49.9	9.8	7.5	9.2	9.3
Central Sinaloa						
1986/87	88.2	8.9	1.3	0.7	0.5	0.4

Source: Appendix D.

a Percentage of area by level of infected areas.

In northern Sinaloa during 1985/86, the season with the highest KB incidence, 84.1% of samples tested had some KB infection, and of these 25.9% had greater than 3% infection (Table 2.6). In 1987/88, a season of low disease incidence, 14.4% of samples tested had some infected grain, but none had more than 1% infection. On average over the 6 years to 1988/89, 59.4% of samples tested had some infected grain, of which 10.5% had infection levels higher than 3%. Assuming that the northern areas of Sinaloa (Los Mochis and Guasave) represent an average of 60% of the total wheat area in Sinaloa, the average production in northern Sinaloa with infected grain was 293,000 t (Table 2.7), compared to an average of 315,000 t with no KB infection.

Table 2.7. Estimates of production (000 t) by level of infected grain (%), northern Sinaloa, Mexico

Year	Percent of infected grain 0.1-0.5	0.5-1	1-2	2-3	>3	Total
1983/84	43	0	0	0	0	43
1984/85	292	29	40	15	36	411
1985/86	248	69	69	37	188	611
1986/87	68	4	2	2	1	79
1987/88	89	0	0	0	0	89
1988/89	304	60	46	56	57	523
Mean, 1984-89	**174**	**27**	**26**	**18**	**47**	**293**

Total yield losses in northern Sinaloa were estimated in the same way as the losses in southern Sonora. The average level of infection for grain with more than 3% infection was calculated from the original data for each year and ranged from 5% in 1986/87 to 12.2% in 1985/86. With average production in northern Sinaloa of 608,000 t, the average loss of production was 1,631 t, or 0.27% per year (Table 2.8). At a grain price of MN$ 456,000/t, the average value of the production lost through lower yields was MN$ 744 million per year for northern Sinaloa.

Table 2.8. Estimates of production losses (t) through lower yields, northern Sinaloa, Mexico

Year	Percent of infected grain 0.1-0.5	0.5-1	1-2	2-3	>3	Total
1983/84	27	0	0	0	0	27
1984/85	183	55	148	91	667	1,143
1985/86	155	129	259	231	5,735	6,509
1986/87	43	8	9	15	17	93
1987/88	56	0	0	0	0	56
1988/89	190	112	172	351	1,135	1,960
Mean, 1984-89	**109**	**51**	**98**	**115**	**1,259**	**1,631**

Similar data for central Sinaloa (Mocorito, Culiacán) are available only for 1986/87 (Appendix D). As a result, it is impossible to estimate losses from KB in central Sinaloa with the same degree of detail. It is known, however, that the disease has been less severe in central Sinaloa than in the north of the state. The approach taken was to assume that the levels of infection found in 1986/87 were typical of the region for all years. Since 1986/87 was a year of low KB infection in northern Sinaloa. this assumption could lead to an underestimate of the losses if the level of infection were low that year in central Sinaloa. For the average production of 301,000 t, the estimated annual yield losses for central Sinaloa were 56 t (0.02% of production), valued at MN$ 26 million. Hence, for the whole of Sinaloa State, the value of the average annual yield losses is estimated at MN$ 770 million (US$ 321,000).

Quality Losses in Sinaloa

Using the same methods for assessing losses in wheat quality because of KB in Sonora, in Sinaloa the average total price discount was estimated at MN$ 5,146 million. As in Sonora, the only portion of the total discount taken as a cost to Mexico is the discount for wheat with more than 3% infected grains. The cost is estimated as MN$ 4,282 million per year for northern Sinaloa (Table 2.9), and MN$ 110 million for central Sinaloa. The total cost to Mexico of quality losses in Sinaloa is estimated as MN$ 4,392 million (US$ 1.83 million).

Table 2.9. Estimated value of quality losses in northern Sinaloa, Mexico[a]

Year	Quality losses (MN$ million)
1983/84	0
1984/85	3,242
1985/86	17,149
1986/87	125
1987/88	0
1988/89	5,174
Mean, 1984-89	**4,282**

a Valued at price of MN$ 456,000/t.

Probability of Karnal Bunt Infection in a Given Year

The estimated yield and quality losses are based on eight years of data in Sonora and six in Sinaloa. These years may or may not represent the long-run incidence of KB losses.

The incidence of KB is determined largely by humidity at wheat heading (which occurs from January to March in northwestern Mexico) and so varies, inter alia, with rainfall incidence at that time (Warham and Flores 1988). The long-term mean rainfall for January-March during 1960-81 was 29.5 mm, compared to an average of

28.6 mm recorded for the same months during 1982-88 (Table 2.10 and Appendix H). The monthly frequency distributions were similar. indicating that rainfall from 1982 to 1988 is representative of the longer term frequencies.

Table 2.10. Rainfall distribution for January-March, Sonora and Sinaloa, Mexico[a]

Range (mm)	Obregón, Sonora 1960-1981	Obregón, Sonora 1982-1988	Ahome, Sinaloa 1960-1981	Ahome, Sinaloa 1982-1987
0.0	5	0	5	17
0.1-10	27	43	42	17
10.1-20	23	14	16	17
> 20	45	43	37	50
	100	100	100	100
Mean rainfall	**29.5**	**28.6**	**25.0**	**32.7**

a Percentage of years in which total January-March rainfall was in the given range.

Similar data for Ahome, Sinaloa, are shown in Table 2.10. The long-term mean rainfall for those months was 25.0 mm, as compared to 32.7 mm for 1981-87. The distributions again are similar, indicating that recent years are representative of the longer term frequencies. On the basis of these figures, we can have some confidence that averages based on data since 1982 can be used to represent the expected average over the long term in southern Sonora and northern Sinaloa.

Loss of Wheat Seed Export Markets

Prior to the outbreak of KB in 1982, southern Sonora exported wheat seed to a number of countries (Table 2.11). In 1983, as a result of the KB infestation in northwestern Mexico, the US and Canada prohibited the importation of seed from Mexico. These countries had not been major clients, but other seed-importing countries also lost interest in importing wheat seed from Mexico. Wheat seed exports from Sonora, which had averaged 13,900 t/yr in the 10 years to 1981, fell to zero by 1984. Since 1984, seed exports from southern Sonora have remained at zero, although some seed was exported from northern Sonora in 1987 and 1988.

Table 2.11. Mexico's wheat seed exports

Year	Sonora (t)	Total (t)	Destination
1964	20	0	USA
1965	40,400	0	India, Guatemala
1966	0	1	--
1967	21,000	66,499	Turkey
1968	1,650	2,607	USA
1969	4,600	5,514	USA, Syria, Libya
1970	11,646	11,814	USA, Algeria, Argentina
1971	59,371	61,189	Iraq
1972	15,493	15,789	Algeria
1973	9,950	10,668	China, Greece
1974	7,495	18,971	China
1975	42,480	30,253	USA, Brazil
1976	10,372	12,252	Spain, Brazil, Greece, Ecuador
1977	14,811	22,797	Libya, Algeria
1978	16,034	13,929	Pakistan, Brazil, Portugal
1979	12,746	14,352	Bangladesh, Libya, Greece
1980	20,161	23,065	Spain, Greece, Bangladesh, USA
1981	4,287	5,000	Greece, Spain
1982	700	638	Greece
1983	71	87	--
1984	0	202	--
1985	0	0	--
1986	0	0	--
1987	2,321	3,500	Bangladesh
1988	2,000	2,000	Tunisia

Source: PRONASE (for Sonora) and SARH (for total). Note that the two series are not directly comparable for all years.

The estimated volume of wheat seed that would have been exported if KB had not existed is difficult to determine. The average of the 10 years to 1981 (13,900 t) and the trend value (based on projecting the trend of the previous 18 years) of 12,700 t/yr from 1983 to 1988 provide possible indications of the volume involved. However, it has been suggested that seed exports have been affected by the fact that several other countries produce varieties derived from the CIMMYT program in Mexico, so that the volume would have declined in any case. In addition, the area sown to wheat in Mexico increased from 700,000 ha in 1980 to almost 1.1 million hectares in 1986, so domestic demand for seed increased sharply.

On the other hand, the world market for wheat seed has been expanding. Saudi Arabian imports of seed of wheat varieties derived from the Mexican program have increased to 150,000 t/yr (Parker 1989), currently imported from the US. If Mexico had been able to supply even a small part of that seed, the volumes involved would have been high. Spain and Turkey are also potential markets for Mexican wheat seed. However, the relatively rapid turnover of wheat varieties in northwestern Mexico means that, unless considerable market information is obtained and seed stocks are held, varieties often are not available when requested. Recent requests for seed by Turkey (10,000 t in 1988) and Saudi Arabia were not met because the varieties requested were unavailable.

It can be argued that seed export embargoes for the KB areas are not necessarily losses for Mexico, provided other KB-free areas could have assumed the role of seed exporter. In this case, the loss of seed exports could be considered a loss for southern Sonora but not a loss to Mexico. Part of the seed export losses, then, can be related to the unresponsiveness of seed producers in other regions of Mexico rather than to KB itself. Nevertheless, since other areas have not taken up seed exports, the seed export losses since 1983 have been real losses for Mexico. When other wheat-producing areas reach the level of organization necessary for seed production that was present in southern Sonora, losses need not continue.

For this report, the volume of lost seed exports is estimated at 12,000 t/yr. This figure was determined as the difference between the average projected trend volume (12,700 t) for 1983-88 and the average seed exports (700 t/yr) over that period.

The cost of lost seed exports is less than the full value of the lost exports, since grain that cannot be exported for seed can still be delivered as commercial grain. The loss of income is valued at the difference between the value of export seed and that of grain delivered to CONASUPO, with the current potential value of seed for export assumed to be the same percentage mark-up from the FOB export price for wheat as it was in 1975-80. Allowing for the extra seed production costs, transport costs from Obregón to Guaymas and the costs of obtaining market information and of holding inventories, the estimated value added by producing export seed wheat is MN$ 220,000/t (Appendix E).

On the basis of 12,000 t/yr lost and a value of MN$ 220,000/t, the average annual value of losses in seed export sales is estimated MN$ 2,640 million (US$ 1.1 million).

Chapter 3

Estimated Indirect Costs of Karnal Bunt in Northwestern Mexico

Losses from Quarantine Restrictions on Planting

Sonora--Quarantine restrictions on planting were imposed on farmers' fields in southern Sonora in 1983/84, following the heavy infestation of KB in 1982/83. If grain delivered to the depot has an infection level of more than 2%, a farmer is restricted from growing wheat for the following three years. If the level of infection is 1-2%, a farmer can sow only durum wheat, whereas if the level is less than 1% there is no restriction. When farmers are prevented from sowing bread wheat, they lose income if bread wheat is more profitable than the alternative. Between 1984 and 1989, an average of 7,357 ha were restricted to "no wheat," and 38,601 ha were restricted to "durum only" (Table 3.1).

Table 3.1. Area (ha) under quarantine restrictions in southern Sonora, Mexico

Year	Yaqui Valley		Mayo Valley		Total	
	No wheat	Durum	No wheat	Durum	No wheat	Durum
1983/84	21,200	24,400	203	205	21,403	24,605
1984/85	4,400 [a]	41,200 [a]	0	408 [a]	4,400 [a]	41,608 [a]
1985/86	4,400 [a]	25,997 [a]	0	3,118	4,400 [a]	29,115 [a]
1986/87	6,602	39,398	360	3,445	6,962	42,843
1987/88	6,614	39,786	360	3,445	6,974	43,231
1988/89	0	46,400	0	3,805	0	50,205
Mean, 1984-89	**7,203**	**36,197**	**154**	**2,404**	**7,357**	**38,601**

a Estimates.

To relate these quarantine restrictions to foregone production of wheat, it is necessary to consider the proportion of the affected wheat area which would otherwise have been sown to wheat the following year. In the four years to 1987/88, wheat in the Yaqui Valley occupied an average of approximately 77% of the total area sown to crops in the invierno (winter) cycle and to cotton (Table 3.2). Thus, on average, only 77% of the area sown to wheat in one year would normally be sown to wheat again the following year. Therefore, of the total of 43,400 ha under quarantine restrictions (Table 3.1) in the Yaqui Valley, 33,418 ha (equivalent to 23% of the average wheat area) can be considered as influenced by the restriction not to sow bread wheat. Of these, 27,872 ha were restricted to "durum only" and

5,546 ha to "no wheat." In the Mayo Valley, assuming 77% of the area would have been sown again to wheat in the absence of restrictions, the areas actually affected by the quarantine were 119 ha for "no wheat" and 1,851 ha for "durum only."

The area restricted to "no wheat" (Table 3.1) was compared to the area sown to the major alternative crops to wheat in the Yaqui Valley (Table 3.2). It is difficult to identify which crops have taken up the area not sown to wheat. Nevertheless, the difference in returns from wheat and those other crops represents an estimate of the losses incurred (i.e., benefits foregone) by farmers who are unable to plant wheat.

Table 3.2. Relative importance of wheat in the Yaqui Valley, Mexico

	Area sown (000 ha)						
Year	**Wheat**	**Barley**	**Safflower**	**Other competitive crops**	**Total invierno cycle**	**Cotton**	**Total**
1984/85	163.5	0.9	2.3	4.4	170.9	21.2	192.1
1985/86	160.2	1.4	4.3	8.2	174.3	9.4	183.7
1986/87	113.6	3.6	9.0	9.5	137.8	33.1	170.9
1987/88	131.9	2.9	5.2	8.2	149.1	40.1	189.2
Mean	**142.3**	**2.2**	**5.2**	7.6	**158.1**	**26.0**	**184.0**

Based on data from farm budgets for the Yaqui and Mayo Valleys, the relative profitability of bread wheat, durum wheat, barley, safflower, and cotton is shown in Table 3.3. The breakdown of wheat yields into bread wheat and durum wheat is based on calculations in Appendix F, where the estimated yield advantage for durum was found to be 10%, or approximately 0.5 t/ha. Production costs for durum and bread wheat are assumed to be the same, based on information from a recent survey of wheat producers in the Yaqui Valley (G. Traxler, CIMMYT, pers. com.). Yields in the Mayo Valley were taken as 90% of those in the Yaqui Valley, and costs per hectare are assumed to be the same in each valley. The output prices used are the local equivalent of international prices (Table 1.2). The figures show that bread wheat is the most profitable crop in each valley, so that any restriction of its cultivation has an economic cost.

Table 3.3. Estimated returns from alternative enterprises in the Yaqui and Mayo Valleys, Mexico

	Bread wheat	Durum wheat	Barley	Safflower
Yaqui Valley				
Yield (t/ha)	4.70	5.20	4.00	1.90
Price[a] ($000/t)	456	407	388	549
Gross income ($000/ha)	2,143	2,116	1,552	1,043
Variable costs ($000/ha)	1,263	1,263	1,268	945
Gross margin ($000/ha)	880	853	284	98
Mayo Valley				
Yield (t/ha)	4.23	4.68	3.60	1.71
Price ($000/t)	456	407	388	549
Gross income ($000/ha)	1,929	1,905	1,397	939
Variable costs ($000/ha)	1,263	1,263	1,268	945
Gross margin ($000/ha)	666	642	129	-6

a Based on international prices (Table 1.2).

In Table 3.4, total losses for farmers from the quarantine restrictions are estimated on the basis of 1) data from the relative losses from producing durum or other crops rather than bread wheat and 2) data on the areas affected. For the Yaqui Valley, 2,000 ha of the "no-wheat" area were assumed to be sown to barley and the remaining 3,546 ha to safflower. For the Mayo Valley, all of the "no-wheat" area was assumed to be sown to barley. The annual losses in southern Sonora, based on current real prices, have averaged MN$ 4,826 million (US$ 2.01 million), with most of the loss coming from land quarantined not to grow wheat.[2] Losses in the Yaqui Valley account for 98% of the total losses in southern Sonora.

Other issues related to the changes in relative production of durum and bread wheat in Mexico are discussed in Appendices G and I.

2 These results are sensitive to the price used for durum wheat. If the marginal value of feed wheat is used, rather than the weighted average value, the price for durum wheat is MN$ 365,000/t. In the Yaqui Valley the loss per hectare where durum replaces bread wheat increases almost ten-fold to MN$ 245,000, and in the Mayo Valley a similar increase occurs. The estimated losses in southern Sonora, using the marginal (feed) value for durum, increase by MN$ 6,439 million to $11,265 million (US$ 4.69 million). Thus if the marginal value is used, the total costs of KB increase substantially.

Table 3.4. Estimated losses from quarantine restrictions, southern Sonora, Mexico

Location and replacement crop	Difference in profitability (MN$ 000/ha)	Area (ha)	Total (MN$ million)
Yaqui Valley			
Bread wheat replaced by:			
· Durum	27	27,872	753
· Barley	596	2,000	1,192
· Safflower	782	3,546	2,773
· Subtotal	--	33,418	4,718
Mayo Valley			
Bread wheat replaced by:			
· Durum	24	1,851	44
· Barley	537	119	64
· Safflower	672	0	0
· Subtotal	--	1,970	108
Total		**35,388**	**4,826**

Sinaloa--Although quarantine regulations have existed in Sinaloa since 1986, they have been essentially ineffective and therefore have caused no losses to date. The area sown to different crops in Sinaloa in recent years is shown in Table 3.5. If quarantine restrictions are imposed rigorously in Sinaloa in the future, the average losses per hectare from quarantine can be expected to be smaller than those in southern Sonora, because wheat yields in Sinaloa are generally lower. The estimated returns of various crops in Sinaloa in 1988/89 are shown in Table 3.6. Again, any restriction on the production of bread wheat is likely to lead to a reduction in farmers' income.

Costs of Testing for Karnal Bunt and Enforcing Karnal Bunt Regulations

Coronel (1988) provides some detailed estimates of the additional costs associated with sampling and testing for KB by Sanidad Vegetal in Sinaloa (Table 3.7). The average costs from 1986 to 1988 were MN$ 362 million (US$ 151,000) in 1989 values.

Table 3.5 Area (000 ha) sown to different crops in Sinaloa, Mexico, 1980-88

Year	Wheat	Safflower	Beans	Chickpeas
1980/81	127	239	126	3
1981/82	182	115	166	11
1982/83	120	237	118	30
1983/84	207	122	91	18
1984/85	279	126	44	50
1985/86	297	62	96	31
1986/87	135	86	150	67
1987/88	91	136	105	19

Table 3.6 Estimated returns from alternative enterprises, Sinaloa, Mexico

	Bread wheat	Durum wheat	Safflower	Beans	Chickpeas
Yield (t/ha)	3.9	4.3	1.0	1.2	1.3
Price[a] (MN$ 000/t)	456	407	549	680	1,890
Gross income ($ 000/ha)	1,778	1,750	549	816	2,457
Variable costs ($ 000/ha)	1,101	1,101	835	1,439	1,049
Gross margin (MN$ 000/ha)	677	649	-286	-623	1,408

a Based on international prices (Table 1.2).

Table 3.7 Costs (MN$ 000) of Sanidad Vegetal associated with sampling for Karnal bunt, Sinaloa, Mexico

Costs[a]	1986	1987	1988
Salaries	30,869	58,458	214,888
Vehicle rental	28,650	54,337	199,591
Extra time	36,960	22,783	91,041
Travelling allowance	7,200	--	23,501
Total	**103,680**	**135,578**	**529,021**
Total (1989 prices)	**346,703**	**182,587**	**556,620**

Source: Coronel (1988).

a Costs refer to salaries of 202 technicians, 202 vehicles, extra time for 154 technicians, and travel allowance for 15 technicians.

As noted earlier, in Sinaloa all samples are taken at harvest from trucks in farmers' fields, whereas in Sonora samples are taken when trucks arrive at grain receival depots; sampling costs in Sonora are therefore considerably lower. Although sampling and testing for other grain characteristics would have been done anyway, there are opportunity costs of the additional time spent analyzing samples for KB. Using an estimate of 50 samples analyzed per day per person, the annual average of 7,871 samples would involve approximately 157 person-days, or 32 person-weeks for a 5-day week. The estimated annual salary for an assistant is MN$ 5,338,000 (March 1989), so the total cost of analysis for KB would be approximately MN$ 3.3 million (US$ 1,400).

Coronel (1988) provides estimates of the costs of meetings held in relation to KB in Sinaloa, estimated at MN$ 2.9 and MN$ 7.2 million for 1986 and 1987, respectively. These represent an average of MN$ 22 million (US$ 9,000) per year at current prices. A similar cost is assumed for both Sonora and Sinaloa.

Since the regulations in Sonora are enforced through the planting permit, there are no extra costs associated with enforcement of KB quarantine regulations.

Costs of Fumigating Grain Shipments

Coronel (1988) supplies estimates for 1987 and 1988 of costs in Sinaloa for fumigating grain shipped to markets outside the KB-infected areas (Table 3.8). The average costs for those years in 1989 values is MN$ 105 million. With average production of 710,000 t, annual fumigation costs for Sinaloa total MN$ 148/t. Using the same cost per ton for southern Sonora, where average production is 1,030,000 t, the total cost for Sonora is MN$ 152 million. Total annual costs for Sonora and Sinaloa are MN$ 257 million (US$ 107,000), provided all grain shipments were fumigated.

Table 3.8. Costs (MN$ 000) of fumigation associated with Karnal bunt, Sinaloa, Mexico

Costs	1987	1988	Average
Fumigation of storage areas	15,437	29,007	22,222
Fumigation of wagons	47,783	89,783	68,783
Treatment of threshers	170	319	245
Total	**63,390**	**119,109**	**91,250**
Total (1989 prices)	**85,369**	**125,323**	**105,346**

Source: Coronel (1988).

However, apparently only grain shipped by CONASUPO is fumigated, and, according to CONASUPO, grain shipments from northwestern Mexico would be fumigated even in the absence of KB. If that is so, no costs of grain fumigation can be attributed to KB. Therefore no grain fumigation costs are included in this report, although it will be an underestimate if some of the fumigation costs can be attributed to KB alone.

In some instances, rail trucks are fumigated as they leave KB-infected areas, even if they do not contain grain. The costs of such operations are not included in this report, because of the difficulty of obtaining data on this activity.

Seed Producers' Losses Related to Karnal Bunt

To limit the spread of KB through seed, the Servicio Nacional de Inspección y Certificación de Semillas (SNICS), the national seed certification authority, has regulated the acceptance of infected seed for certified seed. Prior to 1985/86, a level of up to 1% infected grain was tolerated, but from that year to 1989, the policy was zero tolerance for certified seed. In 1989, the tolerance level was raised to 0.02% following concerns about seed shortages. Seed producers incur losses when crops are rejected for seed after additional seed production costs have been incurred. Seed growers in the Yaqui Valley estimate that the additional costs involved in growing seed are about MN$ 50,000/ha, of which MN$ 35,000/ha are incurred before the crop is assessed as suitable for certified seed. Therefore if a seed crop is found to have KB and is rejected, the farmer incurs a loss of MN$ 35,000/ha.

Seed is rejected for many reasons other than KB infection, including contamination by weed seed and other impurities. The proportion of seed crops in southern Sonora rejected because of KB has ranged from 35% in 1982/83 to 1.1% in 1983/84. An average of 2,299 ha, or 19.2% of the area sown for seed, has been rejected because of KB in the six years to 1987/88 (Table 3.9). Thus, the average losses incurred in southern Sonora for seed producers having seed rejected for KB are MN$ 81 million (US$ 34,000). These losses are lower than they would have been if seed production had not shifted away from KB areas to other areas of Mexico.

For Sinaloa, an average of 773 ha of seed has been rejected each year between 1984 and 1988. At MN$ 35,000/ha, the average annual losses are estimated at MN$ 27 million (US$ 11,000).

Under a policy of zero tolerance for KB in seed, the proportion of crops rejected would be higher than the average of the past six years. In 1987/88, even though only 3% of grain samples in southern Sonora were infected with KB (Table 2.1) (compared to an average of 34% over the previous six years), 23% of seed crops were rejected in southern Sonora because of KB (Table 3.9). In a year with a more severe infection, the rate of seed rejection is likely to be higher. However, in 1989 the tolerance level for KB in seed was set at 0.02%.

Table 3.9. Effects of Karnal bunt on seed production, southern Sonora and Sinaloa, Mexico

Year	Area sown (ha)	Seed rejected because of Karnal bunt (ha)	(%)
Southern Sonora			
1982/83	11,746	4,111	35.0
1983/84	14,750	162	1.1
1984/85	17,075	4,610	27.0
1985/86	14,042	2,948	21.0
1986/87	7,739	510	6.6
1987/88	6,322	1,454	23.0
Mean, 1983-88	**11,946**	**2,299**	**19.2**
Sinaloa			
1983/84	3,664	0	0.0
1984/85	4,977	0	0.0
1985/86	6,797	3,863	56.8
1986/87	622	0	0.0
1987/88	2,572	0	0.0
Mean, 1984-88	**3,726**	**773**	**20.7**

Source: Servicio Nacional de Inspección y Certificación de Semillas (SNICS).

Possible Use of Fungicide

One option for producers to reduce the incidence of KB is the use of Tilt (propiconazole) fungicide. Two sprays (at 0.5 l/ha each) of the fungicide prior to heading have proved to be moderately to very effective against the disease in boot-inoculation experiments (E. Torres, CIMMYT, pers. com.), indicating the potential of the fungicide against natural infection. Tilt costs MN$ 153,500/L (plus aerial application costs of $31,000/ha), so the total cost of two applications is MN$ 215,500/ha. The use of Tilt is likely to be worthwhile only for seed producers. Tilt often leads to yield increases by controlling other diseases such as leaf rust, so its use could have additional benefits. However, as long as no KB was tolerated in seed, the use of this fungicide was unlikely to be profitable for seed producers, since Tilt only reduces the incidence and does not completely eliminate KB. With the higher tolerance for KB in seed announced in 1989, the use of Tilt could become economic for seed producers. This report includes no costs of fungicide, since there is no evidence that farmers have been using it to date.

Loss of Efficiency in Seed Production

The locations where seed is produced have changed markedly since KB became a problem in northwestern Mexico (Table 3.10). Since 1985/86, PRONASE has not produced seed in Sinaloa or southern Sonora. Some certified seed for Sonora and Sinaloa is now produced by PRONASE in Hermosillo, Mexicali, Caborca, Vizcaino, and Chihuahua. However, most of the certified seed for the region is produced by other seed producers.

Table 3.10 Area (ha) sown for wheat seed production, by state, Mexico

State	1984	1985	1986	1987	1988	Mean
Baja California	5,876	4,434	3,277	10,236	5,010	5,111
BCS	702	2,438	3,277	1,973	1,641	2,006
Sonora	21,285	23,431	8,472	21,445	13,824	17,691
Sinaloa	7,129	10,570	1,107	2,243	2,309	4,672
Chihuahua	1,800	1,321	1,130	2,974	3,462	2,137
Durango	952	1,120	--	1,908	1,696	1,135
Coahuila	3,802	1,241	--	485	278	1,161
Tamaulipas	185	48	302	--	878	283
Jalisco	2,163	4,289	--	5,644	2,686	3,046
Guanajuato	4,333	5,745	6,675	5,659	--	4,462
Puebla	--	298	--	1,442	--	348
Tlaxcala	992	--	--	--	--	198
Estado de México	--	--	--	350	199	110
Monterrey	--	--	--	--	3,375	675
Total	49,669	54,935	20,863	54,359	35,358	43,037

Source: SARH-SNICS, 1989. Subdirección de Programación y Servicios del SNICS.

The shift of seed production to other areas can introduce inefficiencies into seed production, such as higher seed production costs; additional transport costs for seed brought in from other areas; and the loss of use of capital equipment installed for seed production in Sonora.[3]

Seed production costs vary between regions. However, when seed is produced under irrigated conditions and yields are high, the costs per ton are likely to be generally similar between regions, with the major cost differences due to extra transportation of seed.

---

3 The PRONASE seed plant at Obregón was built with a capacity of 50.000 t of seed for US$ 15 million. For the past four years, it has been used for wheat seed produced only in Hermosillo, which is processed at Obregón and then transported to other areas. However, there is no wasted capacity at the plant, since it is used for seed of other crops.

The total seed requirements for the Yaqui and Mayo Valleys (222,000 ha in 1988/89) are approximately 35,000 t. at an average seeding rate of 158 kg/ha (G. Traxler, pers. com.). With certified seed production of 16,200 t in 1987/88, the import requirements from other areas in 1988 were 18,800 t. The cost of transporting seed to Obregón from different areas is shown in Table 3.11. The weighted average transport cost for southern Sonora (based on quantities transported by PRONASE) was MN$ 34,000/t, so that the total extra freight costs were MN$ 639 million (US$ 266,000).

Table 3.11. Costs of transporting seed to Karnal bunt-infected areas

Destination	Origin	Distance (km)	Freight (MN$/t)
Cd. Obregón	Mexicali	950	54,045
	Caborca	540	36,357
	Hermosillo	260	24,278
Los Mochis	Mexicali	1,210	65,262
	Caborca	790	47,143
	Hermosillo	510	35,063
Culiacán	Mexicali	1,390	73,027
	Caborca	970	54,908
	Hermosillo	690	42,829

Source: PRONASE.

For Sinaloa, assuming similar seeding rates and an area planted of 179,000 ha (Appendix B), the estimated seed requirements are approximately 28,000 t. With estimated average seed production of 10,000 t, the import requirements to the state are 18,000 t. The weighted average costs for seed imported into Sinaloa (based on quantities transported by PRONASE) are MN$ 41,000/t, so that the total additional costs are MN$ 738 million (US$ 308,000).

Cost of Additional Seed Treatment

Although seed treatment is only partly effective against KB, seed from the quarantined areas of northern Mexico has been treated with PCNB since 1983 to give some control of the level of KB spread in the seed. Using PCNB is more costly than the Thiram seed treatment that would have been used in the absence of KB. In 1988, the cost of the alternative treatments by PRONASE were MN$ 32,500/t of seed for Quintozeno (PCNB 480 g active ingredient per liter, application 2 L/t) and

MN$ 27,413/t for Thiram (Thylate 480 g active ingredient per liter, application 1.7 L/t), a difference of MN$ 5,087/t. With average seed production in Sonora of 18,000 t/yr, the average annual additional costs were MN$ 92 million. For Sinaloa, with average seed production of 10,000 t/yr, the average additional costs were MN$ 51 million. Total costs were MN$ 143 million (US$ 60,000) per year.

Chapter 4

Estimated Total Costs of Karnal Bunt in Northwestern Mexico

The estimated total costs (direct and indirect) of KB in southern Sonora and Sinaloa are shown in Table 4.1. The total costs per year are estimated at MN$ 16,689 million, with the major components being the quality loss of infected crops (37% of total costs), the loss of wheat seed exports (16%), and the losses from planting restrictions (29%). Costs per hectare in southern Sonora are estimated at MN$ 46,941 per hectare, while in Sinaloa they are MN$ 37,423 (Table 4.2).

Table 4.1. Estimated costs (MN$ million) of Karnal bunt in Sonora and Sinaloa, Mexico

Costs	Sonora	Sinaloa	Total
Direct costs			
• Yield loss	313	770	1,083
• Quality loss	1,711	4,392	6,103
• Loss of wheat seed exports	2,640	0	2,640
Subtotal	**4,664**	**5,162**	**9,826**
Indirect costs			
• Losses from planting restrictions	4,826	0	4,826
• Costs for Sanidad Vegetal	25	384	409
• Fumigation of grain shipments	0	0	0
• Rejection losses for seed growers	81	27	108
• Loss of efficiency in seed production	639	738	1,377
• Additional seed treatment	92	51	143
Subtotal	**5,663**	**1,200**	**6,863**
Total costs to Mexico	**10,327**	**6,362**	**16,689**

Table 4.2. Estimated costs per hectare (MN$/ha) of Karnal bunt, southern Sonora and Sinaloa, Mexico[a]

Costs	Southern Sonora	Sinaloa
Direct costs		
• Yield loss	1,423	4,529
• Quality loss	7,777	25,835
• Loss of wheat seed exports	12,000	0
Subtotal	**21,200**	**30,364**
Indirect costs		
• Losses from planting restrictions	21,936	0
• Costs for Sanidad Vegetal	114	2,259
• Fumigation of grain shipments	0	0
• Rejection losses for seed growers	368	159
• Loss of efficiency in seed production	2,905	4,341
• Additional seed treatment	418	300
Subtotal	**25,741**	**7,059**
Total costs to Mexico	46,941	37,423

a Based on area of 220,000 ha in KB-infested areas in Sonora and 170,000 ha in Sinaloa.

This study makes no separate detailed estimates for Baja California Sur (BCS), as the wheat area affected is considerably smaller than in the states of Sonora and Sinaloa. However, the direct costs can be calculated from infection data in Appendix D. Based on average production of 116,000 t, the yield losses are estimated at 0.003%, or a total loss of 4 t per year. The value of this yield loss is MN$ 2 million per year. The discounts for quality average MN$ 7 million per year. However, since these discounts relate only to grain below 3% infection, on the basis of the assumptions used in this report, no losses are incurred by Mexico. The indirect costs per hectare are assumed to be the same as in Sinaloa (MN$ 7,059/ha). Applying that estimate to the average area of 22,800 ha in BCS (Appendix B), the estimated indirect losses are MN$ 161 million (US$ 67,000) per year.

Thus the total losses from KB in northwestern Mexico are estimated at MN$ 16,852 million (US$ 7.02 million) per year (Table 4.3). In terms of the distribution between states, 61% of the total losses are incurred in Sonora, 38% in Sinaloa, and 1% in BCS.

Table 4.3. Summary of costs (MN$ million) of Karnal bunt, northwestern Mexico

State	Direct	Indirect	Total
Sonora	4,664	5.663	10,327
Sinaloa	5,162	1.200	6,362
BCS	2	161	163
Total	9,828	7,024	16,852

Chapter 5

Costs of Karnal Bunt Research in Mexico

Another cost associated with KB is the cost of research. Because research attempts to reduce the other costs of KB, research costs are not included with the direct and indirect costs in Chapters 2 and 3. However, investment in KB research involves an opportunity cost, since resources invested in KB research cannot be used for other types of research.

Karnal bunt research has been done in Mexico since 1981 by INIFAP (Mexico's National Institute of Forestry, Agriculture, and Livestock Research) at CIANO (the Northwestern Agricultural Research Center) and by CIMMYT. The estimated costs of KB research by INIFAP at CIANO are shown in Table 5.1. These costs relate mainly to the salaries of one scientist, one technician, and two field assistants. Approximately 8 scientist-years (with support staff) were devoted to research into KB at CIANO from 1981 to 1988, at an average cost in 1988 prices of MN$ 59 million (US$ 26,000) per year.

Table 5.1. Costs of Karnal bunt research by INIFAP and CIMMYT

	INIFAP at CIANO		CIMMYT	
	Actual expenditure (MN$ 000)	Expenditure 1988 pesos (MN$ million)	Actual expenditure[a] (US$ 000)	Expenditure 1988 pesos (MN$ million)
1981	1,632	126	3.8	12
1982	1,795	87	0.0	0
1983	1,718	41	145.7	406
1984	2,591	38	213.8	576
1985	5,645	52	221.5	585
1986	10,430	52	219.1	559
1987	19,680	42	109.1	270
1988	34,808	35	80.1	192
Total	**78,399**	**473**	**993.1**	**2,600**

a During 1983-86, a large proportion of the KB research cost was the cost of laboratory and field equipment used in conducting the research.

At CIMMYT, where the number of people involved has been greater and the costs of research per scientist are higher, total research costs have been higher than at INIFAP. The staff involved typically have included one scientist full time and other senior scientists part time, as well as one ingeniero, one technician, and a field assistant. In total, 13.5 scientist-years (with support staff) were involved in KB research at CIMMYT from 1981 to 1988, costing a total of MN$ 2,600 million at 1988 values (Table 5.1). The annual average cost was MN$ 335 million.

Between INIFAP and CIMMYT, a total of MN$ 3,073 million (in 1988 values)[4] has been spent on KB research in Mexico since 1981, with average research costs per year of MN$ 384 million (US$ 160,000).

4 This estimate does not include the cost of visiting scientists working on KB, nor does it include the cost of conferences and workshops on KB, which proved too difficult to identify.

Chapter 6

Conclusions

The estimates prepared in this study represent the first attempt to quantify the economic costs of KB. As such, they are based on often inadequate information and would benefit from more precise data. However, the data used are the best available, considering the paucity of data on many aspects of KB.

The estimated economic losses caused by KB in northwestern Mexico are MN$ 16,852 million per year. Effective measures to control the disease could result in considerable savings. The total economic losses from KB were found to include many indirect costs that had been overlooked in the past.

One particular constraint in preparing the estimated economic losses from KB has been the identification of the costs that represent true losses to Mexico and those that represent losses to producers but transfers to others in the industry. The amount of blending and mixing of infected wheat with sound wheat to reduce the average level of infection has proved difficult to assess. To the extent that some grain with less than 3% infection incurs some cost in terms of its end uses, the estimates in this report will understate the true costs. Similarly, if any of the grain with more than 3% infection is used for food and not feed, the estimates presented will overstate the costs to Mexico.

Presently few options are available to farmers to reduce costs in northwestern Mexico, given that KB is widespread in farmers' fields. Possible future developments include improved seed treatment, more economic fungicides, and the development of varieties resistant to KB. To date, chemical treatments are neither very effective nor economic, and few bread wheat cultivars have been found to have high tolerance or resistance to KB. Resistance is available in durum wheat, triticale, and other species and is likely to be transferred eventually to bread wheats, but to confirm the identity of tolerant cultivars and to transfer tolerance or resistance into suitable high-yielding wheat varieties will take time--perhaps four to five years.

However, costs are associated with the extra resources employed in breeding, and indirect costs are associated with the loss of potential gains from other research programs from which those resources have been drawn. Breeding programs have many objectives, such as breeding for further rust resistance, differences in maturity, and heat tolerance. Extra work on KB is likely to have an opportunity cost: slower progress may be made in improving yields or achieving other breeding objectives.

While the losses from KB are important, it is useful to consider them in the context of the total value of production and the costs of other diseases and production constraints. Average annual wheat production in southern Sonora and Sinaloa is approximately 1.93 million tons. At current prices, the value of wheat production is approximately MN$ 878,000 million. An average MN$ 16,852 million cost attributable to KB represents approximately 2% of the value of wheat production, which is less than the economic costs of some other diseases. For example, the use of fungicide to combat the 1977 leaf rust epidemic in the Yaqui Valley was estimated to have resulted in an increase in production of 100,000 t (Dubin and Torres 1981), so that the potential cost of leaf rust was MN$ 46,000 million at current prices. This figure represents the potential loss from a leaf rust epidemic, even though average annual losses have been very low since then because of the level of resistance in the varieties grown and the greater mix of varieties. However, the need for caution in transferring resources from breeding for leaf rust resistance to research on KB is evident.

Comparisons of KB with other diseases do not belie the fact that KB is an important disease in Mexico, and considerable effort and resources are warranted both to prevent the disease from spreading and also control it at economically negligible levels. In determining the appropriate policy response to KB, it is important to consider how much risk would be acceptable in attempting to control the disease. The current policy in relation to KB is one of "no risk," which does not take into account the costs imposed by that policy in relation to the benefits it provides. In a recent review of quarantine services, the Australian Government (1988) endorsed the principle of risk management in the operation of quarantine restrictions. Thus the appropriate strategy for countering a threatening disease or pest is to assess the risk of each of the options available and to compare the costs and net benefits of those options. It is apparent from the estimates presented that control measures often have high costs.

The amount of resources to invest in controlling a disease depends on: 1) the likely annual losses from the disease; and 2) the costs and effectiveness of the control measures. Therefore, before implementing policies in relation to KB, both the costs and the benefits of those policies must be considered.

Many of the policies adopted to control KB in northwestern Mexico need to be assessed in this context. For example, do the price discounts reflect the true cost of KB to Mexico? Do the benefits of the policy offset the costs associated with the use of KB-free seed in areas where the disease is already present? Are the benefits of the quarantine restrictions greater than the costs? Is it appropriate to attempt to quarantine wheat seed and grain movements in northwestern Mexico? Are restrictions placed on all seed transfers, including those by research and breeding institutions, causing greater potential losses to Mexico than the probable savings?

Price discounts that do not accurately reflect the cost of KB-infected grain to Mexico involve income transfers between producers and processors/consumers. Farmers in southern Sonora and Sinaloa bear the burden of most of the costs of KB. The assumption that grain below 3% infection does not represent a loss to Mexico implies that an average of MN$ 1,259 million (based on farmer prices of MN$ 395,000/t) are losses for farmers but gains to the processing sector each year. In view of this imposition, it is understandable that farmers in the Yaqui Valley should consider that KB is the major wheat disease in that region (Appendix I). A price discount that truly reflected that loss of value from lower quality, without transfers from farmers to others, would be a more appropriate policy to pursue.

The current policy on rejection of KB-infected seed may also be imposing considerable costs. One would expect a positive relationship between rates of infection in seed to rates of infection in the resulting commercial grain in an area where the disease was not already present. However, in an area already affected by KB, it is not evident that some increase in the use of infected seed would lead to higher infection in grain. Relaxing the requirements would increase the seed available from the region and reduce the cost of transporting seed from other regions. On the other hand, the aim of the quarantine measures is to ensure that bread wheat is not sown in fields where teliospores are likely to be present. Therefore, even a small tolerance of infected seed can increase the likelihood of producing an infected crop.

On the basis of the estimates in this report, the planting restrictions appear to be economically difficult to justify. In southern Sonora, where restrictions are effective, the direct losses are MN$ 21,164 per hectare lower than in Sinaloa, where the restrictions are ineffective. However, the costs of the planting restrictions are estimated at MN$ 21,936 per hectare, marginally larger than the difference between regions in direct losses. Therefore, before further restrictions are applied, they need to be examined to ensure that the benefits are likely to outweigh the costs.

Another aspect of the KB problem is the effect that recent restrictions on the movement of breeders' seed have on the breeding programs of INIFAP and CIMMYT. Restricting the flow of wheat seed out of the KB-infected areas could prevent the system of two breeding cycles per year from continuing. Restricting the second cycle would effectively halve the expected rate of yield progress each year, as well as increase the vulnerability to some diseases. These results would incur heavy economic costs on the Mexican wheat industry in the future and delay the development of KB-resistant varieties.

One clear implication of the results of this report is the need for continuing research to overcome and control KB. Possible solutions to the problem appear to be the development of resistant varieties and of effective chemicals to control the disease. In addition, research is needed on agronomic practices (such as crop rotation) to reduce the incidence of the disease and on the most effective means of imposing and maintaining quarantine restrictions without incurring large economic losses by producers.

Losses of the magnitude estimated in this study would appear to justify a considerable research expenditure. With annual losses of MN$ 16,852 million, a real discount rate of 12% per annum, a lag of 10 years before research investments generate useful results, and a 50% probability of success after that time, the research investment that could be economically justified is MN$ 2,700 million (US$ 1.1 million) per year. Even if the expected returns from other research projects are higher, so that a higher discount rate is used, it is possible to justify a considerable research expenditure on KB. These amounts are generally higher than what has been spent on such research in the past. If a successful outcome could be achieved in a shorter time, then the levels of expenditure that could be justified for research would be higher.

These first estimates of the economic losses from KB are necessarily tentative, given that many of the costs are hidden, given the conceptual issues involved in identifying the losses caused by the disease, and given the paucity of data. However, the results of this study emphasize the economic importance of KB and the need to research and develop effective measures of control. In addition, the high costs of some of the control measures have been identified, so that the merits of some of the current policies regarding KB can be evaluated.

References

Australian Government. 1988. *Australian Quarantine--Looking at the Future: A Government Policy Statement.* Canberra: Australian Government Publishing Service.

Byerlee, D., and J. Longmire. 1986. *Comparative Advantage and Policy Incentives for Wheat Production in Rainfed and Irrigated Areas of Mexico.* CIMMYT Economics Working Paper No. 01/86. Mexico, DF: CIMMYT.

Coronel, F. 1988. Evaluación del carbón parcial (*Neovossia indica*). Sinaloa, Mexico: Secretaría de Agricultura y Recursos Hidráulicos. Mimeo.

Dubin, H.J., and E. Torres. 1981. Causes and consequences of the 1976-77 wheat leaf rust epidemic in northwest Mexico. *Annual Review of Phytopathology* 19:41-49.

International Wheat Council. 1989. *Market Report.* 15 May.

Matsumoto, T.T. 1986. Searching for *Tilletia indica* in southwest USA. In *Proceedings of the Fifth Biennial Smut Workers' Workshop, Ciudad Obregón.* Mexico, DF: CIMMYT. 8.

Medina, C.L. 1985. Efecto de diferentes niveles de infección con carbón parcial en la calidad de trigo y las características organolépticas del pan. BSc thesis, Technical Institute of Sonora, Ciudad Obregón, Sonora.

Mitra, M. 1931. A new bunt on wheat in India. *Annals of Applied Biology* 18(2):178-179.

Parker, J.B. 1989. Using policies and technology to boost wheat production: The example of Saudi Arabia. *World Agriculture: Situation and Outlook.* Washington DC: Economic Research Service, United States Department of Agriculture, March: 27-32.

Sekhon, K.S., S.K. Randhawa, A.K. Saxena, and K.S: Gill. 1981. Effect of washing/steeping on the acceptability of Karnal bunt infected wheat for bread, cookie and chapati making. *Journal of Food Science and Technology* 18: 1.

Singh, D.V. 1986. Bunts of wheat in India. In L.M. Joshi, D.V. Singh, and K.D. Srivastava (eds.), *Problems and Progress of Wheat Pathology in South Asia.* New Delhi: Malhotra.

Warham, E.J. 1986. Karnal bunt disease of wheat: A literature review. *Tropical Pest Management* 32(3): 229-242.

Warham, E.J., and D. Flores. 1988. Farmer surveys on the relation of agronomic practices to Karnal bunt disease of wheat in the Yaqui Valley, Mexico. *Tropical Pest Management* 34(4): 373-381.

Appendix A

Contacts Made in Carrying Out This Study

Table A.1. Contacts made in carrying out this study

State and organization	Contact
Sinaloa	
SARH/CIAPAN	• Dr. Juan Manuel Ramírez *(Director)* • Ing. Juan Díaz Maldonado *(Subdirector)* • Ing. Salvador Cortez Acosta *(Jefe de Campo)* • Lic. Francisco Coronel Elenes *(Economist)*
SARH	• Ing. Gilberto Contreras Nateras *(Director)*
SARH/ SANIDAD VEGETAL	• Ing. Jorge Ricardo García Ussher, Culiacán • Ing. Rubén Nieblas Toledo, Los Mochis
CONASUPO	• Lic. Oscar Benito Flores Díaz *(Subdirector)*
SARH/SNICS	• Ing. Jesús López Vega
CPIEAS	• Ing. Francisco Javier Palacios Sarabia *(Gerente de la Comisión, Comisión Permanente para la Investigación y Experimentación Agrícola en Sinaloa)*
Sonora	
SARH/CIANO	• Dr. Ernesto Samayoa *(Director)* • Ing. Jesús Martínez Santana • Dr. Emilio Jiménez • Ing. Pedro Figueroa
SARH	• Ing. Alberto Zazueta Nieblas *(Subdelegado Agrícola)*
SARH/SNICS	• Ing. José Rodríguez Vallejo *(Director)*
SARH/ SANIDAD VEGETAL	• Ing. Alejandro Trueba Carranza *(Director)*
SARH	• Ing. Manuel Lira *(Jefe de Programa Agrícola)* • Ing. Rosario Espinosa *(Jefe de Estadística)*

Table A.1. Contacts made in carrying out this study (cont'd)

State and organization	Contact
Sonora, cont'd	
SARH/SNICS	• Ing. Pablo Sánchez
SARH/PRONASE	• Ing. Alejandro Cancino *(Jefe)* • Roberto Torres Lucenilla *(Producción de Campo)* • Juan José Ruíz *(Producción de Planta)* • Salvador Mesa Espinosa *(Comercialización)*
CONASUPO	• Lic. Emeterio Ochoa *(Subdelegado Estatal)*
ANAGSA	• Ing. Adalberto Atondo *(Director)* • Ing. Alejandro Gastelum Zazueta *(Subdirector, Aseguradora Nacional Agrícola y Ganadera, SA)*
Farmers	• Various, Yaqui Valley
Baja California Sur	
INIFAP	• Ing. Oscar Leal Acosta *(Jefe del Campo, Experimental Valle de Santo Domingo)*
Mexico	
CIMMYT	• Dr. G. Vázquez *(Consultant, Wheat and Maize Programs)* • Dr. Pedro Brajcich *(Durum breeder, Wheat Program)* • Dr. E. Torres *(Pathologist, Wheat Program)* • Dr. G. Fuentes *(Pathologist, Wheat Program)* • Dr. P.A. Burnett *(Pathologist, Wheat Program)* • Dr. E. Duveiller *(Bacteriologist, Wheat Program)* • Dr. L. Gilchrist *(Pathologist, Wheat Program))* • Ing. J.L. Feregrino *(Meteorologist, Experiment Stations)* • Sr. R. Márquez *(Superintendant, Experiment Stations)* • Dr. J. Stewart *(Executive Officer, Experiment Stations)* • Dr. R. Varela *(Assistant Head, Experiment Stations)* • K. Hart *(Financial Officer)* • G. López *(Supervisor, Accounting)* • Dr. A. Amaya *(Head, Wheat Quality Laboratory)* • H. Alvarez *(Head, Purchasing)* • J. Díaz. *(Assistant, Purchasing)*

Table A.1. Contacts made in carrying out this study (cont'd)

State and organization	Contact
Mexico (cont'd)	
SARH/SNICS	• Ing. Felipe Orozco
SARH/ SANIDAD VEGETAL	• Ing. Laura Nieto
SARH/PRONASE	• Ing. Rodolfo Díaz de la Vega *(Gerencia Comercial)* • Ing. Juan Hernández *(Jefe del Departamento de Ventas)* • Dr. Jesús M. Sixto Martínez *(Producción)* • Ing. Luis Meya *(Beneficio)*
GAMESA	• Ing. Raúl Miranda *(Gerente de Producción)*
Guanajuato	
SARH/CEB	• Ing. Gerardo Alberto Longoria *(Director)* • Ing. Rafael Bujanos Muñiz *(Subdirector, Campo Experimental del Bajío)* • Dr. Antonio Castrejón S. *(Cereal Pathology)* • Ing. Felipe Delgadillo S. *(Maize, Bean, and Horticultural Pathology)*
SARH	• Ing. Jesús Romero Chávez *(Delegado del Estado)*
SARH/PRONASE	• Ing. Benjamin Gudiño Maldonado *(Delegado Regional PRONASE, Cortazar)* • Ing. David Horacio Sánchez Alvarez *(Coordinador Regional de Producción de Campo)* • Ing. Francisco Hidalgo Torres Ramírez *(Coordinador Regional de Comercialización)*
Jalisco	
SARH/CEAJ	• Ing. Javier Ireta Moreno *(Pathologist, Campo Experimental "Altos de Jalisco")*
Pakistan	
CCRI	• Dr. Ali Hadder *(Wheat Breeder)*

Appendix B

Wheat Area, Production, and Trade Data for Mexico

Table B.1. Wheat imports and exports (t), Mexico

Year	Imports	Exports
1961	6,860	44
1962	24,780	1,034
1963	42,172	72,531
1964	57,862	575,905
1965	11,577	684,815
1966	960	47,660
1967	1,087	278,872
1968	1,376	2,714
1969	596	252,827
1970	601	41,670
1971	177,505	85,642
1972	640,652	15,845
1973	718,570	10,704
1974	975,903	18,971
1975	87,325	36,520
1976	1,505	12,591
1977	476,196	22,879
1978	505,788	15,515
1979	1,147,948	14,380
1980	822,670	23,147
1981	1,127,927	5,457
1982	517,318	1,212
1983	422,627	96
1984	345,037	297
1985	560,506	0
1986	224,093	0
1987	434,580	3,500

Table B.2. Wheat area (000 ha), by state and zone, Mexico

Zone	State	1980	1981	1982	1983	1984	1985	1986	1987	1988	Average
5	Aguascalientes	0.1	0.3	0.1	0.1	0.1	0.0	0.1	0.0	0.1	**0.1**
1	B.C. Norte	60.7	48.5	81.9	89.0	81.9	87.3	95.9	87.1	58.0	**76.7**
1	B.C. Sur	17.7	25.3	26.4	19.9	19.6	26.4	25.9	16.4	27.2	**22.8**
5	Chiapas	0.5	0.1	0.1	0.3	_	_	_	0.0	0.0	**0.1**
4	Chihuahua	48.9	70.9	89.7	90.1	62.0	63.1	58.5	55.0	61.1	**66.6**
4	Coahuila	17.1	33.3	17.9	20.7	13.0	14.9	12.9	11.8	14.5	**17.3**
4	Durango	9.3	16.5	11.6	8.5	7.2	13.8	11.3	10.8	15.1	**11.6**
3	Edo. México	6.6	6.6	7.2	13.4	16.7	11.7	12.5	22.1	35.5	**14.7**
2	Guanajuato	61.9	83.8	91.0	92.2	140.5	172.7	163.0	157.3	116.4	**119.9**
3	Hidalgo	2.3	4.6	2.1	0.8	0.7	0.7	1.3	1.3	7.1	**2.3**
2	Jalisco	21.0	26.2	30.1	17.9	29.1	39.4	42.6	44.1	38.0	**32.0**
2	Michoacán	20.4	32.1	28.9	12.5	21.8	38.0	46.6	47.1	46.0	**32.6**
3	Morelos	0.0	0.3	0.9	0.5	0.5	0.0	0.5	1.0	1.6	**0.6**
5	Nayarit	0.1	0.1	0.0	_	_	_	0.0	0.0	_	**0.0**
4	Nuevo León	19.0	32.3	25.2	39.0	28.0	22.5	12.5	37.0	21.8	**26.4**
5	Oaxaca	14.7	13.0	9.7	13.2	13.1	14.6	8.1	7.7	11.7	**11.8**
3	Puebla	5.6	13.2	24.5	15.4	20.3	20.0	13.1	15.1	18.0	**16.1**
2	Querétaro	3.9	5.8	4.4	4.4	6.4	8.1	7.3	5.5	4.6	**5.6**
5	San Luis Potosí	3.2	2.5	1.4	1.8	4.9	2.4	0.8	1.7	2.9	**2.4**
1	Sinaloa	109.1	125.5	181.0	118.3	205.4	272.1	295.2	133.4	90.6	**170.1**
1	Sonora	283.3	288.4	343.7	292.6	315.0	342.1	358.0	283.6	278.7	**309.5**
5	Tamaulipas	0.4	0.5	1.4	1.1	2.5	8.7	8.0	12.7	24.5	**6.7**
3	Tlaxcala	3.0	11.1	16.5	15.4	20.3	20.6	22.2	28.3	30.7	**18.7**
5	Veracruz	4.7	4.4	0.7	3.0	2.8	_	0.6	0.7	0.2	**1.9**
5	Zacatecas	10.2	14.5	3.4	3.8	5.0	24.9	4.9	8.1	8.0	**9.2**

Zone		1980	1981	1982	1983	1984	1985	1986	1987	1988	Average
1	Northwest	470.8	487.7	633.0	519.8	621.9	727.9	775.0	520.5	454.6	**579.0**
2	Bajío	107.2	147.9	154.4	127.0	197.8	258.2	259.6	254.0	205.0	**190.1**
3	Central	17.5	35.8	51.2	45.5	58.5	53.0	49.6	67.9	92.9	**52.4**
4	North	94.3	153.0	144.4	158.3	110.2	114.3	95.2	114.6	112.5	**121.9**
5	Other	33.4	35.3	16.7	23.0	28.4	50.6	22.5	30.9	47.4	**32.0**
National total		**723.7**	**859.8**	**999.8**	**873.9**	**1,016.8**	**1,204.0**	**1,201.8**	**988.0**	**912.3**	**975.6**

Note: These are preliminary data, subject to revision.

Table B.3. Wheat production (000 t), by state and zone, Mexico

Zone	State	1980	1981	1982	1983	1984	1985	1986	1987	1988	Average
5	Aguascalientes	0.1	0.7	0.3	0.3	0.3	0.0	0.1	0.0	0.2	**0.2**
1	B.C. Norte	220.0	207.0	407.6	449.4	389.3	356.3	391.0	402.4	250.7	**341.5**
1	B.C. Sur	90.2	121.4	140.3	99.2	95.3	143.9	129.4	87.7	134.7	**115.8**
5	Chiapas	0.5	0.1	0.0	0.3	_	_	_	0.0	_	**0.1**
4	Chihuahua	171.2	276.8	384.5	367.3	218.5	237.6	237.4	245.9	211.9	**261.2**
4	Coahuila	32.2	48.3	39.8	42.7	36.5	29.6	30.5	24.3	32.3	**35.1**
4	Durango	14.1	40.0	34.4	22.9	20.4	36.0	26.3	31.3	37.3	**29.2**
3	Edo. México	17.5	16.5	20.1	37.7	46.3	22.2	23.6	38.2	51.1	**30.3**
2	Guanajuato	294.0	397.7	489.4	347.9	700.4	891.1	775.8	841.4	581.2	**591.0**
3	Hidalgo	7.7	16.2	5.5	1.8	1.9	1.6	1.9	2.5	6.9	**5.1**
2	Jalisco	64.6	81.5	117.5	48.9	123.5	178.0	176.9	196.9	137.4	**125.0**
2	Michoacán	49.6	94.4	130.7	27.8	68.7	32.7	195.2	217.9	197.6	**112.7**
3	Morelos	0.1	1.0	1.8	0.8	1.1	0.0	1.6	1.7	2.0	**1.1**
5	Nayarit	0.1	0.2	_	0.0	_	_	0.0	_	_	**0.0**
4	Nuevo León	50.3	64.8	49.9	93.8	83.5	42.7	26.9	65.6	47.1	**58.3**
5	Oaxaca	14.9	17.4	7.5	15.3	17.6	24.3	8.2	6.8	14.9	**14.1**
3	Puebla	11.2	29.6	29.6	15.0	27.4	30.6	17.8	26.5	11.5	**22.1**
2	Querétaro	13.2	24.3	14.1	16.9	27.4	33.6	21.7	20.4	19.9	**21.3**
5	San Luis Potosí	2.2	3.1	1.3	1.9	3.5	3.1	0.2	0.9	2.5	**2.1**
1	Sinaloa	458.2	420.0	849.3	466.6	901.6	1,209.2	1,076.3	612.0	397.7	**710.1**
1	Sonora	1,249.2	1,280.0	1,687.4	1,430.7	1,583.6	1,669.0	1,578.5	1,504.4	1,439.3	**1,491.3**
5	Tamaulipas	1.3	1.2	2.4	3.0	7.0	9.9	12.8	23.2	34.4	**10.6**
3	Tlaxcala	5.6	22.1	22.2	22.3	40.1	43.4	32.4	60.3	27.3	**30.6**
5	Veracruz	5.7	7.9	1.1	9.1	3.1	_	0.2	0.5	0.0	**3.1**
5	Zacatecas	11.3	20.7	5.2	5.3	6.3	25.1	4.9	4.7	8.6	**10.2**

Zone		1980	1981	1982	1983	1984	1985	1986	1987	1988	Average
1	Northwest	2,017.6	2,028.4	3,084.6	2,445.9	2,969.8	3,378.4	3,175.3	2,606.5	2,222.4	**2,658.8**
2	Bajío	421.4	597.9	751.7	441.5	920.0	1,135.4	1,169.6	1,276.6	936.1	**850.0**
3	Central	42.1	85.4	79.2	77.6	116.8	97.8	77.3	129.2	98.7	**89.3**
4	North	267.8	429.9	508.6	526.7	358.9	345.9	321.1	367.1	328.6	**383.8**
5	Other	35.5	51.2	17.8	34.9	37.8	62.4	26.5	36.1	60.7	**40.3**
National total		**2,785.0**	**3,192.9**	**4,441.9**	**3,526.9**	**4,403.3**	**5,019.9**	**4,769.7**	**4,415.4**	**3,646.5**	**4,022.4**

Note: These are preliminary data, subject to revision.

Appendix C

Estimation of Real Commodity Prices

Prices for Crops in Sonora and Sinaloa

The prices received for various crops in Sonora and Sinaloa for the nine years to 1988/89 are shown in Table C.1. These prices are not used as the basis of valuation of losses in this report; rather, real trend prices are used as a more accurate measure of resource costs.

Table C.1. Prices (MN$/t) for crops in Sonora and Sinaloa, Mexico

	Bread wheat	Durum wheat	Feed wheat	Malting barley	Safflower	Cotton
1980/81	4,600	a	--	6,000	7,800	13,275
1981/82	6,930	a	--	--	11,154	23,547
1982/83	14,000	a	--	17,167	26,400	69,668
1983/84	25,000	a	--	19,200	38,500	79,216
1984/85	37,000	a	--	36,500	63,000	112,300
1985/86	58,000	a	50,000	76,749	113,100	250,279
1986/87	120,000	a	95,000	140,000	225,000	837,067
1987/88	310,000	270,000	b	225,000	530,000	1,318,870
1988/89	395,000	343,600	200,000	440,000	666,000	1,610,400

a Durum and bread wheat received the same price.
b No feed wheat price announced.

Real Bread Wheat Prices in International Markets

Prices for Hard Red Winter Ordinary (FOB, Gulf) from 1959/60 to 1987/88 were deflated by the (US) Consumer Price Index to obtain a real price series in 1989 dollars. A log-linear trend was fitted to this series, resulting in the following trend equation:

$$P_r = \underset{(19.56)}{1372.594} - \underset{(2.31)}{606.424 \log T}, \quad R^2 = 0.165$$

where P_r is the real price in 1989 dollars, T is the number of years since 1900, and the figures in parentheses are t-values.

From this equation, the trend prices were calculated for each year, in 1989 dollars. The trend declined at an average of 1.5% per year. The trend price for 1989 is US$ 190/t. Using the approach of Byerlee and Longmire (1986), Mexico City is assumed to be the main consumption point of wheat. Assuming that the freight costs from US ports to Mexico City are similar to those from northwestern Mexico to Mexico City, the world equivalent price (import parity price) in northwestern Mexico can be taken as US$ 190/t (or MN$ 456,000/t at April 1989 exchange rates of MN$ 2,400 = US$ 1.00).

The estimated long-run average discount for feed wheat is 20%, based on a comparison of long-run wheat and maize prices adjusted for differences in feed value. Thus, the wheat used for livestock feed is valued at MN$ 365,000/t, or US$ 152/t.

Real Durum Wheat Price

The annual premium for US Durum Hard Amber No. 2 export wheat over Hard Red Winter No. 2 wheat from 1980 to 1988 ranged from 4.3% to 37.3%, and averaged 14.4% (Table C.2). Based on the estimated trend price for Hard Red Winter Ordinary No. 2, the average real premium for durum wheat in 1989 prices was MN$ 53,000, or US$ 22/t. On this basis, the world FOB price for durum is taken as MN$ 509,000/t, or US$ 212/t. However, durum wheat in Mexico is not all used to make pasta, because production exceeds pasta use. Therefore, the average value of durum produced in Mexico is a weighted average of the value in each of its end uses (Table C.3). Using the above values for the different end uses of durum, and allowing a 5% cost for blending and lower flour extraction where durum is used in bread production, the weighted average value of durum wheat produced in Mexico is estimated at MN$ 407,000/t (US$ 170/t), a discount of 11% from bread wheat. If the extra durum production is valued at the marginal value, then the value is that of feed wheat (MN$ 365,000/t).

Table C.2. Premium (%) for durum wheat, Mexico

Year	Premium[a]
1980	37.3
1981	16.9
1982	4.3
1983	13.9
1984	9.8
1985	7.9
1986	na
1987	19.0
1988	11.0
Mean	**14.4**

Source: International Wheat Council.

a Premium of Durum Hard Amber No. 2 over Hard Red Winter No. 2 (FOB, Gulf).

na = Not available.

Table C.3. Weighted average value of durum wheat in Mexico

End use	Proportion	Value (MN$/t)
Pasta	0.20	509,000
Bread[a]	0.20	433,200
Feed	0.60	365,000
Weighted average value		**407,440**

a A 5% deduction is made to allow for blending costs and for the lower flour yields of durum wheat.

Real Barley Price

The real barley price was determined by comparing the price for No. 3 or Better Malting 65% or Better Plump (Minneapolis) with that for Hard Red Winter Ordinary wheat (Kansas). For the period 1978 to 1987, barley averaged 85% of the wheat price. Applying that percentage to the real wheat price gives a current real trend price of MN$ 388,000/t, or US$ 161.50/t, for malting barley.

Real Safflower Price

Following Byerlee and Longmire (1986), the CIF price for safflower was determined by assuming that 34% is oil and 66% oilseed cake. Oil was priced the same as cottonseed oil, whereas the meal was priced 10% below soybean meal. The value was discounted by 23% to reflect the costs of processing safflower into oil and cake. Using prices from late April 1989 of US$ 0.22/lb for oil and US$ 222.50/t for meal, the estimated CIF value of safflower was MN$ 549,000/t, or US$ 228.61/t.

Appendix D

Proportions of Samples with Levels of Infected Grain

Table D.1. Proportions of samples with levels of infected grain, southern Sonora, Mexico

Year and infection grade[a]	Yaqui Valley samples (No.)	Yaqui Valley samples (%)	Mayo Valley samples (No.)	Mayo Valley samples (%)	Com. Yaquis samples (No.)	Com. Yaquis samples (%)	Total samples (No.)	Total samples (%)
1981/82								
1	1,010	91.7	459	95.8	374	99.7	1,843	94.2
2	86	7.8	19	4.0	1	0.3	106	5.4
3	5	0.4	1	0.2	0	0.0	6	0.3
4/5	1	0.1	0	0.0	0	0.0	1	0.1
Total	**1,102**	**100.0**	**479**	**100.0**	**375**	**100.0**	**1,956**	**100.0**
1982/83								
1	1,296	34.3	92	27.1	158	71.1	1,546	35.6
2	1,863	49.2	184	54.3	62	27.9	2,109	48.6
3	340	9.0	32	9.4	1	0.5	373	8.6
4/5	283	7.5	31	9.2	1	0.5	315	7.2
Total	**3,782**	**100.0**	**339**	**100.0**	**222**	**100.0**	**4,343**	**100.0**
1983/84								
1	3,464	99.1	1,026	46.4	1,224	99.5	5,714	82.4
2	27	0.8	1,055	47.7	6	0.5	1,088	15.7
3	1	0.05	63	2.8	0	0.0	64	0.9
4/5	1	0.05	69	3.1	0	0.0	70	1.0
Total	**3,493**	**100.0**	**2,213**	**100.0**	**1,230**	**100.0**	**6,936**	**100.0**
1984/85								
1	1,233	27.5	192	9.7	1,019	80.9	2,444	31.7
2	2,375	53.1	868	44.0	202	16.0	3,445	44.7
3	366	8.2	249	12.6	19	1.5	634	8.2
4	259	5.8	224	11.4	11	0.9	494	6.4
5	243	5.4	440	22.3	9	0.7	692	9.0
Total	**4,476**	**100.0**	**1,973**	**100.0**	**1,260**	**100.0**	**7,709**	**100.0**
1985/86								
1	1,309	41.3	1,001	41.6	1,284	90.0	3,594	51.3
2	1,414	44.6	1,200	49.8	138	9.7	2,752	39.3
3	180	5.7	117	4.9	5	0.3	302	4.3
4	125	4.0	49	2.0	0	0.0	174	2.5
5	139	4.4	41	1.7	0	0.0	180	2.6
Total	**3,167**	**100.0**	**2,408**	**100.0**	**1,427**	**100.0**	**7,002**	**100.0**

Southern Sonora (cont'd)

Year and infection grade[a]	Yaqui Valley samples (No.)	Yaqui Valley samples (%)	Mayo Valley samples (No.)	Mayo Valley samples (%)	Com. Yaquis samples (No.)	Com. Yaquis samples (%)	Total samples (No.)	Total samples (%)
1986/87								
1	6,024	99.65	2,496	93.48	710	94.9	9,230	97.64
2	20	0.33	170	6.37	37	5.0	227	2.40
3	0	0.00	4	0.15	1	0.1	5	0.05
4	0	0.00	0	0.00	0	0.0	0	0.00
5	1	0.02	0	0.00	0	0.0	1	0.01
Total	**6,045**	**100.00**	**2,670**	**100.00**	**748**	**100.0**	**9,463**	**100.00**
1987/88								
1	5,137	96.90	1,774	97.25	--	--	7,091	97.00
2	163	3.00	49	2.70	--	--	212	2.90
3	4	0.07	1	0.05	--	--	5	0.07
4	2	0.03	0	0.00	--	--	2	0.03
5	0	0.00	0	0.00	--	--	0	0.00
Total	**5,486**	**100.00**	**1,824**	**100.00**	**--**	**--**	**7,310**	**100.00**
1988/89								
1	1,478	44.5	723	31.0	--	--	2,201	38.9
2	1,657	49.9	921	39.5	--	--	2,578	45.6
3	95	2.9	184	7.9	--	--	279	4.9
4	49	1.5	94	8.3	--	--	243	4.3
5	14	0.4	76	3.2	--	--	90	1.6
6	26	0.8	235	10.1	--	--	261	4.7
Total	**2,390**	**100.0**	**2,333**	**100.0**	**--**	**--**	**5,652**	**100.0**

a Scale:

	Scale	Number of infected grains/kg	Percentage infection
	1	0	0
	2	1-130	0.01-0.52
	3	131-250	0.53-1.00
	4	251-500	1.01-2.00
	5	501 or more	More than 2.00
For 1988/89	5	501-750	2.01-3.00
	6	751 or more	More than 3.00

Table D.2. Proportions of samples with levels of infected grain, Sinaloa, Mexico

Infection grade[a]	Los Mochis samples (No.)	Los Mochis samples (%)	Guasave samples (No.)	Guasave samples (%)	Mocorito samples (No.)	Mocorito samples (%)	Culiacán samples (No.)	Culiacán samples (%)
1986-87								
1	1,176	92.9	621	75.7	319	81.0	993	95.0
2	87	6.9	145	17.7	45	11.4	38	3.6
3	3	0.2	23	2.8	15	3.8	4	0.4
4	0	0.0	16	2.0	6	1.5	3	0.3
5	0	0.0	15	1.8	9	2.3	7	0.7
Total	**1,266**	**100.0**	**820**	**100.0**	**394**	**100.0**	**1,045**	**100.0**

Table D.3. Proportions of samples with levels of infected grain, northern Sinaloa, Mexico

Infection grade[a]	1983/84 samples (No.)	1983/84 samples (%)	1984/85 samples (No.)	1984/85 samples (%)	1985/86 samples (No.)	1985/86 samples (%)	1986/87 samples (No.)	1986/87 samples (%)	1987/88 samples (No.)	1987/88 samples (%)
1	78	92.9	110	49.1	203	15.9	1,079	71.2	95	85.6
2	6	7.1	81	36.2	435	34.1	377	24.9	16	14.4
3	0	0.0	8	3.6	121	9.5	24	1.6	0	0.0
4	0	0.0	11	4.9	122	9.5	14	0.9	0	0.0
5	0	0.0	14	6.2	396	31.0	22	1.4	0	0.0
Total	**84**	**100.0**	**224**	**100.0**	**1,277**	**100.0**	**1,516**	**100.0**	**111**	**100.0**

Table D.4. Percentage area with different levels of infected grain, northern Sinaloa, Mexico

Year	Area (ha)	(%)
1988/89		
1	8,938	14.4
2	30,967	49.9
3	6,060	9.8
4	4,646	7.5
5	11,484	18.5
Total	62,094	100.0

Table D.5. Proportions of samples with levels of infected grain, Baja California Sur, Mexico

Infection grade[a]	1985-86 samples (No.)	1985-86 samples (%)	1986-87 samples (No.)	1986-87 samples (%)	1987-88 samples (No.)	1987-88 samples (%)
1	478	93.4	453	96.4	505	96.7
2	32	6.3	17	3.6	17	3.3
3	2	0.4	0	0.0	0	0.0
4	0	0.0	0	0.0	0	0.0
5	0	0.0	0	0.0	0	0.0
Total	**512**	**100.0**	**470**	**100.0**	**522**	**100.0**

a Scale:

Scale	Number of infected grains/kg	Percentage infection
1	0	0
2	1-130	Until 0.52
3	131-250	Until 1.00
4	251-500	Until 2.00
5	501 or more	More than 2.00

Appendix E

Estimation of Value Added by Wheat Seed Exports

Let the following be prices of seed and grain:

P_c = Commercial price for grain at Obregón
P_{sn} = Retail price for national seed
P_{si} = Retail price for international seed (FOB Guaymas)

If T_{og} is the cost of transport from Obregón to Guaymas, then the value of exported seed at Obregón is

$$P_{si}^{*} = P_{si} - T_{og}.$$

The value added (per ton) by national seed production is

$$V_{sn} = (r\,P_c) - C_n,$$

where r is the proportional increase in price received for seed over grain, and C_n is the additional cost per ton of producing seed rather than commercial grain.

The value added (per ton) by international seed production is

$$V_{si} = (P_{si}^{*} - P_{sn}) + V_{sn} - C_i,$$

where C_i is the additional cost (inventories, market information) involved in seed exporting.

Based on prices received for exports of wheat seed from 1975 to 1980, the ratio of the average FOB price received for seed exports to the average FOB wheat export price was 1.91. On that basis, the price received for wheat seed exports can be expected to be 1.91 times the price received for grain exports. Thus:

$$P_{si} = 1.91\,(P_c + T_{og}).$$

Assume:

- World price for grain is MN$ 456,000 (FOB Guaymas),

- Transport costs Obregón-Guaymas are MN$ 19,000/t,
- Additional national seed costs are MN$ 50,000/ha,
- Yields are 5 t/ha,
- Additional return for seed over grain is 15%, and
- Additional costs of seed exports represent 50% of the price difference for national and international seed.

Then T_{og} = 19,000, P_c = 437,000, C_n = 10,000, r = 0.15, P_{sn} = 524,000, P_{si} = 871,000, P_{si}^* = 852,000, V_{sn} = 56,000, C_i = 164,000.

On the basis of these assumptions, the additional value added for Mexico by seed exports (V_{si}), at current prices, is MN$ 220,000/t.

Appendix F

Estimation of Relative Yields of Bread and Durum Wheats

The yields for durum and bread wheat given in Table F.1 were obtained in yield trials at the CIANO Station, Obregón, Sonora during the five years to 1987/88. Each yield value represents the mean of the yields obtained during each year in the trials. The three sowing dates represent the period commonly used by local farmers. The mean durum wheat yields are 7-16% higher than the mean bread wheat yields. For the purposes of this study, durum wheat is assumed to have a 10% higher yield than bread wheat.

Table F.1 Average bread wheat and durum wheat yields (kg/ha), 1983/84 to 1987/88, CIANO, Sonora, Mexico

Wheat type and line	Sowing date 30 Nov	15 Dec	30 Dec	Mean
Bread wheat				
CIANO T79	6,771	6,559	5,860	6,397
Genaro T81	7,313	6,637	6,202	6,717
Ures T81	7,056	6,637	6,202	6,717
Opata M85	6,961	6,911	6,568	6,813
Papago M86	6,284	6,453	6,468	6,335
Oasis F86	8,228	7,777	7,609	7,871
Sonoita F81	6,788	6,766	6,578	6,710
Tonichi S81	6,971	6,642	5,873	6,495
Curcurpe S86	6,837	6,952	6,100	6,630
Mean	**7,034**	**6,816**	**6,362**	**6,737**
Durum wheat				
Yavaros C79	7,603	7,787	7,448	7,613
Altar C84	7,453	7,806	7,332	7,530
Mean	**7,528**	**7,796**	**7,390**	**7,571**

Source: CIANO yield trial data, 1983/84 to 1987/88.

Appendix G

Price and Trade Effects of Changes in Production of Bread and Durum Wheats

Recent changes in bread and durum wheat production have resulted in an overproduction of durum wheat at a time when Mexico is importing bread wheat. These changes, which have had some economic costs for Mexico, raise several questions. First, to what extent is the overproduction of durum wheat caused by KB, and to what extent is overproduction the result of higher durum wheat yields? Second, can durum wheat either be exported onto the (higher-priced) durum wheat market or be used to produce and export semolina or pasta products? Third, can more durum wheat be used to make bread? These questions are addressed in the sections that follow.

Impact of Karnal Bunt on Durum Wheat Production

Total durum production averages approximately 800,000 t/yr, and represents some 20% of total wheat production in Mexico. Over half of the durum wheat produced in recent years has been used for feed (Table C.3).

The estimated area planted to durum wheat in Sonora and Sinaloa is shown in Table G.1. Approximately one-third of the total wheat area in southern Sonora is planted to durum wheat. The relation of the area restricted to durum only (Table 3.2) and the area sown to durum varieties indicates that approximately half of the area sown to durum varieties in southern Sonora is due to restrictions. This conclusion is supported by information from a recent survey of wheat growers in the Yaqui Valley (Appendix I). No durum wheat was grown in Sinaloa before the spread of KB (SARH, Sinaloa). In 1988/89, 11.6% of Sinaloa wheat area was sown to durum wheat.

Table G.1 Estimated area (000 ha) of durum wheat in Sonora and Sinaloa, Mexico

Year	Yaqui Valley	Mayo Valley	Northern Sonora	Total Sonora	Total Sinaloa
1984/85	37.0	na	na	54.7	0.0
1985/86	38.9	na	na	59.6	0.0
1986/87	48.0	na	na	93.6	7.6
1987/88	53.5	na	na	96.2	na
1988/89	50.6	26.5	3.8	80.8	27.0

na = Not available.

Potential for Exports of Durum Wheat Grain or Products

There is an active world market for durum wheat (Table G.2). mainly in the Middle East. Although it appears that northwestern Mexico is not in a favored geographical position to take advantage of that market, both Arizona and California export durum wheats. Indeed, Mexico may recently have sold as much as 100,000 t of durum wheat to Tunisia (International Wheat Council 1989). The most likely market in which Mexican durum wheat can be competitive is the Latin American market of some 350,000-400,000 t annually. However, breaking into this market may involve investment in port facilities, presumably at Guaymas. Some market for pasta products also appears to exist, and a pasta processing plant for export is currently being established in Obregón. However, the volume of durum wheats involved is likely to be small relative to total durum production.

Potential for Greater Use of Durum to Make Bread

There may be greater potential for mixing durum and wheat flour in the manufacture of bread, but mixing would imply considerable logistical problems and processing costs, particularly if a significant extra volume is to be involved. In addition, the flour extraction rate is significantly lower for durum wheat than for bread wheat.

Table G.2. World trade (000 t) in durum wheat

Year	Total exports
1983/84	4,019
1984/85	3,455
1985/86	3,297
1986/87	4,183
1987/88	5,150
1988/89[a]	4,615

Source: International Wheat Council Market Report.
a Estimate.

Appendix H

Climatic Data at Heading of Wheat Crop for Selected Experiment Stations

Table H.1. Climatic data at heading of wheat crop, selected experiment stations, Mexico

Station and month	Rainfall (mm)							Mean temperature 1982-88 (C)	
	1982	1983	1984	1985	1986	1987	1988	Max	Min
Obregón (CIANO)									
Jan	5.3	20.9	40.5	52.5	0.0	1.2	2.4	24.6	8.6
Feb	0.0	38.7	0.0	7.4	6.2	18.3	0.2	25.6	8.5
Mar	0.0	0.4	0.0	6.2	0.0	0.0	0.2	27.4	9.5
Total	**5.3**	**60.0**	**40.5**	**66.1**	**6.2**	**19.5**	**2.8**	--	--
Culiacan (CIAPAN)									
Jan	4.8	13.5	75.4	19.5	15.1	0.7	0.0	27.6	9.6
Feb	0.0	20.4	0.0	0.0	3.0	0.3	0.0	28.8	9.7
Mar	0.0	24.9	0.0	0.0	0.0	0.0	0.7	31.0	10.7
Total	**4.8**	**58.8**	**75.4**	**19.5**	**18.1**	**1.0**	**0.7**	--	--
Angostura (Valle del Humaya)									
Jan	4.3	16.7	11.1	9.5	0.0	0.0	--	27.4	10.1
Feb	4.6	9.8	0.0	0.0	0.0	7.0	--	29.0	9.4
Mar	0.0	10.2	0.0	1.6	0.0	0.0	--	31.3	10.3
Total	**8.9**	**36.7**	**11.1**	**11.1**	**0.0**	**7.0**	--	--	--
Ahome (El Carrizo)									
Jan	5.5	50.0	57.0	60.5	4.0	1.0	--	24.2	9.5
Feb	0.0	10.8	0.0	0.0	18.2	4.0	--	25.1	9.3
Mar	0.0	42.5	0.0	--	0.0	0.0	--	27.7	10.7
Total	**5.5**	**103.3**	**57.0**	--	**22.2**	**5.0**	--	--	--
Ahome (Ahome)									
Jan	5.0	25.0	36.5	44.5	3.0	0.0	--	27.1	11.5
Feb	0.0	8.0	0.0	0.0	13.0	0.0	--	28.0	11.3
Mar	0.0	55.5	0.0	5.5	0.0	0.0	--	30.2	12.5
Total	**5.0**	**88.5**	**36.5**	**50.0**	**16.0**	**0.0**	--	--	--
Guasave (Guasave)									
Jan	4.3	46.5	77.7	49.4	--	0.0	--	26.0	10.8
Feb	0.0	10.2	4.5	0.0	0.0	8.0	--	28.1	10.7
Mar	0.0	39.7	1.0	5.8	0.0	0.0	--	30.5	12.4
Total	**4.3**	**96.4**	**83.2**	**55.2**	--	**8.0**	--	--	--

Table H.1. Climatic Data at Heading of Wheat Crop for Selected Experiment Stations (cont'd)

Station and month	Rainfall (mm)							Mean temperature 1982-88 (C)	
	1982	1983	1984	1985	1986	1987	1988	Max	Min
Toluca (CIMMYT)									
Jul	193.5	200.8	156.5	192.1	195.6	189.3	238.6	20.0	6.4
Aug	162.5	156.1	180.5	124.4	152.3	226.4	148.4	20.4	6.2
Sep	67.5	112.3	129.0	149.7	124.2	93.5	210.8	20.5	5.9
Total	**423.5**	**469.2**	**466.0**	**466.2**	**472.1**	**509.2**	**597.8**	--	--
El Batan (CIMMYT)									
Jul	98.5	108.3	188.1	70.4	97.2	136.1	83.0	25.5	10.8
Aug	91.8	118.8	116.6	116.7	136.8	79.6	46.3	25.1	10.3
Total	**190.3**	**227.1**	**304.7**	**187.1**	**234.0**	**215.7**	**129.3**	--	--
Celaya (CEB)									
Jan	0.0	35.2	23.5	0.7	0.0	1.8	3.2	23.4	5.3
Feb	14.5	0.0	22.2	3.4	4.6	1.2	0.0	24.8	5.7
Mar	5.0	16.8	0.0	0.0	0.0	0.0	27.4	26.7	7.5
Total	**19.5**	**52.0**	**45.7**	**4.1**	**4.6**	**3.0**	**30.6**	--	--
Jalisco (Jesus Maria)									
Aug	173.1	--	124.0	242.0	--	--	--	24.1	13.1
Sep	53.1	199.0	88.5	139.0	--	--	--	24.2	12.9
Oct	21.4	34.0	41.0	103.0	--	--	--	23.8	11.5
Total	**247.6**	--	**253.5**	**484.0**	--	--	--	--	--
Jalisco (Tepatitlan)									
Aug	--	--	--	152.6	150.0	160.9	259.1	24.6	10.9
Sep	--	--	--	78.9	171.6	102.4	87.7	24.9	10.3
Oct	--	--	--	57.7	83.3	0.0	13.9	24.8	8.0
Total	--	--	--	**289.2**	**404.9**	**263.3**	**360.7**	--	--

Appendix I

Survey of Farmers' Perceptions of Durum Wheat and Karnal Bunt, Yaqui Valley, 1989

In June 1989, a survey was conducted of 95 randomly selected farmers in the Yaqui Valley with the objectives of: 1) ascertaining farmers' reason for sowing durum wheat in preference to bread wheat varieties, and 2) determining farmers' perceptions about the incidence and severity of KB and other diseases. The questions about durum versus bread wheat were asked prior to questions about disease to avoid biasing farmers responses on varietal choice.

Results

Of the total wheat area grown by the farmers interviewed, 48% was sown to durum varieties. This percentage is somewhat higher than official statistics on varietal area. Nineteen percent of the sampled farmers grew only durum wheats and another 59% grew both durum and bread wheat. Most farmers claimed to be planting the wheat types and varieties of their choice. About 20% of farmers, mostly those who planted late or who had to replant because of heavy rains at planting time, were unable to obtain seed of their desired variety. Half of these farmers planted durum wheat against their wishes, since bread wheat seed was not available.

Of the 37% of farmers who grew mostly durum wheat, 58% gave higher yields as the main reason for doing so. The remaining 42% mentioned higher yields and better disease resistance. Most farmers felt that durum wheat had good general resistance to diseases, but some durum growers specifically mentioned that KB resistance had influenced their decision. Nearly all bread wheat growers (97%) mentioned the price advantage and/or ease of marketing as a reason for growing bread wheat.

The great majority of farmers in the sample (86%) believe that durum wheat yields better than bread wheat. Farmers perceived an average yield advantage for durum wheats of 900 kg/ha. This figure is somewhat greater than the durum yield advantage of about 500 kg/ha observed in on-farm experiments, and greater than official statistics of varietal yields (Appendix F), and may reflect farmers' tendency to "round" their estimates--in this case to 1,000 kg/ha. Over the whole sample, actual yields for durum wheat were 5,219 kg/ha compared to 5,144 kg/ha for bread wheat.

Of those farmers who grew durum wheat, half had grown it before 1983, the year in which KB was first recognized as a potentially serious problem. This finding is further evidence that, for many farmers (half or more), yield rather than KB resistance is the primary reason for growing durum wheat.

When asked which was the most important wheat disease in the area, 62% of farmers specified KB compared to 34% who specified leaf rust. This response probably reflects the fact that over the past decade losses from leaf rust have been minimal (because farmers plant resistant varieties), whereas KB losses were significant in 1983 and 1985.

Thirty-one percent of the selected fields had had KB infestation sufficiently high to be placed under quarantine restrictions, although only 13% were under restriction in 1989. Almost all the quarantined fields were restricted to growing only durum wheat.

When asked whether they would prefer a KB resistant variety or similar variety with 250-500 kg/ha higher yields, two-thirds of farmers elected the KB resistant variety, thus indicating that farmers' perceived losses from KB are higher than actual losses.

Conclusions

The results of the survey appear to be broadly consistent with other information (Appendix G), which indicates that perhaps half of all durum wheat plantings are motivated at least partly by quarantine measures or farmers' concern about KB. Nonetheless, about half of all durum wheat area is grown purely as a response to perceived higher yields of durum wheat. However, after two years that have seen a 14% price penalty imposed on durum wheats, farmers are now discounting this yield advantage.

Overall, farmers are very aware of KB and attach a higher weight to the disease than economic losses would justify. This no doubt reflects the high level of publicity about KB. Farmers would be willing to make significant yield trade-offs (5-10%) for a KB-resistant variety.

CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIGO
INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER
Lisboa 27 Apartado Postal 6-641 06600 México, D.F. México