KARNAL BUNT (*Neovossia indica*) DISEASE OF WHEAT

PROCEEDINGS OF A CONFERENCE

April 16-18, 1984
Ciudad Obregón, Sonora, Mexico

CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIGO
INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER
Londres 40 Apartado Postal 6-641 06600 México, D. F, México

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INTRODUCTION:

During April 16-18, 1984, an informal conference dealing with Karnal bunt disease of wheat was held near Ciudad Obregón, in the state of Sonora, northwest Mexico. The meeting was jointly sponsored by Mexico's National Institute of Agricultural Research (INIA) and the International Maize and Wheat Improvement Center (CIMMYT), and was conducted at the Northwest Center for Agricultural Investigations (CIANO), a branch of INIA. The conference was attended by 66 participants from many parts of the world, and included representatives from a number of national agricultural institutions, plant quarantine and/or seed health organizations, and farmer cooperatives.

The main purpose of the conference was to provide an informal forum for the presentation and discussion of current research efforts related to Karnal bunt. The conference also provided an opportunity for Mexican, Canadian and American scientists/administrators, as well as other concerned individuals, to personally examine and appraise the Karnal bunt disease situation in northwest Mexico. Highlights of the presentations made at the conference are summarized in this document.

Overview of CIMMYT's Karnal Bunt Program

Dr. J.M. Prescott

Introduction

Karnal bunt disease of wheat was first reported by Mitra in 1930 at the Botanical Research Station in Karnal, Haryana, India. There were infrequent reports of occurrence in northwest India between 1930 and 1960. The incidence of Karnal bunt in India began to increase in the mid-1960s, probably due to the fact that at this time India initiated a major campaign to increase wheat production by planting high-yielding varieties, improving field management, and increasing the use of fertilizer and irrigation, thus drastically altering agronomic practices and field environments. Karnal bunt is now present in most parts of northwest and north central India, the Punjab area of Pakistan and in southern Nepal.

In 1971, Karnal bunt was first reported in Mexico in the Yaqui Valley of the northwestern state of Sonora. The disease was rarely reported in this area during the period 1971-1981, but its incidence began increasing in 1982. The disease became fairly widespread in the Yaqui and Mayo Valleys in 1983. Research on Karnal bunt in Mexico has been conducted jointly by INIA and CIMMYT since 1979. The higher levels of Karnal bunt in 1983, plus the increased interest by North American scientists resulted in the inclusion of the USDA-ARS in the INIA/CIMMYT research project. A special USDA-ARS project was also initiated at Ft. Detrick, Frederick, Maryland. In addition, several Karnal bunt research projects are underway in both India and Pakistan.

The Pathogen

There is some controversy over the proper scientific name of the organism that causes Karnal bunt. Some researchers classify it as *Tilletia indica*, while others classify it as *Neovossia indica*. It is hoped that this disagreement is settled soon, as the present situation leads to confusion in the literature.

The morphology of the fungus is consistent. Teliospores are spherical to oval, with articulations. They measure 22-49 microns in diameter, averaging about 35 microns. A thin hyaline membrane surrounds the spines and the epispore, and persists even when the spores are mature. Sterile cells are usually present in teliospore samples.

Germination

Freshly harvested teliospores do not germinate well: there appears to be a dormancy period of anywhere from 1 to 6 months before satisfactory germination can occur. Even after the dormancy period, teliospore germination is often only in the 10 to 40 percent range. Upon germination, short promycelia (less than 2 mm in length) are formed, which then produce tufts of primary sporidia at their terminal ends. These primary sporidia in turn produce secondary sporida, and it is the primary and secondary sporidia that are the infectious units of this disease. With these short promycelia the rule, it follows that only those teliospores on or very near the soil surface contribute to disease establishment. Germination is favored by soil pH values between 5.5 and 8.5, and occurs under both light and dark conditions (but appears to be enhanced by light).

Infection

Infection occurs by direct penetration of either the outer glume tissue, progressing inward to the ovary wall, or of the ovary wall itself. The fungus is confined between the ovary wall and the endosperm, without penetrating the embryo. Environmental conditions conducive to infection are several: high humidity and/or free water, dew periods of more than 12 hours, and cloudy days appear necessary to prevent dessication of the infectious units, and day/night temperatures averaging about 18 °C also appear necessary.

The cooperative program between INIA, CIMMYT, and the USDA is investigating two main approaches to disease control: (1) genetic resistance and (2) chemical control. The following papers will provide details of this joint effort.

Laboratory Evaluation of Chemical Seed Treatments to Control Teliospore Germination

Ms. E.J. Warham

Thirty-one chemicals (systemics, heavy metals, and organic compound recommended for bunts and smuts) were screened for their efficacy as seed treatments for the control of Karnal bunt. These chemicals include the following:

Bitertanol	(Baycor, Sibutol)
Captan	(Captan)
Chloroneb	(Demosan)
Copper Carbonate	
Copper Sulphate	
Cupric Hydroxide	(Kocide)
DCNA	(Botran)
Ethylmercury Chloride	(Ceresan)
Formaldehyde	
Hexachlorobenzene	(Anticarie)
Imazalil	
Maneb	(Dithane, Maneb, Manzate D)
Maneb + Hexachlorobenzene	(Granox)
Methoxyethylmercury acetate	(Panogen)
MV 785 1.5D	
Nuarimol	(EL 228)
PCNB	(Trigan F, Trigan S, Terrazan F, Terrazan 75PH)
Polyphase	(Guardsan 388, Guardsan 389)
Sodium Hypochlorite	
Thiram	(Thylate)
Triadimefon	(Baymeb)
Tridimenol	(Baytan + Baysas)
Triphenyltin Hydroxide	(Du-Ter)

Of these, 18 compounds effectively inhibited Karnal bunt teliospore germination (Botran, Ceresan, Copper Carbonate, Copper Sulphate, Demosan, Dithane, Duter, Granox, Guardsan 388, Guardsan 389, Maneb 80, Manzate D, Panogen, Sibutol, Terrazan F, Terrazan 75PH, Trigan S, and Thylate 75). Longevity of the effect of the chemicals was also determined by testing germination of teliospores at 24 hours, one week, one month, two months, four months, and six months after chemical application. To determine whether a seed treatment influenced seed germination, simultaneous seed germination tests were also conducted. Chemicals that showed effective inhibition of *Neovossia indica* teliospores are being retested using a range of application rates. Preliminary data indicate that Botran, Ceresan, Manzate, Panogen and Terrazan 75PH are effective over a wide range of application rates.

Field Evaluation of Systemic Fungicides as Seed Treatments

Dr. N.L. Cashion

For a systemic fungicide, applied as a seed treatment, to be effective against infection by secondary sporidia of *Neovosia indica*, it must remain active in the plant for at least two months, or until flowering has been completed. The following chemicals were tested in 1984 in field trials at CIANO:

Baycor-Baytan:	Dust and Slurry
Baytan-Baysas:	Dust and Slurry
Bayleton:	Dust and Slurry
Benomyl:	Dust and Slurry
Etaconazole:	Dust
Furmecyclox:	Dust and Slurry
Imazalil:	Liquid
Nuarimol:	Dust and Slurry
Propiconazol:	Liquid

Unfortunately, no Karnal bunt disease developed, even in the checks, so evaluation of the above chemicals was not possible and the experiment must be repeated.

Laboratory Evaluation of Fungicides to Control Germination of Secondary Sporidia

Dr. N.L. Cashion

A cellophane disk bio-assay was used to evaluate the fungicidal properties of 15 chemicals on the secondary sporidia of Neovossia indica. This test was conducted to determine which fungicides could be used as foliar sprays to protect the plants during heading. Maneb, mancozeb, copper hydroxide, Dithane S-31, and tryphenyltin hydroxide inhibited sporidial germination and/or hyphal growth. Sporidia were not killed by bitertanol, captan, chloroneb, copper carbonate, copper sulfate, demosan, dichloran, hexachlorobenzene, penthachloronitrobenzene, or thiram. Systemic fungicides that stop fungal growth in the plant but do not inhibit spore germination could not be evaluated with this technique. Chemicals showing fungitoxic properties in the laboratory tests, plus several systemic compounds, were chosen for field testing at CIANO.

Field Evaluation of Fungicides with
Soil and Foliar Application

Dr. N.L. Cashion

The laboratory evaluations reported earlier were conducted primarily to determine which chemicals to use in field studies. These field studies were conducted at CIANO experiment station, near Cd. Obregon, Sonora, Mexico, in fields or plots where the incidence of Karnal bunt infection was relatively high during the previous year. In addition to the natural inoculum present, 150 kg of infected seed was ground in a mill and scattered over the soil surface of the test area (approximately 1 ha). Surface irrigation was applied frequently, both to keep the soil surface wet and in an attempt to maintain relatively high humidity within the crop canopy. Overhead irrigation was not used because it might wash off the foliar applications of chemicals.

In one experiment, soil and foliar fungicides were applied in a factorial design. Soil treatments of pentachloro-nitrobenzene (PCNB), copper sulphate, and Maneb were selected because they have been shown to inhibit teliospore germination, have a relatively low cost, and are readily available in Mexico. One application of these chemicals was made when the plants were in the late-tiller to early joint growth stage. Manzate 200, Du-Ter, Tilt, and Baycor were applied four times as foliar sprays between the boot and berry growth stages.

In a second experiment, only foliar applications were made using seven protectant and eight systemic fungicides. The percent of seeds infected and the phytotoxic effects were to be determined. There were no phytotoxic effects noted for the chemicals applied. Unfortunately, Karnal bunt did not develop, even in the checks, so we were unable to evaluate the effectiveness of these chemicals under field conditions. The experiments will be repeated next year.

Evaluation of Inoculation Methods in the Greenhouse and Field

Ms. E.J. Warham and Dr. N.L. Cashion

Screening for genetic resistance to Karnal bunt requires an adequate method of artificial inoculation before large segregating populations or large numbers of entries can be tested. Three methods have been evaluated at CIMMYT, both in the greenhouse and in the field.

Boot Injection

This method consists of injecting 1.0 ml of a water suspension of secondary sporidia into the boot of each head at mid-boot stage or when the awns are beginning to emerge. In the greenhouse, it was not necessary to provide additional humidity as the boot itself serves as a moist chamber. To determine the appropriate inoculum concentration, a range of concentrations was tested, as follows:

Number of Sporidia/ml	Percent Infected Grains
0	0
2500	69
5000	100
10000	100
15000	100
20000	100
50000	100

A minimum of 5000 sporidia/ml is required for optimal levels of infection; however, in another experiment it was possible to obtain satisfactory infection levels with a concentration as low as 1000 sporidia/ml. CIMMYT normally uses 10,000 sporidia/ml when screening germplasm for resistance.

Completely bunted heads were not observed from boot inoculations made in the field. Infection was greater following inoculations with 10,000 sporidia/ml than with 5000 sporidia/ml. Plants that received intermittant overhead sprinkler irrigation following boot inoculation had a higher incidence of disease than those receiving no additional moisture.

Spray Inoculation

In the greenhouse, a water suspension of sporidia (50,000 sporidia/ml) was sprayed on the spikes of wheat plants over a range of growth stages between heading and anthesis. The inoculated plants were then placed in a humidity chamber where high humidity was maintained by mist atomizers. A three-hour constant misting was used initially, followed by a fifteen-minute misting each hour over a twenty-four hour period. Growth stages nearer to heading than to anthesis, gave higher infection levels. This technique appears to be quite effective in the greenhouse, where infection levels of 90 percent can be achieved under controlled conditions. However, in field trials, few infected grains were found on plants that received as many as five inoculation sprays, even when humidity was kept high with overhead irrigation.

Cotton Wool Inoculation

To determine if, following infection, the disease became systemic in the head, small pieces of cotton wool saturated in a water suspension of sporidia were placed either inside the floret or between the floret and the rachis. Results from the greenhouse tests have indicated that the infection can move across all florets of a spikelet and to the spikelets above and below the inoculation point. In fact, several completely bunted heads have been obtained by this technique. In the field this method was tested as a means of screening germplasm for resistance, but it was found to be time consuming and unsuitable due to low levels of infection.

Screening Germplasm for Genetic Resistance in the Greenhouse

Ms. E.J. Warham

During the summer of 1983, resistance screening in the greenhouse yielded 35 lines of bread wheat, durum wheat, and triticale that had no infection. This represented slightly less than 1.0 percent of the material tested. These lines are currently being retested in the greenhouse, using both the boot injection and spray inoculation techniques. Many of the apparently resistant lines have either Tezanos Pinto Precoz (TZPP) or Alondra in their parentage. During the 1984 summer cycle, all available lines of CIMMYT germplasm having either or both TZPP and Alondra in their parentage are being tested. Also, the entire aluminium tolerance screening nursery, the 1B/1R genome collection and the CIMMYT rye collection are being screened using the boot injection and spray inoculation techniques. A search for resistance to Karnal bunt in the USDA world collection of materials that are resistant to the other bunts and smuts is being carried out, using the boot injection technique alone.

Screening for Genetic Resistance in the Field

Dr. R.J. Metzger

In November, 1983, 6280 double row plots, each 1.0 m long, were planted on the CIANO experiment station in a location where the incidence of Karnal bunt infection was relatively high during the previous season (field 910). This activity was a cooperative project between INIA, USDA-ARS, and CIMMYT. The germplasm material planted included the following:

Breadwheat	No. Entries	
CIMMYT crossing block	327	
Advanced lines (PCs)	1145	
Miscellaneous nursery	313	
KB test, 1981-82 reevaluation	185	
KB test, 1981-82 Yaqui Valley	46	
KB test, 1983 greenhouse	15	
World collection	968	
Subtotal		2999

Durum and other tetraploid wheats	No. Entries	
CIMMYT crossing block	340	
Advanced lines (PCs)	584	
Miscellaneous nursery	402	
Durum screening nursery (IDSN)	306	
Hessian fly lines	51	
KB test, 1981-82 reevaluation	142	
KB test, 1983 greenhouse	10	
T. carthlicum lines	75	
Subtotal		1910

Triticale	No. Entries	
CIMMYT crossing block	235	
Triticale screening nursery	208	
Miscellaneous nursery	252	
KB test, 1983 greenhouse	10	
Subtotal		705

Rye	No. Entries	
World collection (WRC)	104	
CIMMYT observation lines	84	
Turkey/Poland lines	72	
Subtotal		260

Others	No. Entries	
Aegilops species	291	
Wild Triticum species	84	
Interspecific hybrids	31	
Subtotal		406
GRAND TOTAL		6280

Ten heads of each line were inoculated using the boot injection technique when the plants were at the mid-boot growth stage. The inoculum concentration used was 10,000 sporidia/ml. Overhead sprinkler irrigation was provided to give optimum environmental conditions for infection and disease development. When mature, the inoculated heads were harvested, threshed and individually examined for the presence of Karnal bunt infection.

Approximately 1700 lines had no Karnal bunt infection. However, during the peak inoculation period, the concentration of the inoculum had to be reduced for several days due to a logistical problem. We feel that this may have increased the number of escapes, thus explaining the high number of "resistant" lines. Whatever the reason, the "resistant" material has been placed in a special nursery, Karnal Bunt Screening Nursery (KBSN), and has been slated for further field-testing under natural conditions and artificial inoculation in Mexico, India, Pakistan, and Nepal during the 1984-85 cycle. Specific information on these "resistant" lines, as well as seed, is available upon request from CIMMYT.

Fungicide Applications to Germplasm Destined for CIMMYT's International Nurseries

Dr. J.M. Prescott

In 1983, a set of regulations governing the movement of wheat and triticale germplasm from Mexico to the USA and Canada was developed by the respective governments of the USA and Canada. Included in these regulations were recommendations for the chemical treatment of seed shipments. It was agreed that if these recommendations were followed by CIMMYT and if no Karnal bunt was detected in the shipments, the regulations would be reviewed in 1984, possibly leading to a relaxation of the regulations for 1984 seed shipments. The regulations included the following:

1) Seed production field(s) must be isolated from areas possibly contaminated with Karnal bunt;

2) Soil in the production field(s) must be treated with PCNB;

3) Multiple applications of Manzate 200 must be made during the growing cycle; and

4) Duplicate nurseries would be grown in known Karnal bunt-free areas as an insurance measure.

CIMMYT agreed to and complied with these regulations, with the hope that in so doing, a relaxation of the regulations governing seed shipments to the USA and Canada could be achieved. All germplasm destined for international distribution by CIMMYT was grown in a separate, 18 ha field, known as 710, of the CIANO experiment station. This field is approximately 2.5 km from field 910, in which artificial inoculation studies were conducted. PCNB was applied in the irrigation water prior to heading, and hand-sprayed on all borders and ridges used for the retention of irrigation water, as well as a 5.0 meter strip around the entire field. Manzate 200 was applied 6 times to the crop by aircraft, beginning when the earliest material was starting to head and continuing at 4 to 5 day intervals. Duplicate plantings were made near Hermosillo, Sonora, Mexico, an area reported to be free of Karnal bunt. At the time of the conference, the material in field 710 was not yet ready for harvest, so about 200 samples (taken at random) were made available for close examination by conference participants. No Karnal bunt was found.

At harvest, the material in field 710 was randomly sampled by APHIS-PPQ staff. The samples were sent to the USDA-APHIS-PPQ headquarters in the USA and subjected to strict visual examination, plus microscopic examination following the centrifuge/wash procedure. No Karnal bunt was found.

Later, a review of the Karnal bunt situation in Mexico was held by the USDA-APHIS-PPQ staff. This review resulted in the relaxation of the regulations governing seed shipments to the USA and Canada in 1984. CIMMYT was notified that since no Karnal bunt was found in the material destined for international distribution by CIMMYT, seed would be accepted for normal field growing in the USA and Canada, provided that a valid phytosanitary certificate was available and that the recipient held a valid permit issued after November, 1983, by the USDA-APHIS-PPQ or Canadian authorities. Karnal bunt research at CIMMYT will continue so that the disease does not adversely affect the exchange and shipment of seed in the future.

Evaluation of Fungicides and Screening for Genetic Resistance Under Natural Conditions

Ms. C. García

The Mexican National Institute of Agricultural Research (INIA) also conducts research on PCNB and other chemicals to control Karnal bunt. These fungicide trials, conducted on the CIANO research station and in farmers' fields, were initiated in the 1981/82 crop cycle. PCNB treatments applied in the irrigation water were found to be quite effective. Trigran F, Trigran S, and Terrazan 75PH were found to be the most effective in inhibiting teliospore germination. Seed treatments with ten different chemicals to inhibit germination of teliospores indicated that chlorothalonil, copper chlorate, Maneb, and Busan were the most effective and did not reduce seed germination.

Screening for genetic resistance is also a part of the INIA program. Initiated in the 1982/83 crop cycle, 200 lines of bread wheat were identified that had no Karnal bunt infection. These 200 lines were then grown at four locations in the Yaqui Valley in 1982/83. Following harvest of this material, 46 lines still showed zero infection. However, when these lines were tested in the greenhouse with the boot injection method of inoculation, all were found to be susceptible. Perhaps these lines possess some degree of field resistance that may be useful in breeding for resistance to this disease.

Karnal Bunt Research at Logan, Utah

Dr. J.A. Hoffmann and Mr. J. Smilanick

Karnal bunt research at Logan, Utah was initiated in the fall of 1982. Investigations conducted to date have provided the following information:

1) Germination of 2-year old teliospores occurred over the temperature range of 5° to 25°C, with the optimum being about 15°C. At 15°C, germination was initiated in about 4 to 6 days and attained a maximum of 40 to 60 percent in 21 days.

2) Continuous, low-intensity light stimuated teliospore germination, increasing the germination percentage by about 20 points.

3) The optimum pH for teliospore germination on water agar ranged from 6.0 to 9.0.

4) Teliospore germination on soil was suspended during periods of drying or freezing, but resumed with favorable conditions of moisture or temperature.

5) The promycelia of teliospores germinating beneath a 2.0 mm layer of soil or agar did not reach the surface of the substrate. This suggests that only those teliospores on, or very near, the soil surface are of consequence in initiating disease development.

6) In continuing experiments, PCNB has inhibited teliospore germination for 30 days. PCNB was, however, not fungitoxic to dry teliospores, nor to teliospores that were soaked in a PCNB/soil extract suspension for up to 14 days.

7) Fumigation of infected wheat kernels with methyl bromide, chloropicrin, or sulphur dioxide at rates sufficient to reduce seed viability, failed to completely kill teliospores in or on the seed.

8) Treatment of infected wheat kernels with formaldehyde solution (5000 ppm for ten minutes), 5.0 percent sodium hypochlorite solution (10 minutes), or hot water (55°C for 10 minutes) reduced teliospore germination to 0.0, 1.0, and 5.0 percent, respectively.

9) Development of methods to determine teliospore viability using glucosidase, lipase, or ATP have not been successful. Other procedures to determine teliospore viability are currently under investigation.

Karnal Bunt Research at Ft. Detrick, Frederick, Maryland

Dr. W.M. Dowler

Comparisons of teliospore morphology and germination temperatures of Indian and Mexican isolates of the Karnal bunt fungus have indicated no differences. Studies comparing teliospores of Karnal bunt and the kernel smut of rice have shown the diameters of the teliospores to be about 40 microns and 30 microns, respectively. Germination may occur in the dark, but is enhanced by low-intensity light. Greenhouse studies at Frederick have shown that the best infection rate is obtained at 15°C, intermittent mist for four days, and cloudy weather. Commercial chlorox can be used to decontaminate teliospores and actually improves their germination rate. In resistance studies, all varieties of wheat tested to date have proven susceptible. Host range studies are also underway.

The Karnal Bunt Situation in Northwest Mexico

Ing. M. Lira

Karnal bunt was first reported in Mexico in 1971. For many years it was rarely reported and not until the early 1980s did the disease become more prevalent. Results from the surveys conducted in the State of Sonora were presented, primarily from the Yaqui and Mayo Valley surveys of 1982, 1983, and the current (1984) survey. Limited information on the other wheat-producing areas of Mexico was also presented. The disease has been reported in the Yaqui and Mayo Valleys only and has not been found elsewhere in Mexico. Surveys will continue and will be intensified. Results of the Karnal bunt surveys of Sonora in 1981/82 and 1982/83 were reported in the following manner:

* 1 kg of wheat seed contains approximately 25,000 seeds; thus:

  250 infected grains in 1 kg seed = 1.0% infection
  500 infected grains in 1 kg seed = 2.0% infection
  750 infected grains in 1 kg seed = 3.0% infection
  1000 infected grains in 1 kg seed = 4.0% infection

* The incidence of infection was classified as follows:

Group	No. Inf. Grains	Percent	Rating
0	0	0	-
1	1 to 130	0.001 to 0.5	Light
2	130 to 250	0.5 to 1.0	Medium
3	250 to 1250	1.0 to 5.0	Heavy

Results of the 1981/82 survey:

Group	Number of Samples				Percent of
	Yaqui	Mayo	Other	Total	Total
0	1010	459	374	1843	94.2
1	86	14	1	106	5.4
2	5	1	0	6	0.3
3	1	0	0	1	0.05

Results of the 1982/83 survey:

Group	Number of Samples				Percent of
	Yaqui	Mayo	Other	Total	Total
0	1296	92	153	1546	36.0
1	1863	184	62	2109	49.0
2	340	52	1	393	8.0
3	280	31	1	315	7.0

The incidence was higher in 1982/83 than 1981/82. In 1981/82, 94 percent of the samples showed no infection. In 1982/83, only 36 percent of the samples showed no infection. As a result of the 1982/83 survey, the government of Mexico divided the Yaqui Valley into blocks, each 2.0 km x 2.0 km, and set the following rules for planting in the 1983/84 crop season:

* If the infection in all or only part of the block was less than 1.0 percent, farmers could plant whatever crop they wished.

* If the infection was 1.0 to 2.0 percent, farmers could plant only durum or triticale, since these crops are much less susceptible to Karnal bunt than bread wheat.

* If the infection was more than 2.0 percent, then farmers could not plant wheat nor triticale. There were 21,100 ha in this category.

* In addition, seed was treated at a double rate with the specified fungicide. Farmers could also plant certified seed with the date of planting well controlled.

The survey for 1983/84 is just now getting underway, with only three samples reaching the receiving stations so far. All were negative for the presence of Karnal bunt. Little or no Karnal bunt is expected this year due to environmental conditions that were unfavorable for disease development.

Mexican Phytosanitary Policy in Relation to Karnal Bunt

Dr. S. Delgado

Karnal bunt is classified as a weak pathogen causing a cyclic disease of wheat. It was detected in Mexico about twelve years ago, with only trace amounts being found in farmers' grain until the 1981/82 season. During the 1981/82 crop cycle, the weather was more favorable for Karnal bunt development and a small number of grain samples were found to be infected. During the 1982/83 cycle, environmental conditions were even more favorable for the disease and a large proportion of commercial samples were found to be infected.

Quarantine laws and regulations in Mexico have been established in an effort to control development of the disease. Seed sown must be treated as prescribed by law. Permission to sow seed will not be given unless all regulations and requirements have been met. These regulations and requirements are available upon request from Sanidad Vegetal in Mexico City, Mexico.

United States and Canadian Quarantine Policies

Dr. R.P. Kahn and Dr. B. Hopper

Two papers were presented that outlined the quarantine policies of the United States and Canada, with respect to Karnal bunt. Briefly, the policies of both countries at the time of the conference did not allow importation of wheat and triticale seed from Mexico, the only exception being experimental seed with entry pre-authorized by the issue of a permit. In addition, a number of safeguards were imposed to further reduce the chance of Karnal bunt establishment in the USA and Canada. There was a "zero tolerance" in both countries for this disease.

The rather strict conditions imposed for experimental seed reflected much more than the scientific viewpoint. The safeguards were established in the belief that if the disease did become established in either the USA or Canada or both, then their export markets would be adversely affected.

Both the USA and Canada expressed keen interest in the research activities underway at CIANO and CIMMYT. They also felt that if no Karnal bunt was found in the international nurseries seed multiplication field, then the import regulations could be reviewed and possibly relaxed.

Closing Remarks
Dr. B.C. Curtis

Germplasm development and its worldwide distribution are the main acitvities of CIMMYT, and if viable solutions to the Karnal bunt disease "problem" and a relaxation of quarantine regulations are not forthcoming, then the activities of CIMMYT could possibly be adversely affected.

It has always been CIMMYT's policy to do everything possible to minimize or eliminate the potential for distribution of diseases along with our seed. The chemical seed treatment "cocktail" that CIMMYT applies to all experimental seed, both leaving and arriving in Mexico, is updated regularly as new and proven chemicals become available. CIMMYT works very closely with Sanidad Vegetal, Mexico's plant quarantine agency, in monitoring and critically evaluating this experimental seed. Furthermore, nearly 50 percent of the CIMMYT Wheat Program staff are trained as pathologists, even though some of them now occupy positions as plant breeders. This staffing profile gives an indication of the Wheat Program's strength in and concern for plant (and seed) health matters. In addition, CIMMYT has recently established a seed health unit to serve the needs of the Center's crop improvement programs.

This meeting has further demonstrated the very active role CIMMYT has taken to better understand the Karnal bunt disease "problem" and to determine effective methods of control, either chemical or genetic. We will continue to work with all affected parties, and make every feasible effort to resolve the issues before us.

APPENDIX I: AGENDA OF THE KARNAL BUNT CONFERENCE

16-18 April, 1984

Cd. Obregón, Sonora, Mexico

LOCATION: CIANO Auditorium

Monday, 16 April, 1984

08:00	Departure by bus from Motel Costa de Oro
08:30 - 08:40	Welcome to CIANO...Dr. A. Valencia V.
08:40 - 09:00	Overview of the Karnal Bunt Problem... Dr. J.M. Prescott
09:00 - 09:20	Laboratory Evaluation of Chemical Seed Treatments to Control Teliospore Germination...Ms. E. Warham
09:20 - 09:40	Field Evaluation of Systemic Fungicides as Seed Treatments...Dr. N.L. Cashion
09:40 - 10:00	Laboratory Evaluation of Fungicides to Control Germination of Secondary Sporidia... Dr. N.L. Cashion
10:00 - 10:20	Field Evaluation of Fungicides with Soil and Foliar Applications...Dr. N.L. Cashion
10:20 - 10:40	Refreshments
10:40 - 11:10	Evaluation of Inoculation Methods in the Greenhouse and Field...Ms. E. Warham and Dr. N.L. Cashion
11:10 - 11:30	Screening Germplasm for Genetic Resistance in the Greenhouse...Ms. E. Warham
11:30 - 12:00	Screening for Genetic Resistance in the Field...Dr. R.J. Metzger
12:00 - 12:30	Fungicide Applications to Germplasm Destined for CIMMYT's International Nurseries... Dr. J.M Prescott
12:30 - 14:30	Lunch

Monday, 16 April, 1984 (continued)

14:30 - 17:30	Visit to field experiments at CIANO... Dr. N.L. Cashion and Dr. J.M. Prescott
17:30	Return to Motel Costa de Oro
19:00 - 20:30	Welcome Party - Motel Costa de Oro

Tuesday, 17 April, 1984

08:00	Departure by bus from Motel Costa de Oro
08:30 - 09:30	Evaluation of Fungicides and Screening for Genetic Resistance Under Natural Conditions...Ms. C. García
09:30 - 10:00	Karnal Bunt Research at Logan, Utah... Dr. J.A. Hoffmann and Mr. J.A. Smilanick
10:00 - 10:15	Refreshments
10:15 - 10:45	Karnal Bunt Research at Ft. Detrick, Frederick, Maryland...Dr. W.M. Dowler
10:45 - 11:15	Karnal Bunt Situation in the Northwest of Mexico...Ing. M. Lira
11:15 - 11:45	Mexican Phytosanitary Policy in Relation to Karnal Bunt...Dr. S. Delgado
11:45 - 14:30	Lunch
14:30 - 17:30	Visit experiments in farmer fields... Ms. C. García
17:30	Return to Motel Costa de Oro

Wednesday, 18 April, 1984

08:00	Departure by bus from Motel Costa de Oro
08:30 - 10:00	Summary and Discussion of Current and Future Research...Dr. B.C. Curtis
10:00	Meeting closed

APPENDIX II: CONFERENCE PARTICIPANTS

M. Alcalá	CIMMYT, Mexico, D.F. Mexico
A. Amaya C.	CIMMYT, Mexico, D.F. Mexico
J. Barnes	USDA - CSRS, Washington, DC, USA
G. Bekele	CIMMYT, Mexico, D.F. Mexico
P. Burnett	CIMMYT, Mexico, D.F. Mexico
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O. Cantu	Northrup King, California, USA
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N.L. Cashion	CIMMYT, Mexico, D.F. Mexico
G. Cepeda V.	CIANO, Caborca, Sonora, Mexico
J. Cisneros D.	PRONASE, Mexico, D.F. Mexico
T.S. Cox	USDA-ARS, Kansas, USA
R. Cross	DSIR, New Zealand
B.C. Curtis	CIMMYT, Mexico, D.F. Mexico
S. Delgado S.	Sanidad Vegetal, SARH, Mexico
W.M. Dowler	USDA, Maryland, USA
C. Figueroa	Sanidad Vegetal, SARH, Mexico
C.E. Fonseca	CIANO, Cd. Obregon, Sonora, Mexico
C. García	CIANO, Cd. Obregon, Sonora, Mexico
A. García A.	CIANO, Cd. Obregón, Sonora, Mexico
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H. Gutierrez	Sanidad Vegetal, SARH, Mexico
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B. Hopper	Agric. Canada, Ottawa, Canada
C. James	CIMMYT, Mexico, D.F. Mexico
R.P. Khan	PPQ-APHIS-USDA, Maryland, USA
A. Mujeeb Kazi	CIMMYT, Mexico, D.F. Mexico
A. Klatt	CIMMYT, Mexico, D.F. Mexico
M.M. Kholi	CIMMYT, Santiago, Chile
W.E. Kronstad	OSU, Oregon, USA

M. Lira	SARH, Cd. Obregon, Sonora, Mexico
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S. Rajaram	CIMMYT, Mexico, D.F. Mexico
P. Sánchez V.	SNICS-SARH, Mexico
Guo Shao-Zheng	JAAS, Nanjing, China
R.P. Singh	CIMMYT, Mexico, D.F. Mexico
J. Smilanick	USDA-ARS, Utah, USA
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R. Warzecha	CIMMYT (Poland) Mexico
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D. Worral	Agric. Exp. St., Texas, USA
F.J. Zillinsky	Ottawa, Canada

APPENDIX III: KEY TO ACRONYMS USED IN THIS PROCEEDINGS

CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
USDA	United States Department of Agriculture
CSRS	Cooperative State Research Service
D.F.	Distrito Federal (Federal District)
D.C.	District of Columbia
USA	United States of America
CIANO	Centro de Investigaciones Agrícolas del Noroeste (Northwest Center for Agricultural Research)
PRONASE	Productora Nacional de Semillas (National Seed Production Organization)
ARS	Agricultural Research Service
DSIR	Department of Scientific and Industrial Research
SARH	Secretaría de Agricultura y Recursos Hidráulicos (Ministry of Agriculture and Water Resources)
Cd.	Ciudad (City)
B.C.	Baja California
PPQ	Plant Protection and Quarantine

APHIS	Animal and Plant Health Inspection Service
OSU	Oregon State University
ITESM	Instituto Tecnológico de Estudios Superiores de Monterrey (Monterrey Institute of Advanced Technical Studies)
SNICS	Servicio Nacional de Inspección y Certificación de Semilla (National Seed Inspection and Certification Service)
AGRIC. EXP. ST.	Agricultural Experiment Station
INIA	Instituto Nacional de Investigaciones Agrícolas (National Institute of Agricultural Research)
JAAS	Jiansu Academy of Agricultural Sciences

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