REPORT OF ACTIVITIES AND RECOMMENDATIONS ON A CONSULTANCY TO BHUTAN (Aug. 12-26, 2007)

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Summary

The main purpose of the consultancy was to visit maize growing areas in the hills of the country, observe, and report on the damaging effect of the disease suggested as turcicum leaf blight (TLB), caused by the fungus Exserohilum (syn. *Helminthosporium*) *turcicum*. The disease had been recently reported as having devastating effects in maize plantings in the hills. Field observations indicated that the reported damaging effect was caused by gray leaf spot, another disease not previously identified caused by he fungus *Cercospora zeae maydis.* Severe incidences of this disease were observed at elevations nearly and above1800 meters above sea level (masl) where *Cercospora zeae maydis* was most prevalent. At the elevations 1700-1800 masl both *C. zeae maydis* and turcicum leaf blight were prevalent. Our observations in farmer's plantings at <1700 masl, turcicum leaf blight was more prevalent, but with incidences of lesser economic significance. A breeding program to select yellow endosperm maize tolerant to the disease using cercospora-tolerant maize germplasm available from Colombia, was outlined. A two-day training, including maize pathology, breeding and agronomy, was given to extension and research personnel.

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1. Purpose of the consultancy

Examine, in a two week period, the situation on the reported high incidence of turcicum leaf blight (TLB), caused by the fungus *Exserohilum* (syn. *Helminthosporium*) *turcicum*, give recommendations on the possible control of the disease, and give a two day training course in maize pathology, breeding and agronomy-production to approximately 40 extension and research personnel.

2. Background

Initial contact was established through Drs. Kevin Pixley and Guillermo Ortíz-Ferrara, CIMMYT-Maize Program, Mexico, and CIMMYT Representative, Nepal, respectively. They originally indicated the interest of Bhutanese authorities to have a study on the high incidence of TLB, its distribution in important maize producing areas in the country, and give recommendations on the possible control of the disease.

With this interest, a letter of invitation was received from Messrs. Sangay Duba, PD[1], and Mahesh Ghimiray, PRO, RNRRC Bajothang, of the CoRRB.

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[1] CoRRB: Council for RNR Research of Bhutan; DoA: Dept. of Agriculture, MoA: Ministry of Agriculture; NPPC: National Plant Protection Center; PD: Program Director; PRO: Principal Res. Officer; RNR: Renewable Natural Resources; RO: Research Officer.

Sun. Aug. 12/07.

Arrived Paro, where Mr. Sangay Wangdi, Sr. RO, was to pick me up. He accompanied me throughout the two week visit to Bhutan.

3. Activities during the consultancy

Mon. Aug. 13/07.

Courtesy visits to authorities in the MoA:

a. Dr. Pema Choephyel, Director CoRRB, MoA, Thimphu.
b. Mr. Ganesh Chettri, Joint Director, DoA, MoA, Thimphu. Due to his busy schedule, we could not visit with Dasho Sherub Gyaltshen, DG, Agric. Div., as originally scheduled.

They emphasized the importance of my visit and pointed out their interest in having a final visit with them at the end of the visit and learn of the findings and recommendations result of the consultancy.

c. Dr. Thinlay, PD, NPPC Semtokha. At his Center, he has the possibility of assigning personnel and equipment to increase inoculum and create the artificial inoculations required in a program of breeding for disease resistance to fungal diseases in maize. He has observed the increased incidence of TLB in cultivar Yangtsipa (=SW1), released in early 90s. During Aug- Sept. 2006, he surveyed several maize producing areas in the country located at up to 2700 masl. In his survey, he reports mostly the presence of TLB. To control the disease, he has recommended spraying the contact fungicide Mancozeb, at commercial rates. In his report, he comments that in some affected fields sprayed with the fungicide (Mancozeb), the control of the disease was not effective, probably due to late spraying and that it requires 2-3 sprays to check spread of the disease. The use of chemical sprays in controlling these foliar diseases using contact, broad spectrum fungicides, in most cases is erratic as the fungicide has to be in continuous contact with fungistatic action on the infectious structures of the fungus.
d. To manage the problem in 2007 season, NPPC, Research and Extension had developed a brief action plan which consisted of seed change, use of fungicide, training of extension and farmers on field sanitation and testing of varieties introduced for disease resistance/ tolerance. With the support from Research Centers Dzongkhag, Extension campaigned for burning of infected materials to reduce the inoculum. In affected areas, seed of improved varieties were also supplied and two sprays of fungicide (Mancozeb) were done. Mancozeb controls both TLB and gray leaf spot (GLS). Research had tested four different varieties in the affected areas but none of them seem to show good tolerance to the disease.
e. At Yusipang, visited with Dr. Lungten Norbu, PD, RNRRC, Yusipang, Western region. After learning of the purpose of the consultancy, he suggested to appoint two agronomists in his staff to participate in the project. Suggested names were Mr. BB Ghalley, and Ms. Hema Devi, based at Chukha and Samtse Dzongkhag where maize is grown. They are both working on cereal production and could participate in the establishment of selection plots at these two locations. In the

field, saw small seed increase blocks of Arun 1 and 2 received from the Nepalese Maize ResearchProgram. Seed increases were at approx. 3 weeks after planting, well managed and clean of diseases, even though plant density was small.

Tue. Aug. 13/07. At the RNRRC at Bajothang, Wangdue Phodrang (1300 masl).

Visited with Messrs. Sangay Duba and Mahesh Ghimiray, PD and PRO, respectively. I did describe to them the intended breeding program I have outlined to be followed in trying to solve the TLB problem. Received from Messrs. Sangay a copy of the publication "Adoption and impact of improved maize technology in Bhutan", which presents interesting data on technologies being disseminated by MoA and implemented in farmer's fields. The document describe the availability of new improved maize cultivars recommended to be grown in areas >1800 masl, including Yangtsipa (SW1), Khangma Ashom 1 (SW 8528), and Khangma Ashom 2 (Palmira 8529).

Drove to Bumthang.

Tue. Aug. 14/07. At the RNRRC, Jakar, Bumthang (2600 masl).

Visited with Messrs. Dorji Wangchuk and Wangda Dukpa, Deputy Chief Research Officer, Horticulture, and Sr. RO, Field Crops, respectively. They showed their interest of participating in the research program. I did describe for them on breeding for disease resistance of maize varieties for the hills. I learned of the lack of collaboration in related projects managed between Centers, the poor coordination in different areas of research between Centers, and the concern in the amount of time that will take to breed resistant germplasm to solve any problem before any increases in production are obtained.

RC-Wengkhar, Mongar Dzongkhag (1800 masl).

Visited with Messrs. Tayan Raj Gurung (PD), and Tirtha Katwal (Deputy Chief Res. Officer), Field Crops. Responsibility for maize research and development is in this Center. Mr. Tirtha took the position as Maize Researcher in 2002 after Vijay Moktan left the program. My personal feeling is that Mr. Tirtha can take the breeding activities involved in a breeding scheme for disease resistance, but would need some technical assistance from experienced scientists, specially during the initial 2-3 stages when hand pollinations are involved. My suggestion is that Nepalese scientists in the Nepalese Maize Program could visit Bhutan and assist Mr. Tirtha during those 2-3 initial stages involving hand-pollinations.

Thu. Aug. 15/07. Chaskar Geog, Mongar Dzongkhag.

Visited approx. 15 farmer's fields. At sites >1800 masl, maize plantings at 2-3 weeks after silking showed an extremely high incidence of gray leaf spot (gls) infection, caused by *Cercospora zeae maydis*. Local varieties, most with yellow endosperm, showed a higher degree of infection than the improved Yangtsipa and its crosses with local germplasm (Photos 1, 2). In general, Yangtsipa seemed to be more tolerant to the disease, probably due to later maturity of the cultivar (Photos 3, 4). In order to confirm if this is true, it is recommended to monitor the incidence of the disease in Yangtsipa in later stages of development. At elevations <1800 masl, incidence of *E. turcicum* could be seen,

but not causing lesser economical damage. It seems the symptoms of gls were mistaken for that of TLB as the problem of gls is new in the country (Photos 5, 6).

Photo 1. Burning of foliage caused by *C. zeae maydis.*

Photo 2. Lesions caused by *C. zeae maydis* in infected maize leaves

Photos 3, 4: Lesser infection by *C. zeae maydis* observed in var. Yangtsipa.

Photo 5, 6: Mixed symtomps of infection of maize leaves by both *E. turcicum* and *C. zeae maydis.*

Urgent Strong recommendations:

Bhutanese hill-maize farmers are facing a new, extremely serious problem with the presence of a disease not previously reported in the country. Wherever this disease has been reported, it has been tackled in all possible ways, especially through disease resistance breeding. In order to slow down and efficiently control the incidence of this disease, the following is recommended:

A. Immediately, request from Dr. Guillermo Ortíz-Ferrara to communicate with Dr. Luís Narro, Maize Breeder in the CIMMYT South American Regional Maize Program (SARMP), in Colombia, requesting names of subtropical and tropical yellow endosperm inbred lines, synthetics, and hybrids developed by the SARMP. It is suggested to request approx. 200 seeds of tolerant inbreds and 250 g of each of the tolerant synthetics and hybrids. With the names and amounts confirmed by Dr. Narro, an Import Permit should be sent to him.

Once this valuable germplasm is received in Bhutan, it should be immediately planted in the coming off season planting (Oct-Nov. 2007), and all desirable entries increased.

Feb-Mar. 2008, normal planting season: Entries increased should be planted in two different plantings, as follows:

i. Planting in farmer's fields at several locations to evaluate their tolerance to the disease, and,
ii. ii. Delayed planting, one month later than in i. above, in a breeding site where 10-12 inbred lines and/or hybrids that show good agronomic characters and tolerance to the disease can be intercrossed in several diallels for the development of several new disease-resistant synthetics. Entries received as synthetics can be increased once their tolerance is confirmed in farmer's fields.

Oct-Nov. 2008, off season planting: Advance seed of F1 synthetics to F2, and seed increase 2-3 best performing synthetics after tested in farmer conditions.

Feb-Mar. 2009, normal planting season: Extensively test new synthetics obtained (F2 seed), plus those 2-3 previously selected and increased. At this stage, not more than 2-3 selected synthetics should be further tested in farmer conditions for release of 1-2 of the best.

B. Use of fungicide sprays should be immediately implemented. However, it is recommended to allow the importation of the systemic fungicide Tilt (active ingredient propiconazole), which has proved to be efficient in controlling the disease. Though it is more expensive than Mancozeb, one spray of this chemical will control the disease more efficiently as this product is systemic, entering the leaf tissues, checking the initial infection and development of the fungus. As previously mentioned, the use of a contact fungicide, such as Mancozeb (Maneb plus $ZnSO_4$) has to be applied several times, in weather conditions where there are no continuous rains to avoid run-off of the product.

These conditions are uncommon in the Bhutanese hills during the main growing season. The possibility of subsidizing the cost of the fungicide Tilt should be considered.

C. It was observed that <1800 m, wherever the improved variety Yangtsipa was planted , farmers could at least harvest the crop. It is suggested that farmers should be recommended to plant improved varieties below 1800 masl.

D. One Program Officer and one Assistant should be appointed full time to Maize Program to work on the selection and breeding for gls-disease resistance, and adaptation throughout locations of the newly developed germplasm. Other activities related with the Maize Program should be responsibilities of this scientist.

E. Suggest one young scientist with Master's degree is selected to undergo doctorate's degree in Plant Pathology. His studies can be completed at one university abroad and research work done in Bhutan working his thesis on Maize Diseases in Bhutan.

Fri. Aug. 16/07. At Drametse Geog (2130 masl).
Visited approx. 10 farmer's fields at this Geog. These are located in opposite hills of the ones visited the previous day. Observations at all sites confirmed that at 1800 masl and above, gls was predominant, causing severe damage in maize plantings. Again, at elevations <1800 masl, TLB lesions could be seen, but causing lesser damage.

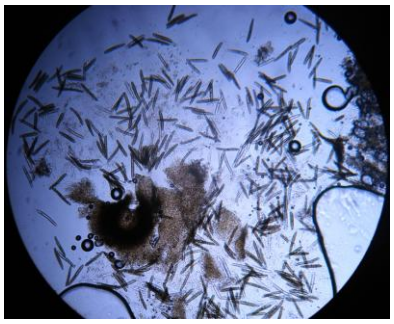
At this site, several samples of fungal maize pathogens were collected to be observed under the microscope in a laboratory. Samples collected and to be checked were *E. turcicum*, *C. zeae maydis*, head smut [*Sorosporium* (syn. *Sphacelotheca*) *reiliana*], a leaf sheath rot, and macrospora leaf blight [*Stenocarpella* (syn. *Diplodia*) *macrospora*] (Photos 7, 8, 9, 10, 11, 12, 13, 14, and 15, respectively).

Photos 7, 8: *E. turcicum* lesions and conidia in maize leaves.


Photos 9, 10: *C. zeae maydis* lesions and conidia in maize leaves.


Photos 11, 12: Head smut symptoms in systemically infected ear, tassel and maize leaves.

Photo 13: Sheath rot in maize caused by unidentified pathogen (*Fusarium* sp.?).

Photos 14, 15: Macrospora leaf blight caused by *S. macrospora* and conidia released from pycnidium.

Sat. Aug. 17/07. At RC-Wengkhar
Spent the morning checking for the presence of structures in the diseased samples previously mentioned. All structures corresponded to the fungi identified in the field (Photos 8, 10, 15). The leaf sheath rot, common in maize plantings at these elevations, was identified as caused by a *Fusarium* sp. Suggested to continue monitoring this disease as it seems to be a possible problem associated with stalk rot.

As mentioned in the Urgent Strong recommendation**,** message was sent to Dr. G. Ortíz-Ferrara, CIMMYT-Nepal, requesting him to contact Dr. Luís Narro, CIMMYT-Colombia, to send names and possible amounts of seed of gls-resistant subtropical entries with yellow endosperm selected in the SARMP. With the incoming information, the Bhutanese Import Permit should be sent immediately to Dr. L. Narro. In his side, he has to apply to Colombian authorities for a Phytosanitary Certificate, taking time in the process of the suggested urgent planting.

Had material for training course prepared.

4. Maize Training Course

Mon. Aug. 20/07.
Initiated a Maize Training Course at Weingkhar RC. A total of 35 persons, including 22 extension agents from various regions, plus other participants from different Centers were present during the two day course.

In the morning, had lectures on origin of maize, its ancestors, distribution, uses, and general aspects of diseases affecting the crop, etiology, epidemiology, and control using pictures showing symptoms of the various fungal diseases collected in the field during this visit and microphotographs of structures of the organisms involved.

In the afternoon, visited one site where symptoms of three diseases described during the lecture (cercospora leaf blight, TLB and head smut).

In the evening, read messages received in emails, and could check that Dr. G. Ortiz-Ferrara replied positively to the request to contact Dr. L. Narro asking for the list of cercospora-resistant entries developed in the SARMP. Also, he sent messages to CIMMYT-Mexico and Zimbabwe where gls-resistant germplasm has been generated. Information of entries available from these programs will be sent to Mr. Tirtha in order to get the corresponding Import Permits.

Tue. Aug. 21/07

Continued lectures on maize ear rots and mycotoxin formation.

As a part of the training, an open session was organized on possible disease management options. A series of activities was agreed to be carried out immediately by Extension, Research and NPPC which will be compiled and subject to further discussion

among the relevant institutions and authorities to agree on an action plan for implementation (Annex 1).

Photo 16: Participants in the Maize Training Course. Aug. 20-21, 2007.

Comments from the training course were requested from all 31 participants. Summary of their comments are included in Annex 2.

Annex 2: Assessment of the Training

Date: 21/8/07

Total participants - 31

1. What is your overall assessment of the training?
   a. Useful - 3
   b. Very useful - 28
   c. Not useful -0

2. From the topics covered which was the most useful?
   a. History of maize -0
   b. Breeding -0
   c. Diseases -15
   e. Field visit -8
   f. All -23

3. Should more training be conducted in future?
   a. Yes - 31
   b . No - 0

4. What are the most important topics you suggest to cover in future trainings?
   Only five top ranked topics are listed
   - Control measures -25
   - Disease identification -22
   - Maize agronomy and diseases - 6
   - Breeding -5

5. With this training your confidence on handling maize problems is
   a. Same - 1
   b. Increased - 24
   c. Increased very much - 6

6. Were the topics covered of your level?
   a. Yes - 29
   b. No, it was too high to understand - 1

7. What is the most important information that you will take for the farmers from this training?
   Only four top ranked topics are listed
   - Control measures -26
   - Information on Variety and seed -5
   - Awareness on ear rots - 3
   - Mobilization of communities for disease management - 1

8. How was the duration of the training ?
   a. Adequate - 20
   b. Too short - 11
   c. Too long - 0

9. Is the timing of the training appropriate?
   a. Yes - 29
   b. No - 2

10. Do you suggest any reference that should be developed or obtained for Extension Agents on maize?
    Only top four top ranked topics are listed
    - Manual on maize diseases / pests – 25
    - Leaflet on maize disease/pest in local language – 5
    - Manual on maize seed selection – 4
    - Package of practices for maize - 2