Successful Transfer of ICRISAT Downy Mildew Resistance Screening Technology: an Example of Transfer of Technology

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Abstract

Technology transfer is an ICRISAT mandate. Successful transfer of sorghum downy mildew disease resistance technique is presented as an example of technology transfer. Components of the technique were demonstrated and successfully transferred to national and regional programs in SAT countries.

Introduction

"Technology-Transfer" can be defined as an extension activity in which results of scientific investigation in any area of production and protection (especially in crop improvement) are applied to practical use in other, usually distant, places.

An intended technique may be transferred in two ways: by training an individual from the "targeted" area at a place where the technique is successful and well established, so that scientist can establish and use the technology upon returning to his or her area of operation; and by demonstrating various components of the technology to individuals at their own facilities, using the resources available. The second method has been the most successful as receiving individuals appear to gain confidence by modifying, as needed, the locally available facilities to establish a particular technique.

At ICRISAT, large-scale field-screening techniques for evaluating sorghum resistance to downy mildew (*Peronosclerospora sorghi*), grain molds (fungal complex), and ergot (*Sphacelia sorghi*), were developed. Similarly, pearl millet resistance to artificially inoculated downy mildew (*Sclerospora graminicola*), ergot (*Claviceps fusiformis*), and smut (*Tolyposporium penicillariae*) diseases in field nurseries was identified.

Although these field-screening techniques were routinely explained and demonstrated to visitors from Africa, the Americas, and Asia enrolled in certain training programs at ICRISAT Center, they have been adopted at only a few locations outside ICRISAT. The main reason for this in many places is lack of basic facilities and experienced hands.

The successful establishment of the ICRISAT sorghum downy mildew field-screening technique in Zimbabwe and Zambia during the 1986/87 and 1987/88 rainy seasons, respectively, is discussed here.

Screening for SDM Resistance

A large-scale screening technique for sorghum downy mildew (SDM) resistance was standardized by scientists at ICRISAT Center, substation Dharwad, Karnataka state, India, during the 1982 rainy season. Temperatures and humidities at Dharwad are favorable for sorghum DM development and spread.

The infector-row field-screening technique for sorghum downy mildew is based on wind-

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borne conidia (asexual spores) of *Peronosclerospora sorghi*, the causal organism of SDM. Conidial showers, blown by wind from infector rows onto test materials, provide the inoculum.

Two especially important aspects of the successful employment of this technique are establishment of the disease in infector rows, and favorable temperatures and humidities for abundant conidial production by plants in the infector rows. Screening should be conducted, therefore, at a location known to be favorable for the disease, as is the Dharwad installation in India.

Source and off-season maintenance of inoculum

Most of the downy mildew diseases have evolved in close association with a number of noncultivated grasses. The DMs have become a concern only when extensive sowings of susceptible genotypes are established in areas where a DM is introduced and/or endemic on a native grass species. In general, grass species that are hosts for DMs are native to the southeastern Asia, and generally of the tribes Andropogoneae and Maydeae. In North America, johnsongrass (*Sorghum halepense*) and shattercane (a feral *S. bicolor*) can become infected naturally in the field by *P. sorghi*. Since oospores and conidia are produced in both species, these spp often serve as sources of primary inoculum. Perennial wild sorghums are common in borders of cultivated fields and in drainage and irrigation ditches. The sources of primary conidial inoculum used for establishment of screening techniques at three locations were:

Dharwad, India. During May 1981, two volunteer plants of a sorghum cv with systemic disease were located. We used these two plants as conidial sources, and increased the inoculum by use of the sandwich inoculation procedure. The conidia inoculum in systemically infected plants was carried over in the off season. Just before the main growing season (rainy season), this inoculum was increased for use in establishing infector rows.

Matopos, Zimbabwe. The primary inoculum was collected from systemically infected ratoons of cultivated sorghums at Kadoma. Infection (plants with systemic disease) on some entries was as high as 60%. These ratoons surely were infected by conidia blown from other infected plants, that had been infected by either oospores or conidia from weedy and wild sorghums. This inoculum was used to infect 20 sorghum lines, using the sandwitch inoculation procedure and some 20 plants with systemic infection were obtained (Pande 1987); these in turn were used to establish infector row screening during the 1986/87 season (Singh 1987) using modified sandwich inoculation. Natural temperatures were found to be congenial for sporulation and infection.

Golden Valley, Zambia. During 1986/87, a severe outbreak of sorghum downy mildew was observed at Golden Valley and some of the entries showed as high as 80% systemic infection (B.N. Verma and W.A.J. de Milliano, personal communication). During the last week of November, few systemically infected weedy and wild sorghums (*S. halepense*) were observed near the irrigation canal. After the first rains, we collected thousands of systemically infected *S. halepense* and shattercane plants from many locations around Golden Valley. Inoculum from these plants was used to establish the infector rows.

Establishing infector rows

The most important and vital component of the ICRISAT SDM screening technique is the infector rows. To establish these, we sow germinated and downy mildew-infected seeds of a highly susceptible cultivar (DMS 652, IS 643, Marupantse, or Sugardrip). On these cvs, the pathogen produces abundant conidia. Pregerminated seeds were inoculated following the sandwich inoculation technique.

In sandwich inoculation, germinated seeds are incubated by placing them on the adaxial surface of a piece of systemically infected leaf, and covering them with another piece of systemically infected leaf, so that the germinated seeds are sandwiched. The procedure is carried out in petri dishes lined with moist filter paper; dishes are incubated in darkness at 18–20°C for 12 to 16 h. By this time, the seedlings are covered with a mycelial mat of the fungus, indicating that the fungus has sporulated and conidia

might have caused the systemic infection in the growing plumule. However, one cannot be sure until the emergence of systemically infected plants in the infector rows.

If incubators and petri dishes are not available, one can modify this seedling inoculation technique (Singh 1987). In this method, germinated seeds are spread on a polyethylene sheet (approximately 1 to 2 m long × 0.75 m wide). Systemically infected potted plants are laid on the seedlings so that the lower leaf surfaces are in contact with the germinating seed. The infected plants are covered with moist gunny bags and finally with polyethylene sheets, to maintain a saturated relative humidity.

These chambers are left overnight under natural conditions for the infection process. The advantage of this technique is that infected plants can be used, repeatedly if "rested" about 12 h between use, and 2 to 3 kg of germinated seeds can be inoculated at one time. However, the effectiveness of this method of inoculation depends upon the availability of systemically infected leaves. If all leaves of the conidia-donor plants are completely systemically infected, screening is more successful because the possibility of uneven infection of the infector rows is reduced.

Recently at Golden Valley, the senior author used seed beds as a substitute for petri dishes, replacing the moist filter papers with moist newspaper. Systemically infected leaves of wild sorghums and 3 to 5 kg of germinated seeds were layered as in the sandwich technique. However, he finally covered the seed bed with polyethylene sheets to maintain the humidity. This inoculation procedure produced 90 to 100% systemically infected plants in the infector rows.

Natural environment can replace incubators if seasonal night temperatures are favorable at the location where SDM infector row field screening is to be established. Incubators may be available when petri dishes are not; then one can use two dinner plates, or two serving trays of equal size. We have successfully used these in this season at Golden Valley.

Seedlings inoculated by either of the above methods are planted in every six or tenth row, depending upon wind velocity at the location. At Golden Valley we have sowed each sixth row as an infector row. However, at Matopos (Singh 1987; De Milliano 1987) each seventh row was sown as an infector row. Once the infector-row plants are established and show heavy DM sporulation (about 20 to 25 days from sowing), the test material should be seeded.

Sowings of test materials

Sow five or nine rows (depending on distance between the infector rows) of test material. The center row of the trial is sown to the same DM susceptible variety as the test rows; it serves as an indicator of disease pressure and as a susceptible control for the test rows between it and the infector rows. The arrangement of infector rows, test rows, and indicator rows may be adjusted to accommodate local situations—such as the availability of land and the number of entries to be screened.

Evaluating resistance

The control row and the test materials are evaluated for DM at the seedling and flowering stages; sorghum lines with no more than 5% of the plants showing systemic disease are regarded as resistant.

With this procedure, 4500 sorghum breeding and germplasm lines were evaluated at Matopos; of these, 1008 were found to be resistant. In this season, senior author has sown more than 5000 sorghum and maize lines, including material from ICRISAT Center, SADCC/ICRISAT, and Zambia's national sorghum- and maize-improvement programs at Golden Valley; of these 928 sorghum and four maize lines were found to be resistant.

Additional Adoptions

Components of this technique have been adopted by several national programs, such as the All-India Coordinated Sorghum Improvement Program at the University of Agricultural Sciences, Dharwad, Karnataka state, India (Anahosur, personal communication). The sandwich technique was successfully used to establish infector rows for SDM screening in Rwanda (Bandyopadhyay 1987).

Several other techniques, such as pearl millet ergot and smut inoculations were conducted at Matopos (Thakur 1986). Singh (1985) success-

fully established the pearl millet downy mildew screening technique in Mali, and Bandyopadhyay (1987) demonstrated the different phases of sorghum ergot screening technique at Rwanda.

Conclusion

In all, good progress has been made by ICRISAT scientists in demonstrating the successful transfer of resistance-screening techniques in places where these diseases are important constraints in sorghum and millet improvement.

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