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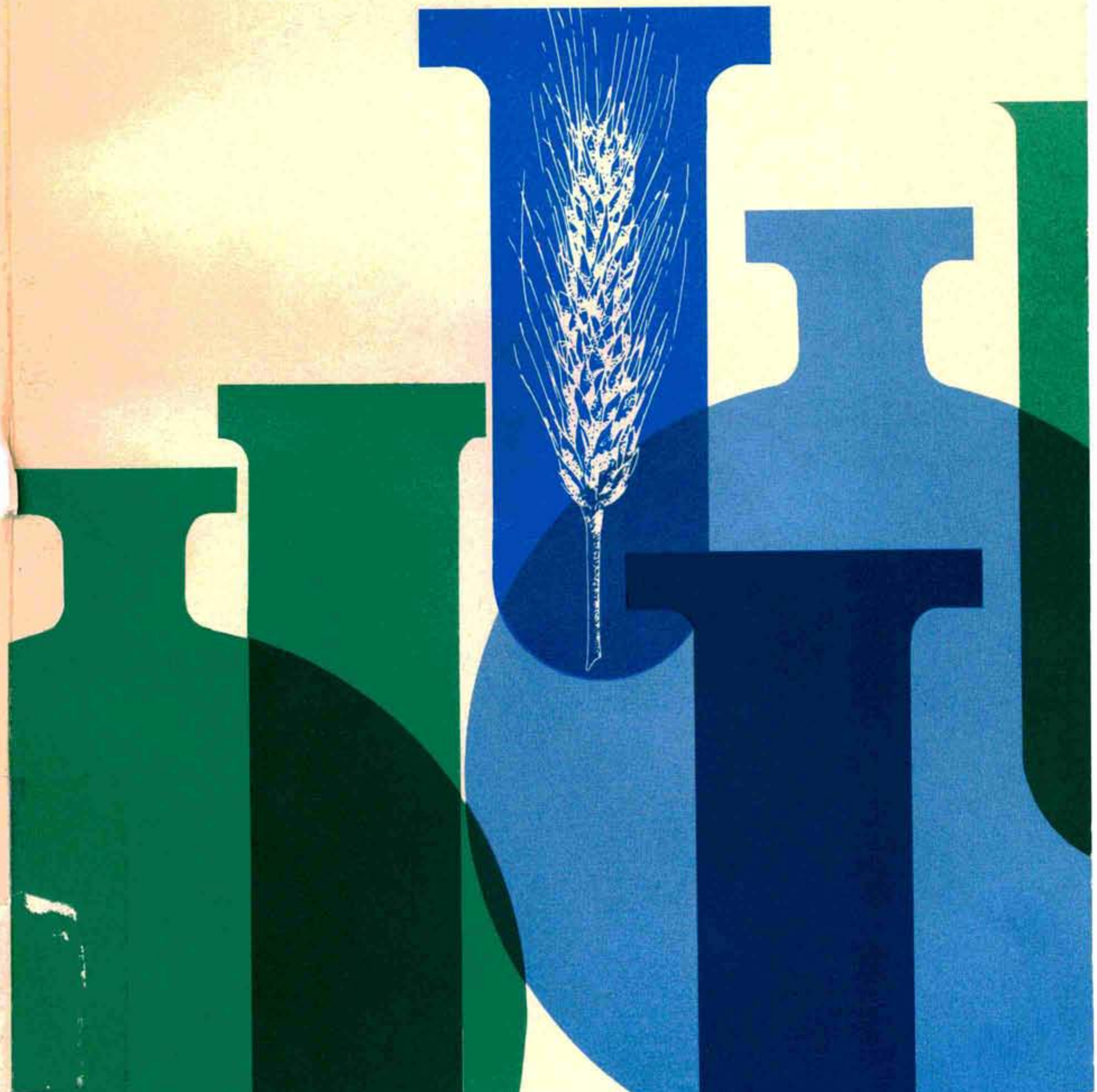

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Contents

Triticale Diseases in CIMMYT Trial Locations

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Abstract This paper describes triticale diseases found by the staff of CIMMYT at their various trial locations in Mexico, records made by cooperators in outreach trials, and the authors' examination of material at and from CIMMYT. At present, a list of pathogens capable of infecting triticale is all that can be attempted. This list will doubtless increase as the crop is grown more widely and receives more attention from plant pathologists throughout the world. Little can be said about the different susceptibilities of triticale to various diseases. Information available from the International Triticale Yield Nurseries on disease incidence is very incomplete, but it would appear that in general triticale has some useful resistance against stem rust (*Puccinia graminis* Pers.) and stripe rust (*P. striiformis*) but is somewhat susceptible to leaf rust (*P. recondita* Rob. ex Desm.). In North Africa and South America triticale has some resistance to septoria disease, which can be severe on wheat in these areas. Estimation of disease severity in terms of yield loss will require more intensive research that can only be contemplated when triticale is more extensively grown.

Résumé Ce texte décrit les maladies du triticale constatées par les chercheurs du CIMMYT aux différents endroits du Mexique où sont situés les champs d'essai, celles signalées par les collaborateurs du Centre dans les essais de diffusion et celles relevées par l'auteur lors d'examens du matériel végétal du CIMMYT ou provenant de cet organisme. Une liste de pathogènes susceptibles d'infecter le triticale est tout ce que l'on a pu établir jusqu'à présent. Cette liste s'allongera sans aucun doute au fur et à mesure que se répandra cette culture et qu'elle bénéficiera de plus d'attention de la part des phytopathologistes du monde entier. On ne peut dire que peu de choses quant à la vulnérabilité des triticales aux différentes maladies. Les renseignements sur la fréquence des maladies émanant des pépinières internationales de multiplication du triticale sont très incomplets, mais il semblerait qu'en général les triticales aient une bonne résistance à la rouille de la tige (*Puccinia graminis* Pers.) et à la rouille striée *(P. striiformis)* mais soient assez sensibles à la rouille des feuilles *(P. recondita* Rob. ex Desm.). Le triticale a révélé une certaine résistance à la septoriose en Afrique du Nord et en Amérique du Sud, régions où cette maladie peut gravement affecter le blé. Un jugement sur la gravité des maladies en termes de pertes de production nécessitera des recherches plus intensives qui ne pourront être envisagées que lorsque la culture du triticale se sera développée sur une grande échelle.

TRITICALE has been grown commercially in Hungary, Spain, Canada, and parts of the USA, but there are few references to disease apart from rusts and ergot, which were covered by Fuentes (1974). Our information on triticale diseases is limited to observations made in Mexico by the staff of CIMMYT at their various trial locations, records made by cooperators in outreach trials, and our own examination of material at and from CIMMYT. Many of these observations are of limited use because of the difficulty of disease diagnosis. Very similar symptoms may be caused by different pathogens in different parts of the world and the same pathogen may express itself in a variety of ways. All trial workers and breeders should be prepared initially to make some preliminary microscope examination of diseased material to determine the identity of the pathogen. Attempts at field diagnosis should only be made when one is familiar with the symptoms of a disease in a particular area, and even these diagnoses should be supported by regular microscope checks. Whenever possible, the help of national or international pathological or mycological services should be used.

There is a well-defined group of organisms known to be pathogenic on wheat or rye, and it is likely that these organisms will eventually be found on triticale. Lesions with organisms not belonging to this group should be examined with care before being reported as a new disease, and efforts should be made to satisfy Koch's postulates. These state that an organism should be isolated into pure culture from lesions, be shown to be capable of reinfecting the host to cause the same disease, and be reisolated into pure culture.

For nonpathologists it would be useful to outline the main points to be noted when looking at fungi from diseased material. Hopefully spores will be present. Are they produced superficially or from inside spherical structures? The spherical structures may be superficial or immersed in plant tissue. If they contain free spores they are probably pycnidia (Fig. 1). If the spores are not free but are contained, usually in groups of eight within sacs (asci, Fig. 2) they are perithecia. For further identification, the shape, size, and colour of the spores need to be noted.

Leaf Diseases

Fusarium nivale (Fr.) Ces. (*Micronectriella nivalis* (Schaff.) Booth)

A leaf blight caused by this fungus occurs extensively at Toluca and also at El Batan, but it has not been recorded on triticale elsewhere, or to any extent on other cereals (Richardson and Zillinsky 1972); therefore, except at Toluca, it would seem to be of little importance at present. It should, however, be watched for in areas with a climate similar to that of Toluca, with relatively warm day temperatures, frequent heavy rain for spore dispersal, and long periods of leaf wetness for infection. Lesions are extensive, irregular, dull grey-green, and water-soaked in appearance. The fungus produces pustules of spores through each of the stomata, which can be seen with a hand lens ($\times 10$) as parallel rows of regularly spaced whitish to pinkish dots (Fig. 3). The spores are colourless, 10–30 (40) $\times$ 4–5.5 μm, curved, with 0–3 septa (Fig. 5). Very old lesions may also have the perithecial state.

Septoria Leaf Blotches

Much work has been done at CIMMYT with *Septoria tritici* Rob. and Desm., but there are three or four species of *Septoria* that may occur in different areas (Richardson and Noble 1970). Spores of all species are colourless, cylindrical, and produced in pycnidia.

The current position is as follows:

Septoria tritici, with spores 50–90 $\times$ 2 μm (Fig. 6), has been recorded from Mexico (Anon. 1973), Portugal and Tunisia (CIMMYT 1972), and Algeria (Floyd, personal communication). Lesions tend to be buff, irregular, and extensive, and speckled with small, dark pycnidia.

Septoria nodorum Berk. (*Leptosphaeria nodorum* Müller) is the common wheat pathogen in Europe, causing both leaf and glume blotch. The spores are short, rarely more than 25 μm long $\times$ 3–4 μm (Fig. 7). Pycnidia are

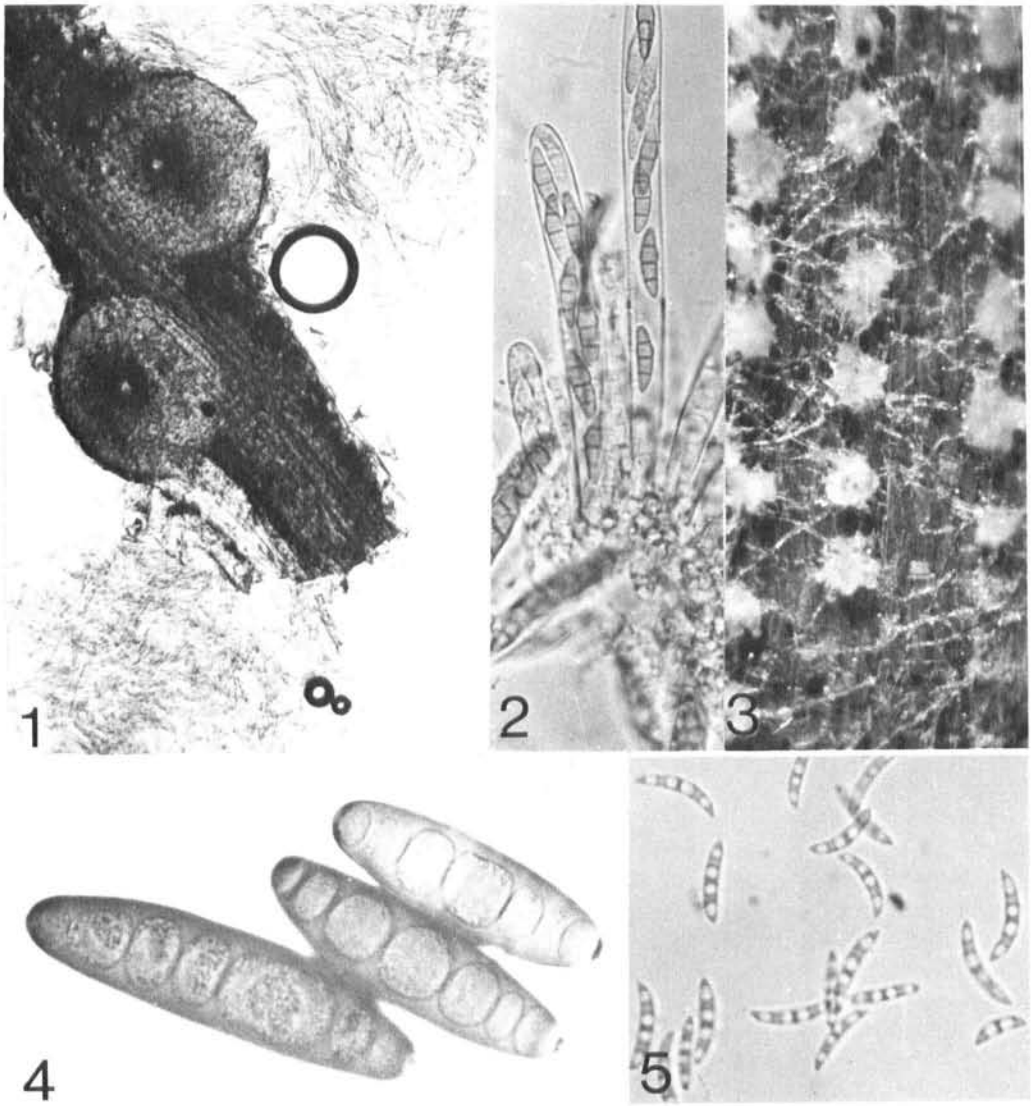

FIG. 1. Pycnidia (×84). FIG. 2. Asci (×336). FIG. 3. *Fusarium nivale* sporulation through stomata of leaf (×84). FIG. 4. *Drechslera sativa* spores (×630). FIG. 5. *Fusarium nivale* spores (×630).

often pinkish and transparent, but may become darker with age. It has been recorded on triticale in Tunisia (CIMMYT 1972) and at Toluca.

Septoria avenae f.sp. *triticea* Johnson (*Leptosphaeria avenaria* f.sp. *triticea* Johnson) is the wheat form of the oat *Septoria*. *Septoria secalis* Prill. and Delacroix occurs on rye. Both species have spores 30–50 × 3–4 μm (Fig. 8) and such spores have been obtained from triticale at El Batan and Toluca. Which of the two species is involved, if in fact they are distinct, cannot be ascertained until infection tests have been carried out. Lesions of *S. nodorum* and *S. avenae* f.sp. *triticea* on both wheat and barley, and *S. secalis* on rye can all be similar, often buff with chlorotic margins, but very dark lesions with *S.*

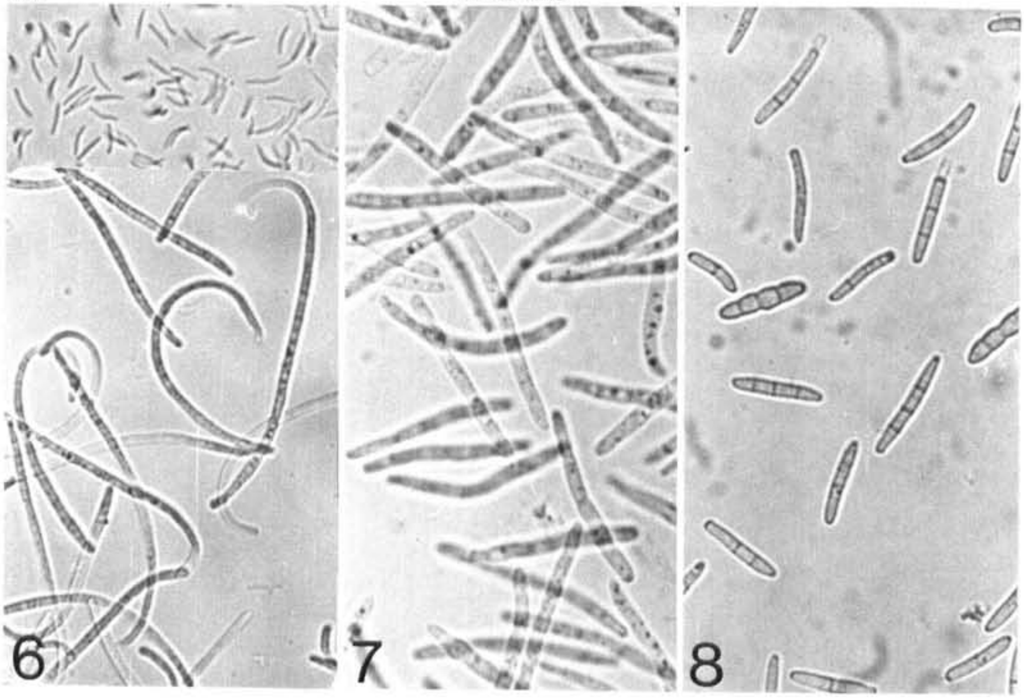

FIG. 6. *Septoria tritici* micro- and macro-spores (× 660). FIG. 7. *Septoria avenae* f.sp. *triticea* spores (×660). FIG. 8. *Septoria nodorum* spores (×660).

nodorum and *S. avenae* f.sp. *triticea* or *S. secalis* pycnidia have been observed on triticale from Toluca. Pycnidia are much less obvious than those of *S. tritici* and are best seen with transmitted light.

It is possible that some of the outreach records of *S. nodorum* are in fact records of this longer spored *S. avenae* f.sp. *triticea*/*S. secalis*. It is not widely known and there is a tendency to identify as *S. nodorum* any *Septoria* on wheat that is not obviously *S. tritici*.

Drechslera (Helminthosporium) sativa (Cochliobolus sativus **(Ito and Kuribay) Drechsl. ex Dastur**)

This fungus is a cosmopolitan cereal pathogen causing both a foot rot and leaf spot. It has been recorded on triticale collected from both Toluca and El Batan, and will no doubt be recorded in many places where triticale is grown. The leaf spot can be similar to those produced by *Septoria* spp., but the lesions produce large, superficial, dark-brown, septate, banana-shaped spores up to 120 × 18–25 μm (Fig. 4).

Two other leaf diseases that have not yet been recorded on triticale should be mentioned. *Rhynchosporium secalis* (Oud.) Davis causes scald of barley, but was first described from rye. Lesions are water-soaked with dark margins and produce colourless, beaked, two-celled spores abundantly over the surface. *Alternaria triticina* Prasada and Prabhu causes a leaf disease of wheat in India. *Alternaria* is a large genus and many species grow saprophytically on dead tissue, so it should not be assumed that any *Alternaria* associated with a lesion is either *A. triticina* or the cause of the lesion.

Nonpathogenic Abnormalities

Frequently, pathological symptoms that are not caused by pathogenic organisms occur on plants. Often these are confused with symptoms caused by known pathogens, thus obscuring the true cause of the condition and perhaps overestimating the effect of other diseases. These nonpathogenic abnormalities may be caused by adverse environmental conditions, such as mineral deficiencies or toxicities, moisture stress, temperature extremes, or they may be largely influenced by the genotype of the plant.

Environmental stresses that do not induce pathological symptoms may nevertheless predispose the plant to attacks by pathogenic organisms.

A prominent chlorotic leaf speckle occurs uniformly throughout Cinnamon triticale both at Toluca and El Batán. All attempts to isolate a pathogen that could be responsible for this have failed, and the condition appears to be an intrinsic character of the crop. The chlorotic speckling reduces the photosynthetic area of the leaves and later appears to facilitate the establishment of weakly pathogenic organisms that hasten leaf senescence.

Many species of fungi grow as saprophytes on leaf surfaces especially on areas of dead or moribund tissue. These do no harm, and it should not be assumed that any fungus seen in association with a lesion is the cause of it. *Alternaria* spp., *Cladosporium* spp., *Epicoccum,* sooty moulds, and yeasts are common leaf saprophytes that are very frequently seen growing on lesions primarily caused either by other fungi, viruses, or nonpathogenic causes.

Root and Stem Base Diseases

Generally, these diseases receive less attention than those affecting the aerial parts of the plant. This is largely because they are more difficult to observe and record; also they are usually reckoned to be less dangerous than leaf diseases and spread during a season is very small. Frequently root and stem base diseases are only noticed when they induce severe symptoms on the aerial parts of the plants, such as severe stunting, chlorosis, "white heads," etc. However, "subclinical" attacks producing no easily detectable aerial symptoms can restrict yields by reducing tillering, ear size, and grain weight.

Information on root and stem base diseases of triticale is at present very scant. Take all, *Gaeumannomyces (Ophiobolus) graminis* (Sacc.) Arx and Olivier, is locally severe in Armadillo PM 13 at El Batan but does not seem to be widespread. Krolow (personal communication) reports that take all occurs in triticale in Europe where the octoploids appear to be most susceptible. Eyespot *(Cercosporella herpotrichoides* Fron) also occurs there but has not been observed in Mexico, but *Rhizoctonia (Corticium) solani* Kühn was isolated from an ill-defined eyespot lesion at the base of the stem of a prematurely dead plant of Armadillo from El Batan. Fusarium foot rot has been reported from the USA and is doing some damage in triticale at El Batan where it is associated with *Cochliobolus (Helminthosporium) sativum,* a fungus frequently observed sporulating on moribund stem bases.

Insects and Other Pests

Very little information is available on pest attacks on triticale, although pests such as Hessian fly can be important on cereal crops in North Africa. Shoot flies are causing some damage at Toluca and El Batan, where grubs boring along the stem prevent ear emergence.

Bacterial Diseases

Bacterial leaf striping can be severe on some lines of triticale (e.g., Jenkins Foundation Research No. 6A/203) at El Batan, and has been very severe in Sonora in the past. However, selection of resistant lines at Navojoa has greatly reduced the problem. This disease also occurs on triticale in India and it would seem that the crop may be more susceptible than either wheat or rye. *Xanthomonas translucens* (Jones, Johnson and Reddy) Dowson has been reported to be the cause in most instances, but *Pseudomonas striafasciens* (Elliott) Starr and Burkholder has been isolated from bacterial leaf striping at El Batan.

Seed-Borne Fungi

Apart from the direct loss caused to the growing crop by disease there are two other aspects that should be mentioned. Many pathogenic fungi that occur extensively on cereal leaves can also infect the grain and so provide the fungus with an ideally placed inoculum to infect the seedlings produced when that seed is sown. Poor seed germination should not automatically be blamed on the genetic constitution of the line concerned. It may be the result of a high level of seed-borne inoculum. It may be the result of an attack of the seed or seedling by soil organisms. Seed that is in poor physiological condition because of poor harvesting, storage, or handling conditions is especially vulnerable to such attack when sown.

Seed treatment with fungicides can help to control both of these problems.

In the preliminary study, 13 seed stocks were examined in October 1973 for the presence of seed-borne pathogens, by plating out 100 seeds of each on potato dextrose agar after 10 min surface disinfection with 1% sodium hypochlorite solution and incubating for 7 days. The results are given in Table 1.

The other aspect relates to the comment made by Larter (1974) concerning the poor results from feeding trials, which he attributed to the presence of ergot in the sample. Many fungi less conspicuous than ergot, especially storage fungi, e.g., *Aspergillus*, and species of *Fusarium* produce toxins. Some of these, e.g., Zearalenone produced by *F. graminearum* Schwabe *(Gibberella zeae* (Schw.) Petch), are oestrogenic and result in sterility, abortion, and unthriftiness in animals. *F. graminearum* is a common cereal pathogen and has been found on triticale at El Batan. It causes a foot rot with resultant whiteheads and purple superficial perithecia at the base of the culms, and a head blight, commonly known as scab. Affected ears produce large numbers of both perithecia and conidia.

Epidemiology and Disease Resistance

The true impact of a disease on a crop can only be observed when the crop is grown extensively under field conditions, thus permitting the development of natural epidemics. Large areas of triticales are present in only a few, scattered locations in the USA

TABLE 1. Seed-borne pathogens of triticale.

Seed stock	Source and harvest date	% infection		
		F. nivale	*D. sativa*	*F. 'roseum'*[a]
Armadillo 105		0	4	2
Armadillo PM 13		0	0	2
Cinnamon	El Batan Oct. 1972	0	11	2
Koala		10	0	0
Camel		0	11	0
Armadillo 105		0	0	0
Armadillo PM 13		0	0	0
Cinnamon	Obregon May 1973	0	0	0
Koala		0	0	0
Camel		0	0	0
Winter Triticale (Hungary)		0	0	2
Winter Triticale (F_4 S-6)	Toluca Aug. 1973	2	0	1
Winter Triticale (USSR)		1	0	2

[a]*F. 'roseum'* is a name used to include *F. culmorum*, *F. graminearum*, and *F. avenaceum*. It was not possible in the short period of our study to identify the species with certainty.

and Europe and the development of disease epidemics in these crops has not been studied. Disease observations on triticale have been very largely limited to small plots; diseases in these can be greatly influenced by inoculum produced outside the crop, whereas epidemics within large acreages depend mostly on inoculum generated within the crop. Inoculum production is an important criterion for assessing field resistance in small plot observation.

In some triticale diseases, sporulation of the pathogen is rather sparse, e.g., stripe rust *(Puccinia striiformis* Westend) and some *Septoria* diseases. "Slow rusting" and increasing adult plant resistance in some lines of triticale has been reported by Zillinsky (1973). These are manifestions of generalized or horizontal resistance that may be operable against all or most races of a particular pathogenic fungus, and it seems likely that such resistance may be present in triticale. Unfortunately, this type of resistance cannot be adequately selected for in small segregating populations without intensive "in depth" studies on mechanisms of infection and disease development. Nevertheless, the screening of all promising lines on a global scale in the international nurseries, and the inclusion of lines showing overall resistance in all areas in the general breeding program should ensure that some horizontal resistance is both detected and perpetuated.

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