Phytopath. medit., 1997, *36*, 167-181

REVIEW

Current status of wheat and barley diseases in the Central Anatolian Plateau of Turkey

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Summary. During the years 1992, 1993 and 1994, extensive field surveys of wheat and barley diseases were conducted in the Central Anatolian Plateau (CAP). A total of 299 wheat fields and 79 barley fields, representing the main growing areas, were checked systematically for fungal and viral diseases as well as for nematodes. The most frequently occurring disease of wheat was foot and root rot, and *Fusarium* spp. were the predominant pathogens isolated. In barley, the most frequently occurring disease was barley leaf stripe, followed by foot and root rot. *Cochliobolus sativus* was the main pathogen causing foot and root rot. The incidence of these wheat and barley diseases was around 10% in infested fields and this can be equated to the actual losses caused. Other foliar diseases of wheat encountered were leaf spot, septoria blotch, yellow, leaf and stem rusts, cereal cyst and seed gall nematodes, head and glume blotch, powdery and downy mildews, and tan spot. Other barley diseases found were scald, net blotch, powdery mildew, leaf and stem rusts, leaf spot, and cereal cyst nematode. Among bunts and smuts, loose smut of wheat was the most frequently occurring and at high incidence, up to 36% in some fields. Losses due to loose smut are equated to percentage incidence. Common bunt of wheat and covered smut of barley were also frequently observed. Flag smut of wheat was found in one location. Pathogens recorded for the first time on the CAP are *Wojnovicia graminis* causing root rot, *Leptosphaeria nodorum* causing septoria nodorum blotch, and *Sclerophthora macrospora* causing downy mildew. Among the viral diseases, barley yellow dwarf (PAV and RMV serotypes) was found at extremely low incidence (less than 1%); wheat streak mosaic virus (WSMV) and barley yellow striate mosaic virus (BYSMV) were only detected in specific regions and with very low incidence.

Introduction

Turkey is the seventh largest wheat (*Triticum aestivum* L. and *T. turgidum* L. var. *durum*) and the eighth largest barley (*Hordeum vulgare* L.) producer in the world (Saad, 1993). Winter/facultative types of wheat and barley are grown in the Central Anatolian Plateau (CAP) and its transitional zones. The CAP is a high plateau rising progressively towards the East from about 700 m asl in the West to 1600 m asl in the East. A total of 6.3 million ha are devoted to cereals on

the CAP. Wheat is grown on 4.5 million ha which comprises 90% bread wheat and 10% durum wheat, whereas barley is grown on 1.8 million ha (Anonymous, 1993). The two main bread wheat cultivars are 'Gerek 79' and 'Bezostaya' and they cover 30% and 18% of the wheat-cultivated area, respectively. Landraces and cultivars released before 1969 still occupy 30% of the cultivated area. Several other bread wheat cultivars are grown (Anonymous, 1996). The leading winter/facultative durum wheat cultivars are 'Kunduru', 'Çakmak' and 'Kızıltan 91'. The barley cv. Tokak, a 2-row type, covers almost all (97%) of the barley cultivation area in the CAP (Anonymous, 1996).

Major diseases of wheat reported on the CAP are stripe rust, caused by *Puccinia striiformis* West. f. sp. *tritici* (Kınaçı and Kınaçı, 1991; Byauh and Saari, 1992); common bunt [*Tilletia laevis* Kühn and *T. tritici* (Bjerk.) Wint.] (Saydam *et al.*, 1972; Aktas, 1974; Finci, 1981; Finci *et al.*, 1983; Aktas *et al.*, 1995); loose smut [*Ustilago tritici* (Pers.) Roster.] (Iren, 1981; Parlak, 1981). Dwarf bunt, *T. controversa* Kühn, is known to occur in the mountainous areas of eastern Turkey (Özkan *et al.*, 1976; Özkan and Damgaci, 1984; Akça *et al.*, 1995). Other wheat diseases of minor importance are flag smut [*Urocystis agropyri* (Preuss) Schroet] (Iren, 1981; Parlak, 1981); leaf rust [*P. recondita* Rob. ex Desm. f.sp. *tritici*] (Kınaçı and Kınaçı, 1991; Arslan and Baykal, 1995); stem rust [*P. graminis* Pers. f. sp. *graminis*] (Iren, 1955; Kınaçı and Kınaçı, 1991); powdery mildew [*Erysiphe graminis* DC. ex Merat. f.sp. *tritici*] (Gümüstekin and Soran, 1991; Özer *et al.*, 1995); foot and root rot [*Cochliobolus sativus* (Ito & Kurib.) Drechs. ex Dast.] (Kınaçı and Kınaçı, 1991), [*Fusarium* spp.] (Damgaci, 1981a; Kınaçı and Kınaçı, 1991; Muratçavusoglu and Hancıoglu, 1995), [*Gäumannomyces graminis* (Sacc.) Arx & Oliv] (Turhan *et al.*, 1985; Kınaçı and Kınaçı, 1991), [*Pseudocercosporella herpotrichoides* (Fron) Dei.] (Kınaçı and Kınaçı, 1991); septoria leaf blotch [*Septoria tritici*] (Iren, 1981; Kınaçı and Kınaçı, 1991); tan spot [*Pyrenophora tritici-repentis* (Died) Drechs.]; and black point, *Alternaria* spp. (Kınaçı and Kınaçı, 1991).

The major diseases of barley reported from the CAP, in descending order of importance, are barley leaf stripe, caused by *Pyrenophora graminea* Ito & Kuribay (Aktas, 1983; Aktas *et al.*, 1986; Damgacı and Aktuna 1988; Kınaçı and Kınaçı, 1991); scald [*Rhynchosporium secalis* (Oud.) J.J.Davis] (Doken 1988; Kınaçı and Kınaçı, 1991; Damgacı, 1981, 1991); covered smut [*Ustilago hordei* (Pers.) Lagerh.] (Saydam and Cöpçü, 1975; Damgacı, 1991a); and loose smut [*U. nuda* (Jens.) Rostr.] (Kınaçı and Kınaçı, 1991). Diseases of local or minor importance reported are foot and root rot caused by *C. sativus* (Aktas and Bora, 1981), *Fusarium* spp., *P. herpotrichoides* and *G. graminis* (Kınaçı and Kınaçı, 1991); and net blotch [*Pyrenophora teres* Drechs.] (Aktas, 1987). Also known to occur are leaf rust (*P. hordei* Otth.); and powdery mildew (*E. graminis* f.sp. *hordei*).

Seed gall nematode [*Anguina tritici* (Steinbuch)] (Yüksel *et al.*, 1980), cereal cyst nematode [*Heterodera avenae* Woll.] (Lung, 1992; Enneli *et al.*, 1994; Oztürk *et al.*, 1994; Greco, 1995), probably also *H. latipons* Frankl. (Greco, 1995) are reported to occur in the CAP. Root lesion nematodes, *Pratylenchus* sp. and *Tylenchorhynchus* sp., have also been identified from wheat (Lung, 1992; Greco, 1995), but only limited information is available regarding local distribution and frequency of occurrence of these nematodes.

Among virus diseases, barley yellow dwarf (BYDV) on wheat and barley has been reported from Turkey (Kınaçı and Yakar, 1984; Yurdakul *et al.*, 1994), but is not regarded as important (Bremer and Raatikainen, 1975). Another virus disease, called wheat mosaic, has been found on wheat in the Eskisehir area (Süzen, 1988), but no information on its etiology was provided. It has been assumed for many years that it is the wheat soil-borne mosaic virus (WSBMV) (Bremer and Raatikainen, 1975) but no strong evidence was presented. Other virus diseases occurring in Turkey are the mite-transmitted wheat streak mosaic potyvirus (WSMV) (Bremer and Raatikainen, 1975) and the seed-borne barley stripe mosaic potyvirus (BSMV) (Bremer, 1972).

Although scattered information on the diseases of wheat and barley is available, no major disease survey has been carried out on the CAP during the last decade. Therefore, disease surveys were conducted in 1992, 1993, and 1994 with the following objectives: to (1) identify wheat and barley diseases in general, especially viral

(1) Identification of the nematode specimens was by Dr G. Lung, Institute of Phytomedicine, University of Hohenheim, Stuttgart, Germany.

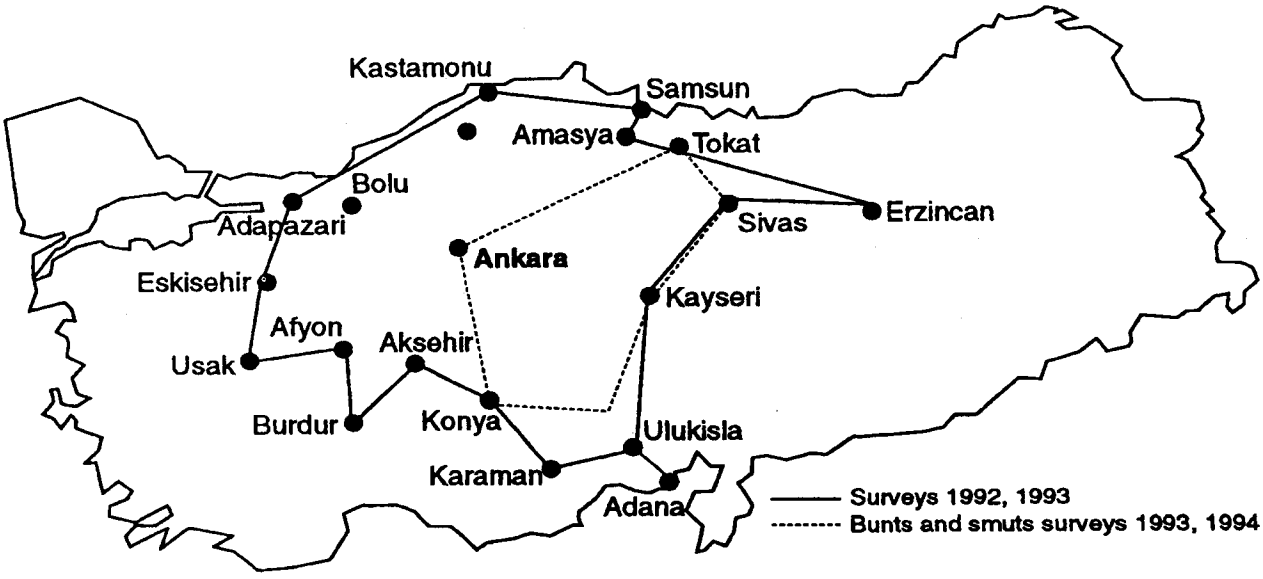

Fig. 1 - Area surveyed and outermost boarders of routes followed during the surveys in the Central Anatolian Plateau of Turkey.

diseases and their vectors; (2) record the occurrence and distribution of these diseases and estimate the possible losses that they cause; (3) test the methods and techniques for surveying plant diseases on large scale; and (4) generate systematic information on wheat and barley diseases on the CAP.

Materials and methods

Field surveys. Dates: the field survey for foliar and foot and root diseases, as well as loose smut of wheat and barley, were conducted from 28 May to 6 June 1992 and from 14 to 22 June 1993, whereas surveys for bunts of wheat and covered smut of barley were conducted during 19-22 July 1993 and 4-7 July 1994.

Routing: two mobile teams traveled in a designated routing for the surveys in 1992 and 1993, and one team traveled for the bunts and covered smut surveys in 1993 and 1994. The area surveyed and the outermost boarder of the routes followed were: Adana - Ulukısla - Nigde - Kayseri - Sivas - Erzincan - Niksar - Tokat - Amasya - Havza - Samsun - Bafra - Gerze - Kabalı - Tasköprü - Kastamonu - Araç - Karabük - Gerede - Bolu - Adapazarı - Nallıhan - Ayas - Ankara - Polatlı - Sivrihisar - Eskısehir - Usak - Afyon - Burdur - Isparta - Aksehir - Kadınhanı - Konya - Karaman - Eregli - Ulukısla - Ankara (Fig. 1). The 1992 survey covered a distance of 4756 km, whereas the 1993 route covered 4429 km. The bunts and covered smut survey covered 1337 km in 1993 and 1394 km in 1994.

Field inspection and sampling: the first stop of each day was made at the first cereal field at or after 10 km from the edge of the town or city limits. Subsequent stops were at 30-km intervals. If cereal fields were present on both sides of the road, observations were recorded for both at the same stop. Observations in each field were made at 5 locations on the two diagonals of the field or on a half circle. In each location, 20 plants (totaling 100 plants) were checked for foliar diseases and five (totaling 25 plants) were

(2) Identification of the *Fusarium* specimens was by Dr L.W. Burgess, Department of Plant Pathology and Agricultural Entomology, University of Sydney, Australia.

(3) Testing for *P. graminis* was by Dr H. Maraite and Dr A. Legneve, Louvain University, Belgium and by Dr E. Schlosser, University of Giessen, Germany.

(4) Isolation and identification of *O. brassicae* was by Dr E. Schlosser.

uprooted to check for root diseases. Usually the roots were checked outside the field and where possible were washed carefully with water. Observations and detailed information from each field were recorded. Samples were collected for those diseases requiring confirmation and/or diagnosis through laboratory tests. Leaves and roots with lower stem parts were kept in envelopes, air-dried, and brought into the laboratory of the International Center for Agricultural Research in the Dry Areas (ICARDA) or sent elsewhere for identification. Root specimens with cysts were kept in small vials with alcohol (70%) and sent for nematode identification [1].

Scoring: the frequency of disease occurrence (prevalence) was calculated from the number of infected fields out of the total fields checked. Disease incidence in each field was recorded by percentage of infected plants. Severity of foliar diseases was recorded on a 1-9 scale, with 8 representing the complete coverage of leaf/plant area and 9 representing spike infections (Saari and Prescott, 1975). For rust diseases, the modified Cobb's Method, percentage pustule coverage of green tissue and reaction type was used (Peterson *et al.*, 1948). For recording root nematode severity, a four-category scale was used: VL (very low = one cyst/plant), L (low = 2-3 cysts/plant), M (medium = 5 cysts/plant), and H (high = > 5 cysts/plant).

Laboratory tests. Leaf samples, to diagnose the diseases unidentified in the field or to confirm preliminary field diagnosis and to identify the causal agents, were microscopically examined, and the routine standard laboratory tests for fungal diseases were carried out. For foot and root rots, 40 pure *Fusarium* cultures isolated from the specimens collected during the surveys were first tested for their pathogenicity. The seedling test was conducted on solidified growth medium (6 g agar in 10 ml Hoagland/1 litre distilled water) under sterile controlled conditions (20 ml medium/culture tube of 20 cm length and 2.5 cm diameter). From this seedling test, 19 isolates with the highest pathogenicity level, and representative of all collection areas, were selected and sent for further identification [2]. Fifty-three randomly collected bunted heads were examined to identify the bunt pathogens. The teliospore wall structure was used to differentiate the *Tilletia* spp. (Mamluk and Zahour, 1993).

Samples with symptoms suggestive of virus infection collected from the fields during the surveys of 1992 and 1993, were desiccated in paper bags and brought to the laboratory for testing. Testing was conducted as per the double-antibody-sandwich ELISA procedure described by Clark and Adams (1977), with the exception that samples were extracted in 0.2 M phosphate buffer, pH 6.0. The antisera used were those for barley yellow dwarf luteovirus (BYDV) types PAV, MAV, SGV, RPV and RMV provided by R. Lister, Purdue University, USA; barley stripe mosaic hordeivirus (BSMV) provided by the Virology Laboratory of ICARDA; wheat streak mosaic potyvirus (WSMV) provided by S. Haber, Agriculture Canada, Winnipeg, Canada; and barley yellow striate mosaic rhabdovirus (BYSMV) provided by M. Conti, Institute of Applied Plant Virology, Turin, Italy. Samples were considered positive if their ELISA value (A_{405}) was higher than the healthy mean plus five standard deviations.

Results and discussion

The weather conditions during the years of the surveys were variable. The 1992 season was dry. In 1993, although more precipitation was received in early spring, the late spring and summer were similarly dry. Crop development in both seasons was in general 'average'.

During the 1992 survey, 108 wheat fields (91 bread and 17 durum) and 33 barley fields (29 two-row and 4 six-row type) were inspected. In the 1993 survey, 113 wheat fields (89 bread and 24 durum) and 35 barley fields (all two-row type) were inspected. In the 1993 common bunt and covered smut survey, 32 wheat fields (30 bread and 2 durum) were inspected; whereas in the 1994 survey, 46 wheat fields (40 bread and 6 durum) and 11 barley fields (10 two-row and 1 six-row type) were inspected. In total, 299 wheat fields and 79 barley fields representing all wheat and barley growing areas of the CAP were inspected during the surveys. Some rye and oat fields were also checked during the surveys. Rye plants as mixtures in wheat fields were also inspected for possible infection with wheat diseases.

During the survey of 1992, most of the surveyed wheat fields were in the grain-filling growth stage (29%), in the flowering (23%) and heading (23%) stage; whereas the barley fields were mainly in the grain-filling (52%) and

TABLE I. - Foliar and root diseases of wheat encountered in the Central Anatolian Plateau of Turkey; 1992 and 1993.

Disease	Year	No. infested fields (a)	Disease incidence (%)			Highest severity (b)
			1-10	11-20	>20	
Foot and root–rot	**1992**	**15**	**15**	**–**	**–**	**–**
Cochliobolus sativus		4	4	–	–	–
Microdochium nivale		4	4	–	–	
C. sativus & Fusarium spp.		2	2	–	–	–
No sample available		2	2	–	–	–
No pathogen recovered		3	3	–	–	–
	1993	**34**	**26**	**6**	**2**	**–**
M. nivale		9	7	1	1	–
Wojnowicia graminis		2	2	–	–	–
Fusarium spp. & W. graminis		8	5	3	–	–
No sample available		11	9	2	–	–
No pathogen recovered		4	3	–	1	–
Leaf spot	**1992**	**10**	**5**	**1**	**4**	**6**
C. sativus		2	1	–	1	6
Alternaria sp.		4	3	–	1	4
No pathogen recovered		4	1	1	2	5
	1993	**28**	**13**	**5**	**10**	**8**
M. nivale		1	1	–	–	8
C. sativus		2	1	–	1	7
Alternaria sp.		5	2	–	3	7
C. sativus & Alternaria sp.		4	–	2	2	8
Alternaria sp. & *Fusarium* sp.		2	–	1	1	7
Cladosporium sp.		5	1	2	2	7
No sample available		5	4	–	1	3
No pathogen recovered		4	4	–	–	4
Yellow rust	**1992**	**3**	**–**	**–**	**–**	**10MS**
Puccinia striiformis	**1993**	**28**	**–**	**–**	**–**	**50S**
		18	–	–	–	5S
		5	–	–	–	20S
		5	–	–	–	50S
Septoria tritici blotch	**1992**	**1**	**–**	**–**	**1**	**2**
Mycosphaerella graminicola	**1993**	**14**	**8**	**–**	**6**	**7**
Powdery mildew	**1992**	**6**	**2**	**1**	**3**	**3**
Erysiphe graminis	**1993**	**8**	**1**	**4**	**3**	**8**

Stem rust	**1992**	**0**	**0**	**0**	**0**	**0**
P. graminis	**1993**	**12**	**–**	**–**	**–**	**50S**
		9	–	–	–	5S
		1	–	–	–	20S
		2	–	–	–	50S
Leaf rust	**1992**	**1**	**1**	**–**	**–**	**10MS**
P. recondita	**1993**	**8**	**–**	**–**	**–**	**50S**
		5	–	–	–	5S
		3	–	–	–	50S
Cereal cyst nematode	**1992**	**0**	**0**	**0**	**0**	**0**
Heterodera avenae	**1993**	**7**	**5**	**1**	**1**	**H**
Septoria nodorum blotch	**1992**	**2**	**1**	**–**	**1**	**4**
Leptosphaeria nodorum	**1993**	**4**	**2**	**1**	**1**	**3**
Head and glume blotch	**1992**	**0**	**0**	**0**	**0**	**0**
	1993	**4**	**3**	**1**	**–**	**–**
Gibberella zeae		1	1	–	–	–
F. culmorum		1	1	–	–	
Alternaria sp.		1	–	–	1	–
No sample available		1	1	–	–	–
(Eye spot)	**1992**	**0**	**0**	**0**	**0**	**0**
M. nivale	**1993**	**6**	**5**	**–**	**1**	**–**
Tan spot	**1992**	**1**	**–**	**–**	**1**	**–**
Pyrenophora tritici-repentis	1993	1	1	–	–	3
Downy mildew	**1992**	**1**	**1**	**–**	**–**	**–**
Sclerophthora macrospora	**1993**	**0**	**0**	**0**	**0**	**0**
Seed gall nematode	**1992**	**0**	**0**	**0**	**0**	**0**
Anguina tritici	**1993**	**1**	**1**	**–**	**–**	**–**

(*a*) Out of 108 checked in 1992 and 113 in 1993.
(*b*) Rusts: % coverage of leaf and reaction type (S = susceptible; MS = moderately susceptible); other foliar diseases: 1-9 scale; nematodes: H = high, 5 cysts/plant.

TABLE II. - Foliar and root diseases of barley encountered in the Central Anatolian Plateau of Turkey; 1992 and 1993.

Disease	Year	No. infested fields (a)	Disease incidence (%)			Highest severity (b)
			1-10	11-20	>20	
Barley leaf stripe	**1992**	**24**	**22**	**–**	**2**	**–**
Pyrenophora graminea	**1993**	**19**	**12**	**4**	**3**	**–**
Foot and root rot	**1992**	**10**	**10**	**–**	**–**	**–**
Cochliobolus sativus		4	4	–	–	–
Microdochium nivale		4	4	–	–	–
No pathogen recovered		2	2	–	–	–
	1993	**19**	**11**	**3**	**5**	**–**
C. sativus		6	2	3	1	–
M. nivale		1	–	–	1	–
C. sativus & Fusarium spp.		3	2	–	1	–
C. sativus; Fusarium spp. & *Gäumannomyces graminis*		2	1	–	1	–
No sample available		6	5	–	1	–
No pathogen recovered		1	1	–	–	–
Scald	**1992**	**7**	**5**	**2**	**–**	**2**
Rhynchosporium secalis	**1993**	**15**	**6**	**1**	**8**	**8**
Net blotch	**1992**	**2**	**1**	**–**	**1**	**3**
Pyrenophora teres	**1993**	**19**	**6**	**4**	**9**	**8**
Powdery mildew	**1992**	**3**	**2**	**–**	**1**	**5**
Erysiphe graminis	**1993**	**6**	**5**	**–**	**1**	**7**
Leaf rust	**1992**	**0**	**0**	**0**	**0**	
Puccinia hordei	**1993**	**5**	**–**	**–**	**–**	**15S**
Leaf spot/blotch	**1992**	**0**	**0**	**0**	**0**	**0**
	1993	**4**	**1**	**1**	**2**	**7**
C. sativus		2	–	1	1	5
Alternaria sp.		2	1	–	1	7
Cereal cyst nematode	**1992**	**0**	**0**	**0**	**0**	**0**
Heterodera avenae	**1993**	**2**	**1**	**–**	**1**	**M**
Stem rust	**1992**	**0**	**0**	**0**	**0**	**0**
Puccinia graminis	**1993**	**1**	**–**	**–**	**–**	**–**

(a) Out of 33 checked in 1992 and 35 in 1993.
(b) Rusts: % coverage of leaf area and reaction type (S = susceptible); other foliar diseases: 1-9 scale; nematodes: M = medium, 5 cysts/plant.

TABLE III. - Bunt and smut diseases of wheat encountered in the Central Anatolian Plateau of Turkey; 1992, 1993 and 1994.

Disease		Fields		Disease incidence (%)		
		checked	infested	1-10	11-20	>20
			28 May to 6 June 1992			
Loose smut	*Ustilago tritici*	**108**	**44**	**36**	**6**	**2**
Flag smut	*Urocystis agropyri*		**1**	**–**	**–**	**1**
Common bunt	*Tilletia* spp.		**0**	**0**	**0**	**0**
			14–22 June 1993			
Loose smut	*U. tritici*	**113**	**49**	**42**	**5**	**2**
Common bunt	*Tilletia* spp.		**3**	**3**	**–**	**–**
			19–22 July 1993			
Common bunt	*Tilletia* spp.	**32**	**12**	**7**	**3**	**2**
			4–7 July 1994			
Common bunt		**46**	**18**	**16**	**–**	**2**
	T. laevis		15	13	–	2
	T. laevis & T. tritici		3	3	–	–

flowering (5%) stages. In the 1993 survey, the wheat fields were in the grain-filling (55%) and flowering (24%) stages and the barley fields were mainly (83%) in the grain-filling stage. At these growth stages most foliar diseases symptoms were obvious and possible to evaluate. During the bunts and smuts surveys of 1993 and 1994, all wheat and barley fields were in the full ripe stage.

Rye was observed as a dominant natural mixture in the majority of wheat and barley fields that were inspected. The percentage of rye mixture was up to 50%. However, the only disease observed on rye was loose smut and that was in only one field and with low incidence (1%).

Zinc- and iron-deficiency symptoms were frequently encountered. Boron- toxicity symptoms were also observed, especially in barley fields and at lower altitudes. Boron-toxicity was first identified in Turkey in 1988 at Konya and Zn-deficiency in 1990 at Eskisehir (Braun, 1994). Since then, Zn-deficiency in particular has been found to be widespread on the CAP (Eyüboglu, 1994; Çakmak *et al.*, 1996).

Fungal and nematode disease data are summarized in Tables I and II for wheat and barley, respectively. Diseases are listed in descending order of their prevalence. Disease data for bunts and smuts are shown in Tables III and IV.

W h e a t d i s e a s e s . The most frequently encountered wheat disease, in 15 of the 108 fields inspected in 1992 and in 34 of the 113 fields in 1993, was foot and root rot (Table I). Pathogens isolated from foot and root rot specimens collected during both years of the survey were *C. sativus, Fusarium* spp., and *Wojnowicia graminis* (McAlp.) Sacc. & Sacc., with *Fusarium* spp. being predominant. The main *Fusarium* species associated with foot and root

TABLE IV. - Smut diseases of barley encountered in the Central Anatolian Plateau of Turkey; 1992, 1993 and 1994.

Disease		Fields		Disease incidence (%)		
		checked	infested	1-10	11-20	>20
			28 May to 6 June 1992			
Loose smut	*Ustilago nuda*	**33**	**3**	**3**	–	–
Covered smut	*U. hordei*		**14**	**14**	–	–
			14-22 June 1993			
Loose smut	*U. nuda*	**35**	**6**	**5**	**1**	–
Covered smut	*U. hordei*		**7**	**7**	–	–
			4-7 July 1994			
Covered smut	*U. hordei*	**11**	**4**	**4**	–	–

rot was *Microdochium nivale* (Ces. ex Berl. & Vogl.) Samules & Hallet. *W. graminis* is a weak parasite causing root rot and is often confused with *G. graminis* (Wiese, 1987). This is the first report of *W. graminis* occurrence in Turkey. Two additional pathogens, *G. graminis* and *P. herpotrichoides*, have been reported causing foot and root rot of wheat and barley in some parts of Thrace region and in irrigated areas of Konya (Turhan *et al.*, 1985; Kınaçı and Kınaçı, 1991); the distribution of and damage caused by these pathogens is yet to be determined. In drier areas, *Helminthosporium* spp. and *Fusarium* spp. are the major pathogens causing root rots. However, more detailed work on these diseases in the CAP is needed. Although the percentage of disease incidence did not exceed 10% in 1992, it exceeded 20% in two fields in 1993. This disease complex should be taken seriously considering the damage that it could cause (percentage losses can be equated to percentage incidence). Lack of crop rotation, i.e. monoculturing of wheat and barley could increase the occurrence and consequently the damage due to these diseases.

Leaf spot occurred in 10 and 28 of the fields inspected in 1992 and 1993, respectively. In 14 infected fields disease incidence exceeded 20%, with disease severity ranging from 3 to 8. Pathogens isolated from specimens with leaf spot were *C. sativus*, *Fusarium* spp., *M. nivale*, *Alternaria* sp., and *Cladosporium* sp. No studies have been carried out to investigate the relationship between these pathogens causing leaf spot and their role in causing foot and root diseases.

Yellow rust, *P. striiformis*, was the most frequent rust encountered, occurring in 3 and 28 of the fields inspected in 1992 and 1993, respectively. However, at the time of the survey the disease was not severe. The highest severity recorded was 50S on cv. Kose near Sivas on 16 June 1993. Almost at the same time, 'Bolal' scored 40S near Nevsehir and 'Gerek 79' scored 20S-MS near Yozgat. Yellow rust epidemics are known to occur in the CAP every 5 to 10 years. The latest yellow rust epidemic that occurred in 1991 caused 26.5% loss in yield of the susceptible cv. Gerek 79 (Braun and Saari, 1992). The early onset of the disease under favourable weather conditions contributes to the development of the epidemics. Yellow rust was also found in the CAP on the wheat wild relatives, *Aegilops cylindrica* Host. and *Ae. tauschii* Coss. Yellow rust races detected were 2E16, 6E16, 6E150 and 2E0 (Anonymous, 1988; Louwers *et al.*, 1992).

Septoria tritici blotch, *Mycosphaerella graminicola* (Fuckel) Sand., was found in 15 fields, of which 14 were in the 1993 survey. Six

of these fields had an incidence of more than 20%, with the highest severity score of 7.

Powdery mildew, *E. graminis* f.sp. *tritici*, was encountered in 6 and 8 fields in 1992 and 1993, respectively. Disease incidence exceeded 20% in 6 fields. The highest severity recorded was 8.

Stem rust, *P. graminis* f.sp. *tritici*, and leaf rust, *P. recondita* f.sp. *tritici*, were also found, but at lower frequencies than yellow rust. Stem rust was encountered in 1993 only, in 12 fields. Highest severity, 50S, was recorded on a local cultivar near Hafik. This location is close to a forest in a mountainous region, which possibly harbours an alternative host of the pathogen. Stem rust is considered the least damaging of the three rusts as it develops late in the season. However, significant yield losses due to the disease have been reported from the CAP (Iren, 1955). Leaf rust was encountered in 9 fields, 8 of them in 1993. The highest severity of 50S was found on a local cultivar near Seben, Bolu-Nallihan.

Cereal cyst nematode (CCN), *H. avenae*, was found in 7 fields in the 1993 survey. Most fields showed an incidence of 5% and the severity was high, i.e.>5 cysts per plant. These findings may not reflect the actual prevalence and incidence of the disease caused by this nematode in the CAP, since only root samples were checked during the survey. Other investigators found *Heterodera* sp. widely spread, in 41.1% of the surveyed fields, in the Konya region (Oztürk *et al.*, 1994). Nematodes have only recently been identified as a potential problem for cereal production in the CAP (Lung, 1992). In two separate surveys conducted in 1992, the rhizosphere nematode population count exceeded the economic production threshold for *H. avenae* in 60% of the samples and for *Pratylenchus* spp. (*P. neglectus* and *P. thornei*) in 48% of samples. During these surveys it was observed that wheat plants showing zinc-deficiency symptoms were frequently also infected with CCN. Lung (1993) showed that phytosiderophores (PS, amino acids) are highly attractive to juvenile *H. avenae* and suggests that PS are the chemical substances responsible for the far-orientation of CCN juveniles. The interaction between zinc deficiency and CCN infestation and the negative effects on root health may explain the high seeding rate of 200-300 kg/ha used by farmers on the CAP to compensate for the frequently observed "winter killing".

Septoria nodorum blotch (*Leptosphaeria nodorum* Müll.) was found in 6 fields in both years of the survey, but disease incidence exceeded 20% only in 2 fields. The highest severity score was 4. Most samples diagnosed in the field as tan spot revealed the presence of only septoria nodorum blotch pathogen after incubation in the lab. Morphological investigations and pathogenicity tests confirmed the presence of the disease. This is the first record of septoria nodorum blotch from the CAP. Another blotch disease found was the head and glume blotch. The pathogens isolated from diseased specimens included *Gibberella zeae* (Schw.) Petch., *F. culmorum* (W.G. Sm.) Sacc. and *Alternaria* sp. Head and glume blotch was found in only 4 fields of the 1993 survey, with relatively low incidence. Other stem-and leaf-spotting diseases found scattered in the CAP were eye spot and tan spot. Eye spot was wrongly diagnosed in the field, as laboratory examination and identification established the causal agent to be *M. nivale*, in this case a leaf-spot pathogen. The disease was encountered in 6 fields in 1993, with low incidence. Tan spot, *P. tritici-repentis*, was found in 2 fields, with high incidence in 1 field.

Downy mildew, *Sclerophthora macrospora* (Sacc.) Thirum., Shaw. & Naras., was found in only 1 field in 1992, with an incidence less than 10% near Emirdag. The disease has been reported previously from the Aegian region (Çöpçü *et al.*, 1974), but not from the CAP.

The seed gall nematode, *A. tritici*, was found in 1 field only near Hasanoglan, east of Ankara, and with 1% incidence.

Barley diseases. The most frequently encountered barley diseases were barley leaf stripe, *P. graminea*, followed by foot and root rot (Table II). More than half of the fields checked in each year of the survey showed barley leaf stripe. The majority of infested fields exhibited an incidence of up to 10%. However, losses are still important, since incidence is equated to loss. The absence of adequate seed-treatment induces high losses due to barley leaf stripe. Previous work also indicated the wide spread of the disease in the region. In surveys conducted in 1987, 1988 and 1989, disease incidence was 4.7, 5.5 and 4.2%, respectively (Damgacı and Aktuna, 1988) . Barley leaf stripe seems to be the most important barley disease in the highlands of other Central and West Asian countries. Observation made by the senior author in the highlands of north Iran, Tabriz-Moghan,

in May 1995 revealed the presence of the disease in all fields checked. Disease incidence recorded was up to 50%, i.e. a value equated up to 50% loss (ICARDA, 1995).

Foot and root rot disease came next in frequency, in 10 and 19 of the fields in 1992 and 1993, respectively. The majority of infested fields showed an incidence of up to 10%. Since percentage incidence is also equated to percentage loss, disease damage is significant. Pathogens isolated from diseased samples were *C. sativus, Fusarium* spp. and *G. graminis*, with *C. sativus* being dominant.

Scald, *R. secalis*, and net blotch, *P. teres*, were encountered in 22 and 21 of the surveyed fields in both years. Eight of the 15 fields infested with scald in 1993 exhibited an incidence of more than 20%; the highest severity scored was 8. Nine of the 19 fields infested with net blotch in 1993 showed an incidence of more than 20%; highest scored severity of net blotch was 8. Both net and spot forms of *P. teres* were recorded from infested fields and isolated from diseased samples.

Other barley diseases of lesser prevalence were powdery mildew (*E. graminis* f.sp. *hordei*), leaf rust (*P. hordei*), leaf spot/leaf blotch (*C. sativus*; *Alternaria* sp.), the cereal cyst nematode (*H. avenae*) and stem rust (*P. gaminis*). These diseases were encountered in 9, 5, 4, 2 and 1 field, respectively in both years.

Bunts and smuts. Bunt and smut diseases of wheat found were loose smut (*U. tritici*), common bunt (*T. laevis* and *T. tritici*), and flag smut (*U. agropyri*) (Table III). A comprehensive review of bunt and smut diseases, also from Turkey, is found in Saari *et al.* (1996). Loose smut of wheat was encountered in 44 (41%) and 49 (43%) of the fields checked in 1992 and 1993, respectively. In some fields the incidence exceeded 20%, especially where 'Gerek 79' was planted. In one field near Boyabat, an incidence of 36% was recorded and in another, near Kirikkale, 30%. Loose smut occurs in several pathotypes in Turkey. Studies on loose smut revealed the presence of 5 races (Parlak, 1981), whereas Nielsen and Thomas (1996) reported 3 races, T1, T2 and T11, to occur in Turkey.

Common bunt of wheat was encountered in 3, 12 and 18 fields in June 1992, July 1993 and July 1994, respectively. Only in 3 of the 18 infested fields in 1994 both pathogens (*T. laevis* and *T. tritici*) were present. *T. laevis* was the dominant pathogen in the CAP, as it is throughout Turkey (Mamluk and Zahour, 1993). Thirty seven and 88 races of common bunt were identified from Turkey in 1981 and 1983, respectively (Finci, 1981; Finci *et al.*, 1983). However, the most prevalent races in the majority of wheat-growing areas of Turkey are F-1, F-3, F-6, C-1, and C-3, referring to L-1, L-3, L-6, T-1 and T-3, respectively (Finci, 1981; Finci *et al.*, 1983). Studies at ICARDA's principle station, Tel Hadya, northwest Syria, on the virulence pattern of common bunt pathogens from different countries of West Asia, revealed the presence of five virulences against the resistant genes Bt-1, Bt-2, Bt-3, Bt-4, and Bt-7 in isolates obtained from Turkey. These are also the dominating virulences in West Asian countries (Mamluk, unpublished).

Flag smut was found in one field only, at Tarsus-Pozanti, with 30% incidence. The field was planted to a mixture of landraces.

No dwarf bunt (*T. controversa*) was found during our surveys. However, Özkan and Damgacı (1984) found dwarf bunt infecting wheat in 2 sites near Nigde and in 1 site near Sivas within the area we surveyed.

In all bunt samples collected during our survey, no Karnal bunt was found. Finci *et al.* (1983) surveyed the whole of Turkey for bunts during the period 1975 to 1981 and also found no Karnal bunt. However, Zillinsky (1983) and Lambat *et al.* (1983) report Karnal bunt from some countries in the Middle East, including Turkey, but the basis of the former author's claim is the unconfirmed report of the second author who must have intercepted spores of Karnal bunt in seed shipments forwarded from Turkey.

On barley, loose smut (*U. nuda*) and covered smut (*U. hordei*) prevailed in the area surveyed (Table IV). Loose smut was encountered in 3 and 6 fields in 1992 and 1993, respectively. This does not reflect the actual prevalence of loose smut in the CAP, since on the dates of the survey most of the fields were at an advanced stage and the disease could have been overlooked. More serious is covered smut which was encountered in 14 (42%), 7 (20%) and 4 (36%) fields in 1992, 1993 and 1994, respectively. The incidence of covered smut of barley was only up to 10% in all of the infested fields.

Losses due to bunts and smuts of wheat (Mamluk and Zahour, 1993) and barley can be equated to percentage incidence in each field.

These losses could be easily overcome if seed is adequately treated. However, most farmers in the CAP do not use certified seed, nor do they possess the means to treat the seed.

Viral diseases. Virus incidence, based on disease symptoms observed in the fields surveyed, was low and could be estimated at less than 1% in both 1992 and 1993. The symptoms observed that could be ascribed to viral infection were general yellowing, yellowing of the leaf tips, stripe mosaic, streaking and reduced growth (stunting). The nutritional level of the plants in a large number of fields surveyed was not optimal, as nutrient-deficiency symptoms were visible. In such conditions, virus disease symptoms are not reliable. Laboratory testing of the 183 samples collected during 1992 (135) and 1993 (48) showed that only 11 samples were positive for the PAV type of BYDV, and one sample for the RMV type. Five samples were positive for the mite-transmitted WSMV. None of the wheat samples collected were infected with the seed-borne BSMV. The low BYDV incidence was not a surprise, as the observed aphid activity during the survey was extremely low. BYDV was reported earlier to occur on cereal crops in Turkey (Kınaçı and Yakar, 1984), but no extensive surveys have been conducted to determine its relative importance. These surveys indicated that during 1992 and 1993, BYDV occurred on cereals in Turkey at a very low incidence (<1%) and consequently had no effect on yield. The survey also suggested the possible involvement of a virus in the soil-borne rosette disease of wheat in the Eskisehir-Alpu area, but further work is required on the etiology of this disease.

During both 1992 and 1993, a wheat disease characterized by severe stunting, excessive tillering, rosetting and poor heading, was observed in Alpu near Eskisehir. The disease was observed in patches which appeared in the same spot in the field over a number of years suggesting the involvement of a soil-borne causal agent. Filamentous virus particles about 12 nm thick and 500-660 nm long were detected in the leaves of infected plants (Makkouk *et al.*, 1994). Characterization of this virus is not yet complete, however, preliminary morphological studies have indicated that it resembles the fungus-transmitted barley yellow mosaic bymovirus but serological tests indicated that it has no relationship with other known fungus-transmitted bymoviruses or other potyviruses which are supposed to be mite-borne. *Polymyxa graminis* was not detected in the soil where the disease occurred, or in the roots of the infected wheat plants[3]. However, *Olpidium brassicae* was isolated from Alpu/Eskisehir soil sample where virus symptoms were observed [4]. There is, however, no experimental evidence to suggest whether or not this fungus is a vector of this wheat soil-borne virus.

During 1993, symptoms of streaking/striping in wheat fields were also observed in the Isparta-Aksehir-Konya region. Of the 20 leaf samples from plants with the above symptoms tested serologically for the presence of the plant hopper-transmitted barley yellow striate mosaic rhabdovirus (BYSMV), 14 were positive. The virus was detected in field samples of bread and durum wheat, barley, triticale and oat. Plant hopper collections from the same region were sent to different laboratories for identification. The plant hopper *Laodelphax striatellus* (hemiptera: Delphacidae) was identified by M. Conti, Turin, Italy, and the leafhopper *Psammotettix* sp. was identified by the British Museum. The fact that BYSMV can only be transmitted by plant hoppers lends further support to the natural occurrence of this virus in the CAP. A more detailed study on the etiology of BYSMV on cereals in Turkey has been published recently (Makkouk *et al.*, 1996).

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Accepted for publication: July 12, 1997