GUIDELINES

FOR MONITORING DISEASES, PESTS AND WEEDS IN CEREAL CROPS

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Photo cover (clockwise from top left):
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PREFACE

The role of agricultural science and practice is one of the most important objectives in enhancing food security in the world. The Central Asian countries are experiencing rapid population growth trends that significantly require agricultural commodities. However, the demand for agricultural products in Central Asian countries is much higher than the global index. Therefore, strong agricultural practice is crucial for the improvement of agricultural productivity and efficiency, which in turn both lead to agricultural development, food security, and poverty reduction. Wheat is the main staple food crop for the Central Asian population, and provides more daily calories and protein in the region than any other crop. According to statistical data, the region is characterized by the highest level of wheat consumption per capita – more than 200 kg per year (FAO, 2013). Therefore, cereal crops play an important role for enhancing national food security.

The statistical analysis information shows that the production of wheat in Central Asian countries is increasing every year. However, the grain production per capita is not changed, and even in some countries it's gradually declining. Wheat yield still remains low if compared with developed countries. Farmers growing wheat in the region face many challenges; among those the most dangerous is widespread incidence of diseases and pests that cause significant damage to grain yield. In addition, the spreading of weeds and some abiotic factors such as drought, frost and soil salinity also negatively influence grain yield.

Previous studies have shown that the most devastating foliar diseases of cereals in the region are the rusts, and also tan spot, powdery mildew and septoria. Over the last 15 years in the region six outbreaks of yellow rust have been recorded that led to significant grain losses (Koyshibayev, 2000; Pett et al., 2005; Hodson and Hovmøller, 2009). The seed borne diseases (mainly bunt and smut) are also dangerous, as they may decrease the quality of grains and seeds of cereals. Therefore, in order to increase the productivity, one of the important ways is an effective protection of crops from diseases, pests and weeds through the improved management

practices, as well as the breeding and introduction of varieties resistant to diseases and tolerant to climatic factors.

Since 2011, the FAO Subregional Office for Central Asia (FAO-SEC), in close collaboration with the International Winter Wheat Improvement Programme (IWWIP), CIMMYT and ICARDA, and with the support of national consultants in the field of plant protection has provided technical assistance to the countries in the region on the monitoring of diseases, pests and weeds in cereal crops. The main purpose of this work is to collect information about the prevalence of major diseases, pests and weeds, as well as identification of varieties resistant to diseases, particularly to aggressive races of stem rust. The first results of the monitoring of diseases, pests and weeds in cereal crops were discussed at the Regional Experts Consultation Meeting held during 27-28 February 2013 in Almaty, Kazakhstan. Following the meeting, it was decided to prepare unified guidelines for the monitoring of diseases, pests and weeds in cereal crops.

Following colleagues contributed to the improvement and design of the guidelines: Alexey Morgunov, Mahbubjon Rahmatov, Anvar Jalilov, Bahromiddin Husenov, Amir Dababat and the national consultants of FAO Muhtasim Ahmadov (Azerbaijan), Sandugash Babkenova (Kazakhstan), Risbek Botalynov (Kyrgyzstan), Munira Otambekova (Tajikistan) and Saidmurat Baboev (Uzbekistan).

Based on the request of the participants of the side event on Monitoring and Surveillance of Pests, Diseases and Weeds in Cereal Crops in Central and West Asia and North Africa (CWANA) Region held during the 2nd International Wheat Stripe Rust Symposium on 30 April 2014 in Izmir, Turkey, the guidelines are translated into English.

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ABBREVIATIONS AND ACRONYMS

CIMMYT International Maize and Wheat Improvement Center

ICARDA International Center for Agricultural Research
in the Dry Areas

IWWIP International Winter Wheat Improvement Program

FAO Food and Agriculture Organization of the United Nations

FAO-SEC FAO Subregional Office for Central Asia

ET Economic threshold of harm

x

SPECIFIC FEATURES OF CHOOSING THE ROUTE AND TIME FOR MONITORING DISEASES, PESTS AND WEEDS

The prevalence level and development of diseases and pests, and the density of weeds depend on many factors, particularly climatic conditions, farming systems (irrigation or rainfed), crop management, forecrop and varieties. During the phytosanitary monitoring of cereal crops it is necessary to take into account the following:

- The main zones of cereal crop cultivation in the country, in particular the steppe or lowland, foothills and mountains. The route can lie from east to west and from south to north to cover more area;
- Cropping and farming systems (irrigated and rainfed);
- Forecrop (fallow, perennial grasses, vegetables and industrial crops);
- Planting dates and diversity of crop varieties;
- Application of fertilizer and pesticides.

Pests and diseases appear in different phases or stages of crop development. For example, the field of cereal crops is damaged by Hessian fly and barley flea beetle mainly during the seedlings' emergence, bunt diseases appear after heading, and grain armyworm during the grain formation of wheat. In this context, the field monitoring should be conducted at least 2-3 times during the growing season at the following growth stages: seedling, tillering, booting, heading and milky-dough maturity. When this is not possible, the monitoring should preferably be conducted during the emergence of main or dominant pest species, which roughly coincides with the milky-dough maturity stage of cereals.

If the monitoring route is too long (from 200-300 to 500-600 km) and the landscape is uniform, e.g. a steppe, then it's possible to conduct 1-2 field surveys after each 30-40 km. Over the vertical zoning locality, depending on the landscape, the distance between stops should be reduced by 1.5-2 times. In such cases, the monitoring in the mountainous zones should be conducted every 10-15 km, which would be good to reflect the situation in the vertical zoning. More accurate information can be obtained during a survey of about 10% of the crop acreage in a farm or administrative region

or province. During the conducting of monitoring it is necessary to use GPS (Global Positioning System) equipment for identification of geographic locality to provide for the mapping of the monitoring route (Fig. 1).
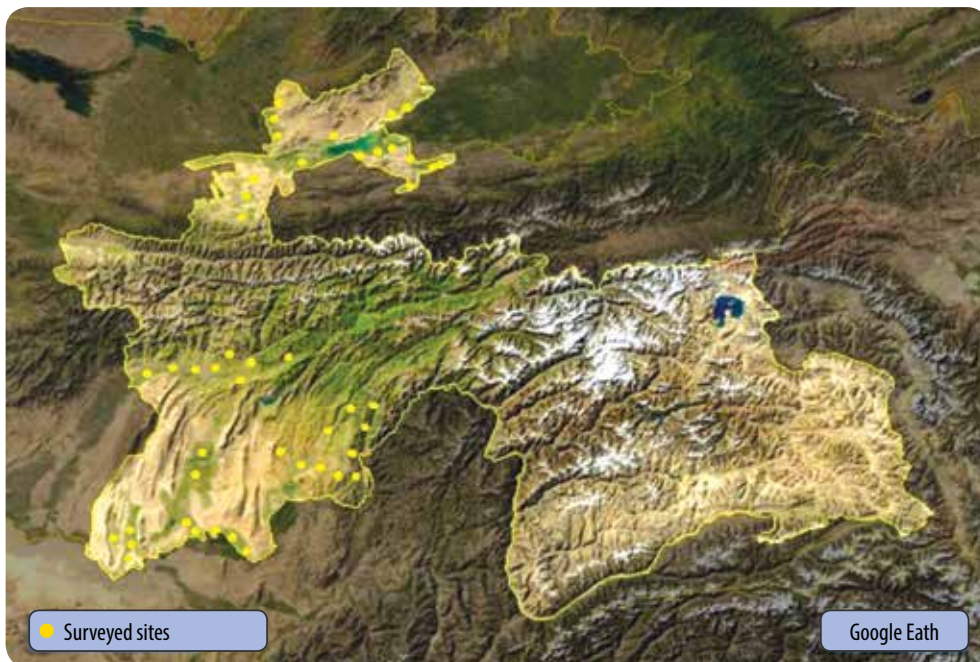
Figure 1. The survey route for recording diseases and pests of cereal crops in Tajikistan in 2012

Many pests and diseases are usually spread in the field more or less evenly, except for some of them. To characterize the phytosanitary condition of the fields which is needed to conduct a sufficient survey starting from the field edge, i.e. depending on the field size enter it to the depth of 20-30 m, and eliminate the edge effect by inspecting at least 8-10 sites in every 25 to 50 m, approximately 0.5-1 m^2 each, or 50-100 plants or stems. If necessary, a survey should be carried out diagonally or from two opposite corners of the field by taking samples at certain distances, e.g. every 50-100 steps.

SELECTION OF STATIONS FOR CONDUCTING CONTINUOUS MONITORING AND OBSERVATION

To get more detailed information about pest and weed population dynamics and development of diseases it is preferred to select 3-4 stationary plots in one, two or three farms. It is necessary to take into account the main zone (steppe or foothill) and cultivation conditions (irrigated or rainfed), diversity of crop varieties and forecrops. Recording of the dynamics of pest dissemination, growth of their number and disease development is carried out in the main stages of cereal crop development: germination – tillering, booting, heading – flowering, milky-dough or full maturity of grain according to the Zadoks scale (Fig. 2).

00	07	10-13	21	25	30	31	37	49	51	60-65	70-75	80-92

Pre-sowing	Emergence and seedlings	Tillering	Booting – Heading	Maturation
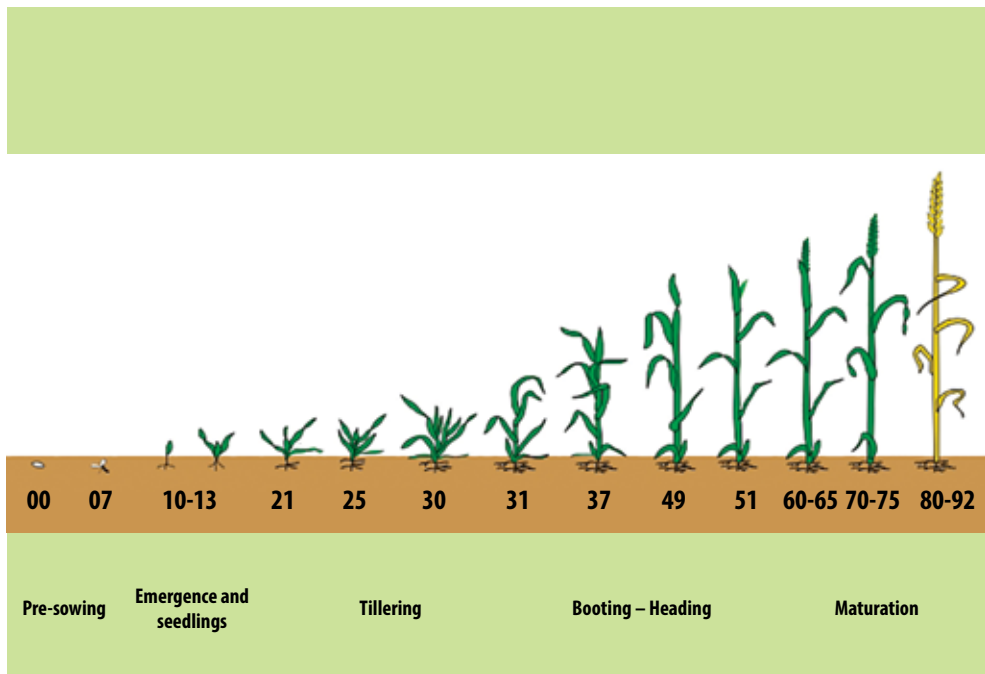
Figure 2. The development stages of cereal crops according to Zadoks (1974)
(http://agroplus-group.ru/inf/rykovodstvo/zernovie)

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SPECIFIC FEATURES OF RECORDING WEEDINESS OF THE CROPS BY DOMINANT WEED SPECIES AND THEIR ECONOMIC THRESHOLDS OF HARM

Weediness of cereal crop fields is determined twice: in spring during the regrowth stage or tillering before chemical treatment of cereal fields and in the period of milky-dough and full maturity of grain. This is normally observed visually using the following scale:

- **Low** – individual weeds occur in the fields;
- **Moderate** – weeds are in a negligible quantity, approximately at the economic threshold level;
- **Severe** – weeds dominate, their number is 2-3 times higher than the economic threshold.

If necessary, quantitative account of weeds should be made on 50x50 cm area for row or narrow-row planting and on 125x20 cm for maize and sorghum with 6-8 replications. Main biological groups are determined: monocots and dicots, annuals, biennials and perennials, including rhizomatous and soboliferous plants (Table 1).

Table 1. Main species of weeds detected in cereal crops and their approximate economic threshold of harm (ET)

Name of weed		Botanical group, family	Biology	Approximate ET, pcs / m²
English	**Latin**			
Monocots				
Common wild oat	*Avena fatua*	Poaceae	annual	10-15
Cockspur grass	*Echinochloa grusgalli*	same	annual	10-15
Green foxtail	*Setaria viridis*	same	annual	40-50
Wild barley	*Hordeum spontaneum*	same	annual	10-15
Sea clubrush	*Bolboschoenus maritimus*	same	perennial rhizomatous	1-2

Couch grass	*Agropyrum repens*	same	same	2-5
Bermuda grass	*Cynodon dactylon*	same	same	2-5
Johnson grass	*Sorghum halepense*	same	same	1-2
Phragmites	*Phragmites australis*	same	same	-
Dicots				
Goosefoot	*Chenopodium album*	Chenopodiaceae	annual	10-15
Chickweed	*Stellaria media*	Caryophyllaceous	annual, wintering	10-15
Russian tumbleweed	*Salsola ruthenica*	Chenopodiaceae	annual	5-20
Hemp	*Cannabis ruderalis*	Cannabaceae	annual	5-10
Shepherd's-purse	*Capsella bursa pastoris*	Brassicaceae	annual	10-20
Wild radish	*Raphanus raphanistrum*	Brassicaceae	annual	5-10
Red-root amaranth	*Amaranthus retroflexus*	Amaranthaceae	annual	5-10
Field pennycress	*Thlaspi arvense*	Brassicaceae	annual, wintering	10-20
Black henbane	*Hyoscyamus niger*	Solanaceae	biennial	3-5
Canadian thistle	*Cirsium arvensis*	Asteraceae	perennial rhizomatous	1-2
Field bindweed	*Convolvulus arvensis*	Convolvulaceaous	same	3-5
Field sow thistle	*Sonchus arvensis*	Asteraceae	same	1-2
Blue lettuce	*Lactuca tatarica*	Asteraceae	same	1-2
Euphorbia	*Euphorbia wirgata*	Euphorbiaceae	same	1-3
Absinthe wormwood	*Artemisia absinthium*	Asteraceae	same	1-3
Field horsetail	*Equisetum arvensis*	Equisetaceae	same	-
Curly dock	*Rumex crispus*	Polygonaceae	same	-
Russian knapweed*	*Acroptilon repens*	Compositae	same	-
Perennial ragweed and other species*	*Ambrosia psilostachya*	Compositae	same	-

* Quarantine weeds. When they are identified, all the plants in that area will be completely destroyed

MAIN METHODS OF DISEASE MONITORING

Monitoring covers the fields of most common varieties planted in different forecrops and at different times. To determine the extent of disease spreading and intensity of its development after every 25-50 steps about 10 samples or 10-15 stems (leaves) in each sample are inspected. With a uniform spreading of a disease, samples can be selected from any side of the field, within a triangle or rectangle, retreating up to 25-50 m from the edge and entering into the field up to 100-200 m deep depending on the field size, and if the spreading is uneven in staggered order.

The visual scoring of disease development intensity is usually carried out according to following scale:

0 – healthy plants;
1 – weak damage of plant parts;
2 – moderate damage, no severe damage to the plant;
3 – severe damage of organs and the plants' death.

Assessment of a disease is determined by two indexes: disease prevalence or the number of plants damaged in the fields, and its development or the extent of damage to plant organs. The first index (P) is calculated according to the formula:

$$P = n \times 100/ N,$$

where:

N – The total number of plants in the samples;
n – The number of diseased plants.

The average percentage of disease prevalence (P_{cp}) for a farm or region is calculated according to the formula:

$$P_{cp} = \Sigma SP/ S,$$

where:

ΣSP – The sum of products when the field acreage is multiplied by the corresponding percent or grade;

P – Disease prevalence;

S – Surveyed field, ha.

The degree of disease development (R) or the average damage of individual organs is determined percentagewise according to the formula:

$$R = \Sigma ab / NK$$

where:

Σab – The sum of products when the number of diseased plants is multiplied by the corresponding grade or percent of damaged leaves, stems or spikes;

N – Total number of analyzed plants (organs) in the samples;

K – The scale's highest grade.

Stationary plots are used for constant monitoring of the expression and dynamics of rusts, helminthosporium and other leaf spot diseases prevailing in the zone. For this purpose 2-3 typical fields of no less than 5-10 ha each are selected, and the survey in the main plant development stages is conducted.

To determine the level of plant damage by root rot, rusts and spots, special scales characterizing the development of disease intensity are used.

Table 2. Main cereal crop diseases and their approximate economic threshold of harm (ET) depending on plant development stages

Name of the disease and its causative agent	Damaged organ	Time of expression	ET depending on the stage of plant development, %	
			30-39*	49-60*
Winter and spring wheat, triticale				
Common bunt (*Tilletia tritici; T. laevis*)	Spike and grain	Dough stage of grain	-	Up to 0.1
Dwarf bunt (*Tilletia controversa*)	Spike and grain	Dough stage of grain	-	same
Loose smut (*Ustilago tritici*)	Spike	Heading stage	-	Up to 1

Powdery mildew (Blumeria graminis f. sp. tritici)	Leaves, stems, spike	Seedling – milky-dough stage of grain	1	5-10
Leaf rust (Puccinia triticina)	Leaves	Booting – milky-dough stage of grain	1-5	5-10
Stem rust (Puccinia graminis f. sp. tritici)	Leaves, stems, spike	Booting – full maturity of grain	0.1-1	1-5
Yellow rust (Puccinia striiformis f. sp. tritici)	Leaves, glume	Tillering – full maturity of grain	0.1-1	
Septoria (Septoria tritici / Stagonospora nodorum)	Leaves, stems, spike, grain	Booting – milky-dough stage of grain	5-10	10-20
Tan spot (Drechslera tritici-repentis)	Leaves, stems	Booting – milky-dough stage of grain	5-10	10-20
Root rot (Bipolaris sorokiniana, Fusarium spp.)	Roots, lower internode	Seedling – full maturity of grain	-	10-15
Winter and spring barley				
Covered smut (Ustilago hordei)	Spike and grain	Milky stage of grain	-	Up to 0.1
Loose smut (Ustilago nuda)	Spike	Heading	-	0.5-1
Stem rust (Puccinia graminis f. sp. tritici)	Stems	Tillering – full maturity of grain	0.1-1	1-5
Yellow rust (Puccinia striiformis f. sp. hordei)	Leaves, glume	Tillering – full maturity of grain	0.1-1	1-5
Leaf rust (Puccinia hordei)	Leaves	Tillering – milky stages of grain	1-5	5-10
Powdery mildew (Blumeria graminis f. sp. hordei)	Leaves, stems, spike	Seedling – milky-dough stage of grain	1	5-10
Net blotch (Drechslera teres)	Leaves and stems	same	5-10	10-20
Spot blotch (Bipolaris sorokiniana)	Leaves, glume	same	5-10	10-20
Scald (Rhynchosporium secalis)	Leaves	same	5-10	10-20
Barley Stripe (Drechslera graminea)	Leaves, stems, spike, grain	Seedling – full maturity of grain	1-5	5-10
Root rot (Bipolaris sorokiniana, Drechslera spp. Fusarium spp.)	Root, base of stem	Seedling - full maturity of grain	–	10-15

*Note: * - The stages of plant development according to Zadoks (Fig. 2)*

BUNT AND SMUT DISEASES

The symptoms of these diseases are not apparent until after stem elongation begins. The symptoms of loose smut distinctly appear in the flowering period of cereal crops, but the symptoms of common (covered) and dwarf bunts appear in the milky-dough and full maturity phases of grain. Cereal grains infected by bunt can be seen in the field, but are often not detected until harvest. The fields diseased by bunt emit a foul smell like of rotten fish. Cereal kernels infected by bunt have a gray-green color and are wider than healthy kernels. Moreover, the normal spike tissue of plants infected by loose smut is completely replaced with dark masses of fungal spores, giving the spikes a black powdery appearance. The disease prevalence is determined with number of damaged spikes in the field. To analyze the damage from smut and bunt at least 1000 of stems are analyzed, and quantities of afflicted stems are identified for each of the diseases. For this purpose approbation bundles or samples can be used; they are collected diagonally over the field in at least 10 locations by inspecting 100 plants at each of them.

ROOT ROTS

Root rot diseases in cereal crops cause premature crop losses manifested as patches of white heads scattered throughout a field. The record of cereal crops' damage is made in the phase of 2-3 leaves and before harvest. Infected plants are often dark at the base and have poor root development. With a field up to 100 ha, 10 samples from two rows at a 0.5 m^2 area or 25-30 uprooted or pulled out plants are collected. The base of stems is cleaned out of leaves and the scoring is carried out according to the stem surface darkening (%) at the level of the root collar (Fig. 3):
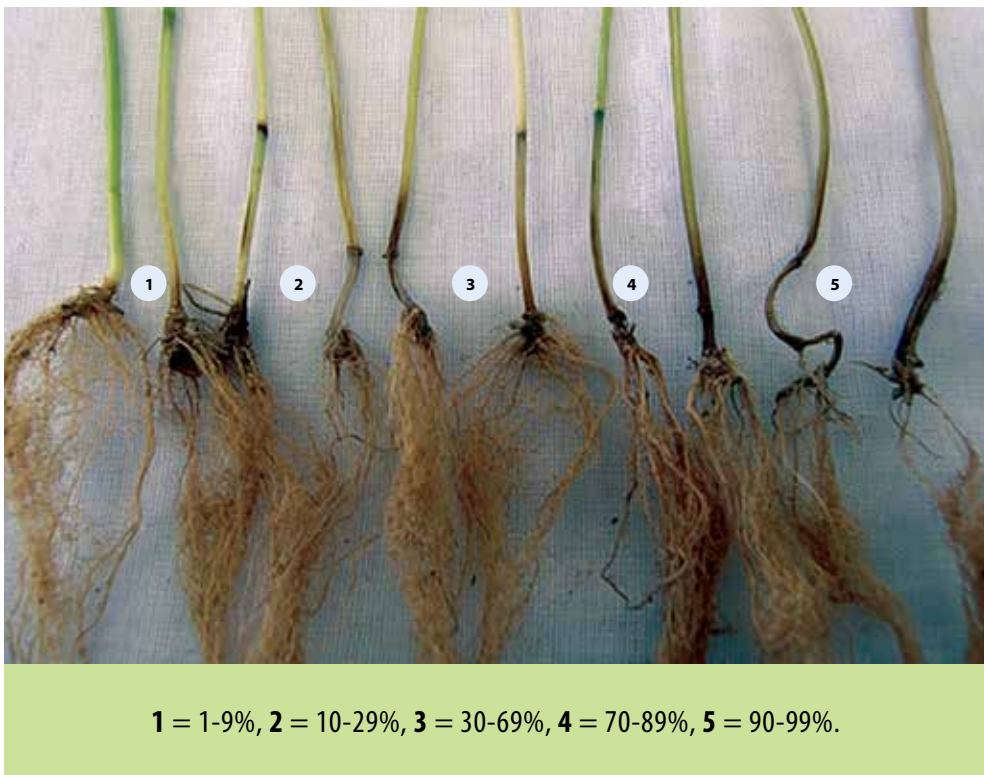

1 = 1-9%, **2** = 10-29%, **3** = 30-69%, **4** = 70-89%, **5** = 90-99%.

Figure 3. The scale for scoring the infestation of plants with root rots

THE RUSTS

Yellow rust, leaf rust and stem rust diseases are three of the most widespread and important diseases of cereals in the region. Many epidemics of yellow rust and leaf rust have occurred periodically several times with significant yield losses in the wheat producing areas in Central Asia. The surveillance and monitoring of rust diseases is the best strategy to minimize crop losses and reduce the chemical-input application. Therefore, constant monitoring of the appearance and prevalence of rusts in cereal crops is essential. The survey of yellow rust, leaf rust and stem rust of winter wheat and rye is conducted in autumn. During the emergence of 2-3 leaves or on the tillering stage of winter cereals, at 10-15 field sites at least 300-500 seedlings are inspected. In the spring, after full winter regrowth of the cereals, the same way of assessment is used for rusts. During the vegetation period, starting from the tillering or booting stages, a regular observation is conducted in order to determine the time of field infection by rusts diseases. When the primary rust pustules are identified in the cereals, the rust survey is conducted along the field diagonal or a triangle by collecting at equal distances 20-25 samples, 10 plants each. The intensity of rust development is determined by percentage using the modified Cobb scale (Fig. 4, 5 and 6). If the scoring is conducted in the period of the booting – heading stages, then two of the lower and middle leaves, including flag leaves, are assessed. The last survey of leaf and yellow rusts should be carried out in the phases of milky-dough maturity of grains, and the stem rust in the period of dough or full maturity of grain. In addition, barberries (*Berberis* spp.) serve as an alternate host for emergence of new virulent races of stem rust and yellow rust (Jin et al., 2011). More than ten wild barberry species are present in Central Asia. The surveillance protocol for sampling of aecial infection on *Berberis* spp. leaves is developed by Hansen et al., 2013.

Therefore, it is suggested to consider the surveillance and monitoring of *Berberis* spp. in the region.
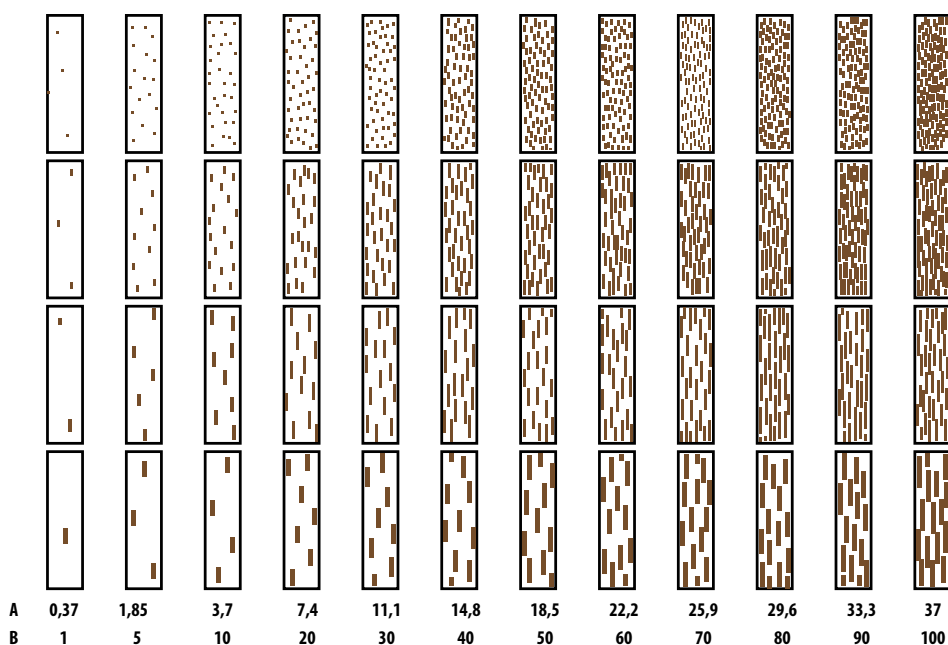
A	0,37	1,85	3,7	7,4	11,1	14,8	18,5	22,2	25,9	29,6	33,3	37
B	1	5	10	20	30	40	50	60	70	80	90	100

**Figure 4. The scale for damage of cereal crops by rusts (CIMMYT)**

Note:

A – Factual percentage of leaf surface occupied by rust spors;

B – Rust severities according to the modified Cobb scale (Peterson et al., 1948; Roelfs et al., 1992).

Evaluation of the reaction of wheat varieties and other cereal crops to rusts and rust severities should be conducted according to following scale:

O – No disease;

R – Resistant (pustules formed distinct chlorosis spots, the leaves' severity up to 5-10%);

MR – Moderately Resistant (very small pustules surrounded by a chlorotic area with the leaves' severity up to 10-30%);

MS – Moderately Susceptible (small/medium pustules, the leaves' severity up to 40-50%);

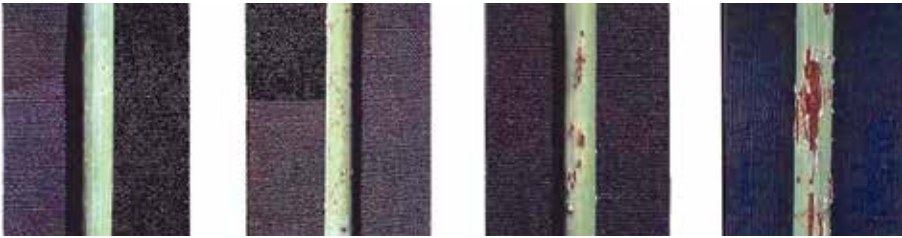**S** – Susceptible (large pustules, the leaves' severity up to 75-100%).
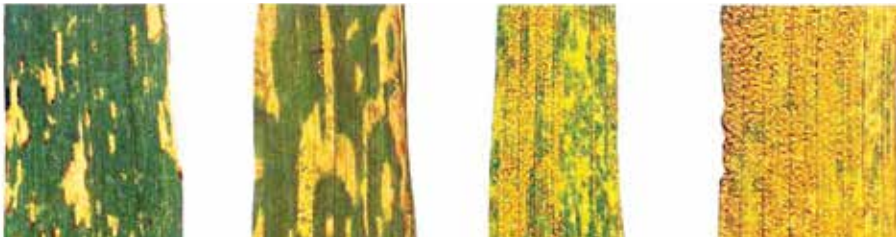
LEAF RUST
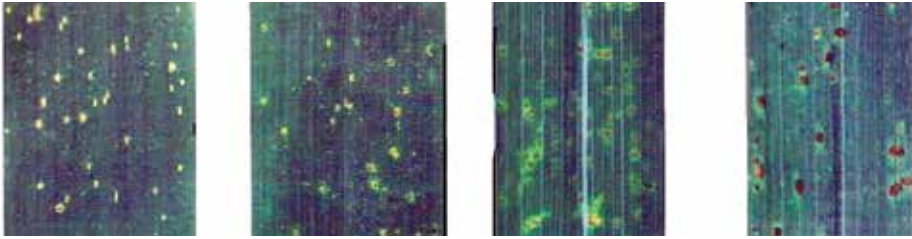
| R | MR | MS | S |

STEM RUST

| R | MR | MS | S |

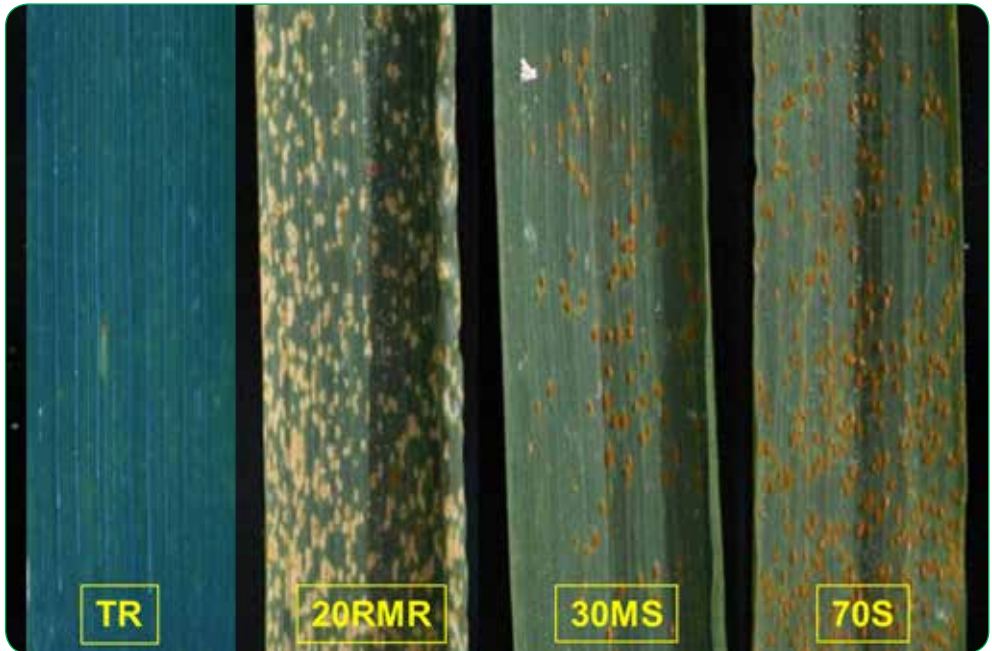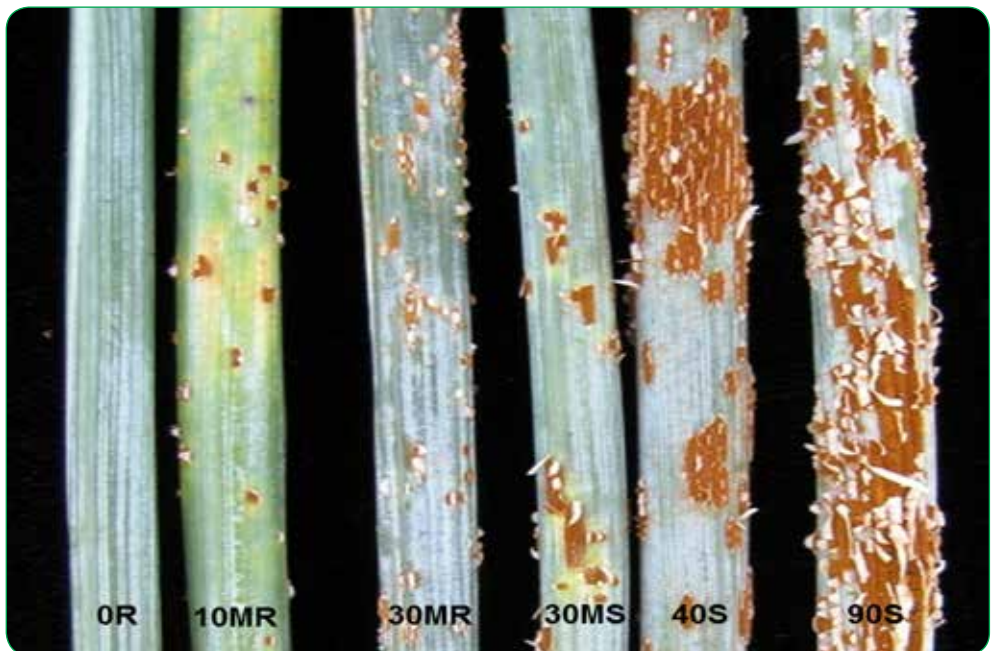**STEM RUST**

| R | MR | MS | S |

Figure 5. The scale for the assessment of leaf, stem and yellow rusts in cereals (CIMMYT)

Leaf rust

Stem rust

Yellow rust
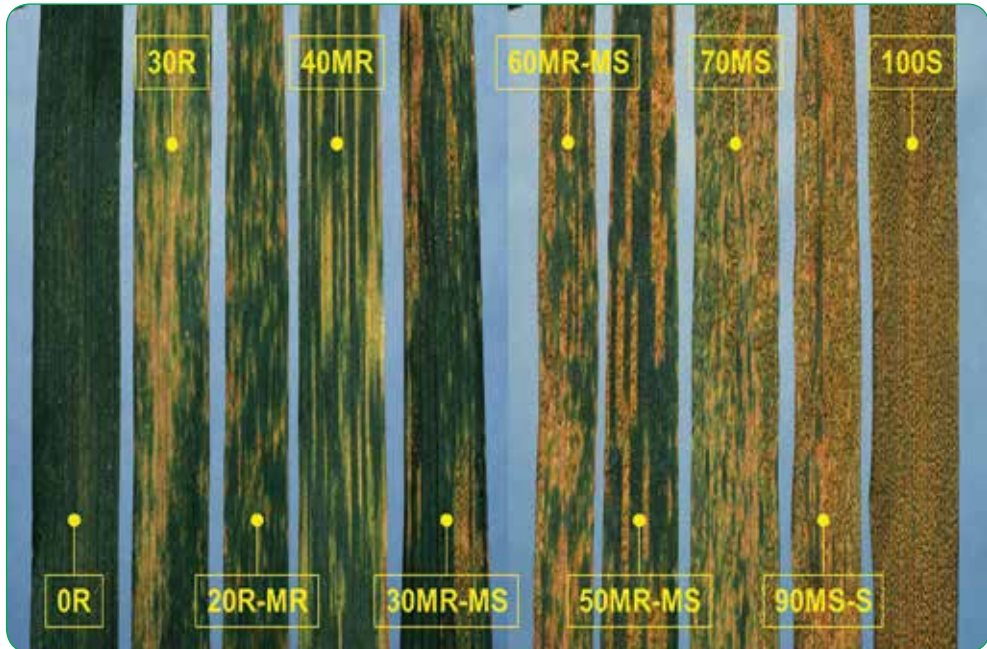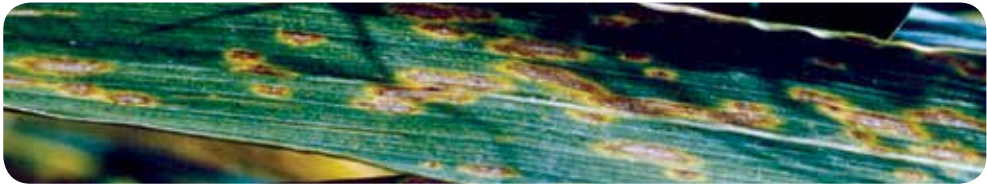

Figure 6. The scale for the assessment of leaf, stem and yellow rusts in cereals (McIntosh *et al.*, 1995)

POWDERY MILDEW AND LEAF SPOTS

In regions where winter cereal crops are cultivated, observation of powdery mildew is conducted in autumn and early spring during the monitoring of rusts. The severity level for leaves and other organs of plants is determined according to E. E. Geshele's scale. In winter and spring wheat the survey of tan spot and septoria species can be conducted separately or with other fungal leaf spotting diseases. The severity level for leaves and internode stem is determined using percentage scales (Fig. 7 and 8). The survey of net blotch, spot blotch, barley stripe and scald of barley is conducted separately or among other dominant species. Oat helminthosporium is also surveyed on the basis of the similar scales used for leaf spots or septoria (Fig. 7).

0 = 0% affected; **1** = 10%; **2** = 20%; **3** = 30%; **4** = 40%; **5** = 50%;
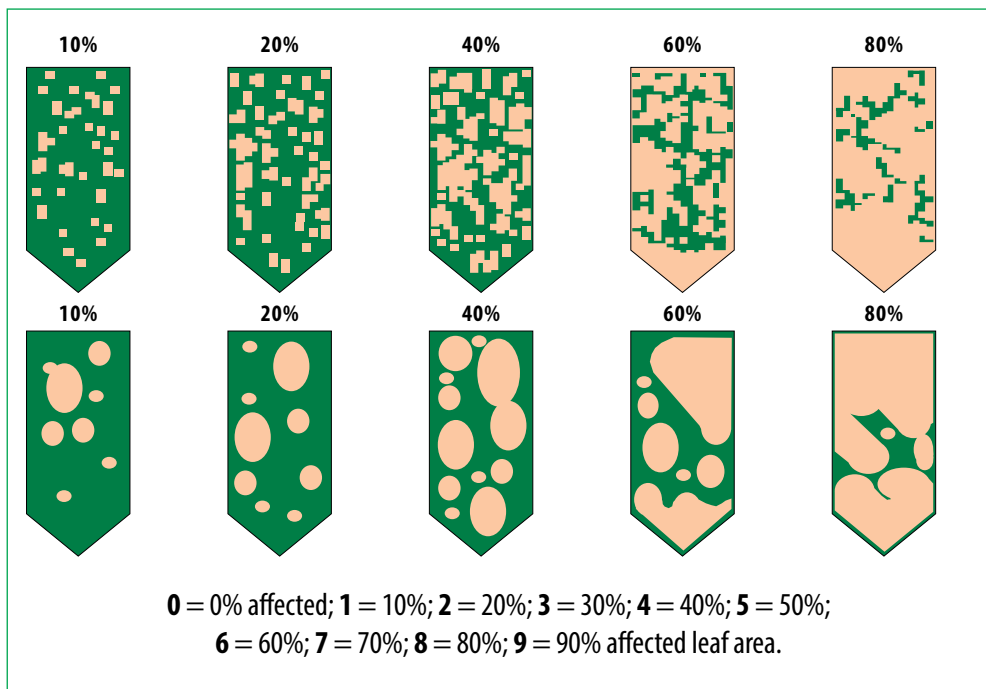**6** = 60%; **7** = 70%; **8** = 80%; **9** = 90% affected leaf area.

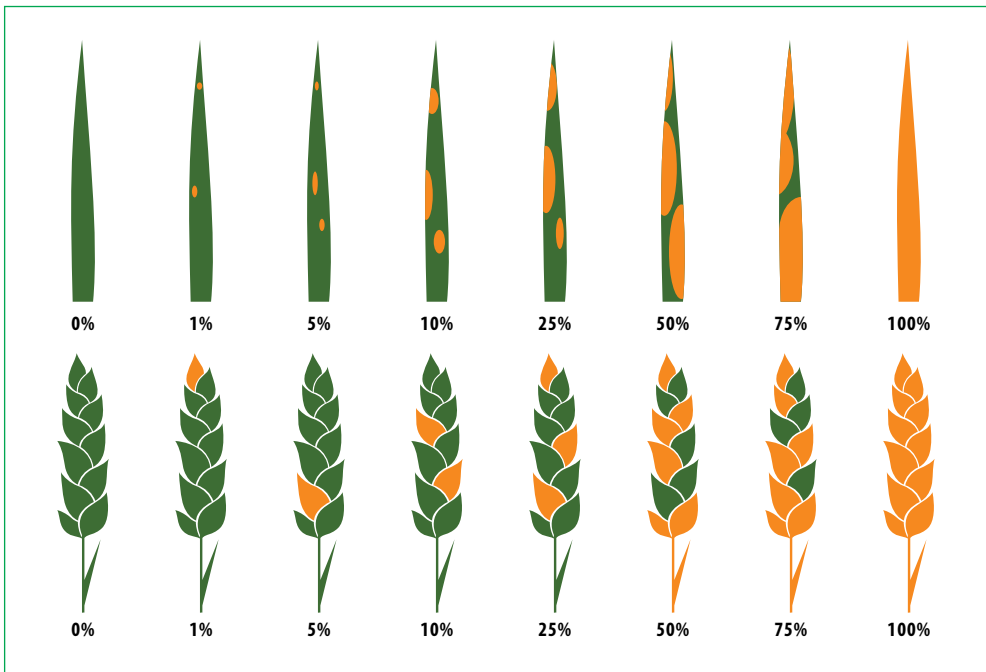**Figure 7. The scale for determination of leaf damage by leaf spots (CIMMYT)**

Figure 8. The percentage of leaf and spike surface damage by septoria
(The Septoria Diseases of Wheat: Concepts and methods of disease management, CIMMYT, 1987)
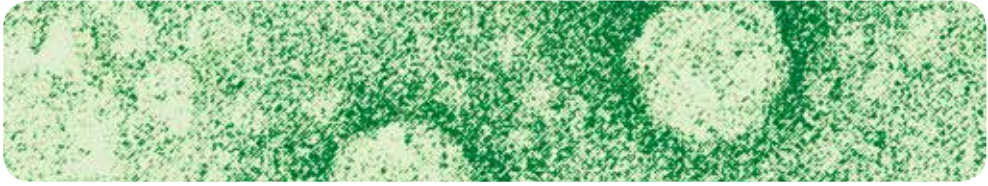
VIRAL DISEASES

The prevalence of viral diseases is determined during the period of heading – milky maturity stages of grain. For this purpose, at 10 sites along the field's diagonal or on 1 running meter the total number of plants, including diseased plants, is counted. The level of severity is determined according to G. M. Razvyazkina's scale:

0 – No disease;
1 – Weak damage, symptoms of mosaic in leaf;
2 – Moderate damage, obvious symptoms of mosaic in leaf;
3 – Severe damage, leaf with bright mosaic, dwarf plant.

SPECIFIC FEATURES OF RECORDING PESTS AND THEIR ECONOMIC THRESHOLDS OF HARM

The dominant pests of the cereals in Central Asia are the sun pest, cereal fleas, cereal aphids, thrips, bugs, leaf beetle, cereal beetles, ground beetle, grain armyworm, Hessian and Swedish flies, sawfly, etc. Their species' composition and their harmfulness may significantly vary depending on crop species (wheat, barley, and oat) and cultivation area. Furthermore, pests usually damage certain organs in particular stages of plant development. For example, Hessian fly and barley flea beetle basically damage seedlings of cereals, grain armyworm lays eggs in spikes during flowering, while larvae feed on grain prior to the milky-dough stage. The larva of ground beetle damages seedlings of winter wheat in the autumn/spring period, and beetles feed on grain. In view of this, the survey of pests is conducted in various growth stages of cereals. The below table indicates the composition of major pests in cereals, damaged plant organs, deleterious phases during plant development, and also approximate economic thresholds of harm (Table 3).

Table 3. Main pests of cereal crops and their economic thresholds of harm (ET)

English and Latin name of pest	Damaging stage	Damage		ET
		Organ	Stage of plant development	
Sun pest (*Eurygaster integriceps*)	Adults and larvae	Leaves, ovary, grain	Seedling – dough stage	1-2 adults or 5 larvae in 1 m^2
Cereal bugs (*Trigonotylus ruficornis* etc. spp.)	Larvae and adults	Leaves, ovary, grain	Seedling – dough stage	same
Stinkbugs (*Aelia furcula, A. sibirica* etc. spp.)	Larvae and adults	Spike, grain	Booting – dough stage	same
Cereal aphids (*Sitobion avenae, Schizaphis graminum, Metopolophium dirhodum*)	Larvae	Leaves	Booting – milky stage	10-20 individuals per stem at the occupation density of 10%

Wheat thrips *(Haplothrips tritici)*	Adults and larvae	Spike, grain	Booting – dough stage	8-10 adults per stem or 40-50 larvae per one spike
Leaf beetle *(Oulema melanopus)*	Beetle and larvae	Leaves and spike	Tillering – milky stage of grain	At the beginning of tillering 40-50 beetles per 1m^2
Ground beetle *(Zabrus morio)*	Larvae and beetle	Leaves, root, spike and grain	Seedling – full maturity	In spring 2-3 larvae and in the milky-dough stage 8-10 beetles per 1m^2
Bordered apamea *(Apamea anceps)*	Larvae	Spike and grain	Flowering – full maturity	15-20 larvae per 100 spikes
Cereal beetles *(Anisoplia austriaca, A. Agricola, A. segetum)*	Beetle	Spike and grain	Milky – full maturity	3-5 beetles per 1m^2
Sawfly *(Cephus pygmaeus)*	Larvae	Stem	Stem elongation – dough stage	40-50 adults per100 sweeps of the net
Barley flea beetle *(Phyllotreta vittula)*	Beetle	Leaves	Seedling	300-400 beetles per 1m^2
Stem fleas *(Chaetocnema aridula, Ch. hortensis)*	Larvae and beetle	Stem	Tillering – booting	30 beetles per 100 sweeps or 10% damaged stems
Hessian fly *(Mayetiola destructor)*	Larvae	Lower internode	Seedling – tillering	5-10 puparia per 1m^2 or more than 30% seedlings populated by them
Swedish fly *(Oscinella frit)*	Larvae	Stem	Seedling – tillering	40-50 flies per 100 sweeps or 5-10 damaged stems
Cereal leafhoppers *(Psammotettix striatus, Laodelphax striatella)*	Adults and larvae	Leaves and stem	Tillering – milky stage of grain	
Wheat flower mite *(Steneotarsonemus panshini)*	Adults	Ovary	Heading – dough stage	
Swarming and non-swarming locusts *(Dociostaurus maroccanus, Calliptamus italicus* etc. spp.*)*	Adults and larvae	Leaves, stem, spike	Seedling – full maturity	5-10 per 1 m^2

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