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SUPPLEMENTARY INFORMATION

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The global burden of pathogens and pests on major food crops

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Supplementary Information

Supplementary Figure 1. Survey responses and crop area. Each map shows the approximate location of survey responses per crop. Land area from the Global Administrative Areas Database[54]. Background shows the harvested area per crop[55] in quintiles. Symbol size scaled by the product of crop loss magnitude and crop loss frequency.

Supplementary Figure 2. Bar chart of distributions of survey responses by crop and by increasing quartiles of national crop production. PQ1: countries with national production below the first quartile; PQ2: countries with national production between the first and the second quartile (i.e., the median); PQ3: countries with national production between the second (i.e., the median) and the third quartile; PQ4: countries with national production above the third quartile. Percentage figures at the top of the bars indicate the proportion of world production (not of the total production covered by the survey) of each crop accounted for by successive groups of countries.

Supplementary Figure 3. Crop specific associations between losses, yield, climate, food security hotspots and key pests. Each panel is a correspondence analysis map based on the survey responses for that crop. Active variables (loss magnitude, yield quartiles, climate type) are in bold and supplemental variables (food security hotspot, key pests) are in italics. ARID=Arid; CONT=Humid continental; EQUAT=Equatorial; MEDIT= Mediterranean; MONSO= Monsoon; OCEAN=Oceanic; SUBTR=Subtropics; TROPH=Humid tropics. USM&C=US Midwest and Canada; SB&A=South Brazil, Paraguay, Uruguay and Argentina; NWE=Northwest Europe; WANA=West Asia and North Africa; SSA=Sub-Saharan Africa; CHINA=Mainland China; IGP=Indo-Gangetic Plain; SEA=Southeast Asia.

Supplementary Figure 4. Screen capture of web-page of the online survey (http://globalcrophealth.org) for wheat, and accompanying explanatory text from the web-page.

Supplementary Table 1. List of contributors to the Global Survey on Crop Losses.

Supplementary Table 2. Characterisation of pathogens and pests. Common and scientific names, emergence status, number of survey responses, extent and diversity.

Supplementary Table 3. Crop loss estimates. Losses by individual pests and pathogens globally and in food security hotspots.

Supplementary Table 4. Summary of analyses on contingency tables. Chi-square analyses and interpretations to examine different factors related to global crop losses.

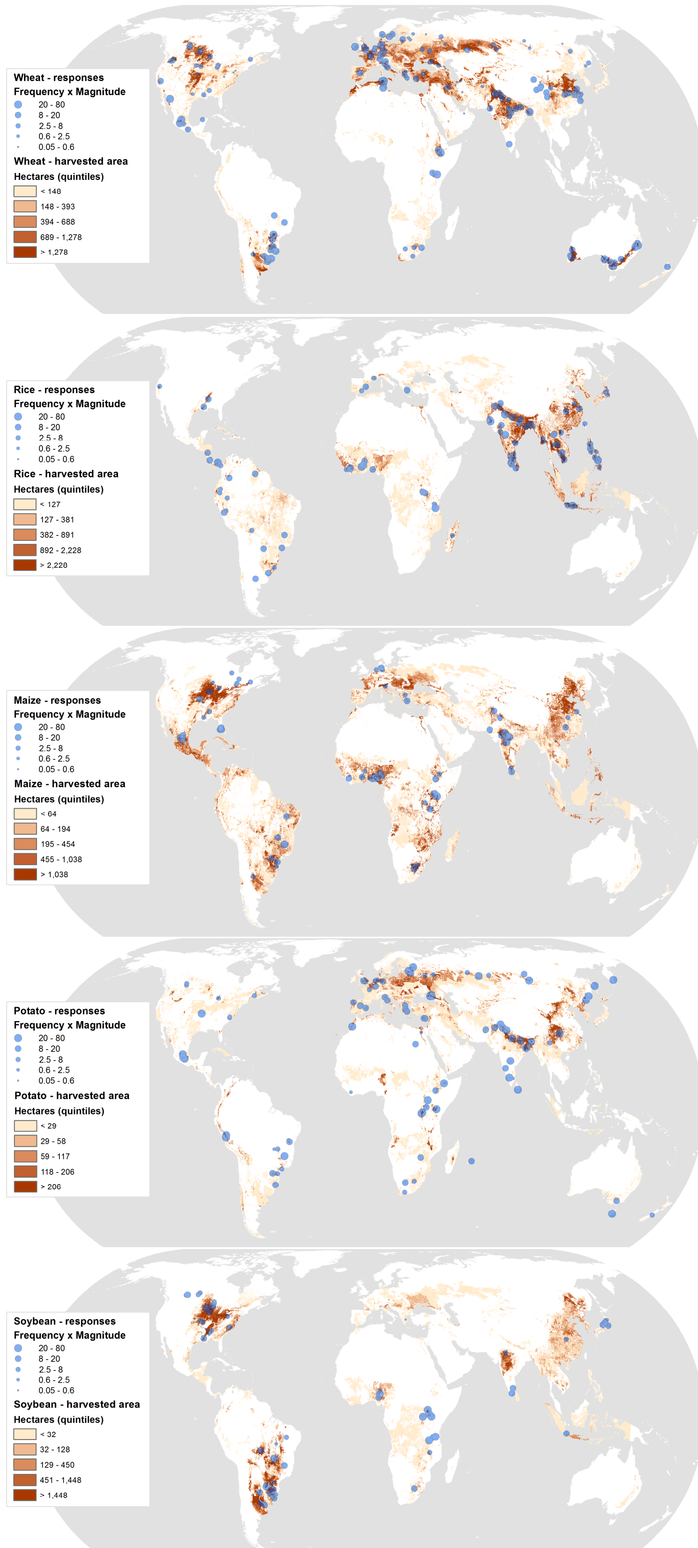
Supplementary Table 5. Interpretations of correspondence analyses. Main statistical results and their interpretation.

Supplementary Table 6. Outputs of correspondence analyses.

Supplementary Note 1. Email sent by Serge Savary, Vice-President of the ISPP and Chair of the ISPP Subject Matter Committee on Crop Losses to the members of the ISPP.

Supplementary Note 2. Note published in the ISPP Newsletter of November 2016[49], republished with permission of the ISPP, announcing the conduct of the survey to the total membership of the ISPP.

Supplementary References



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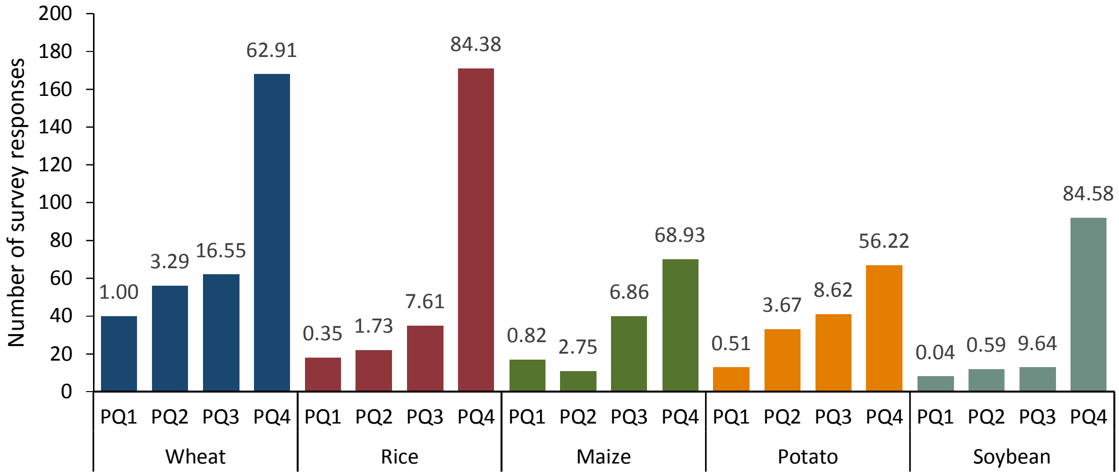

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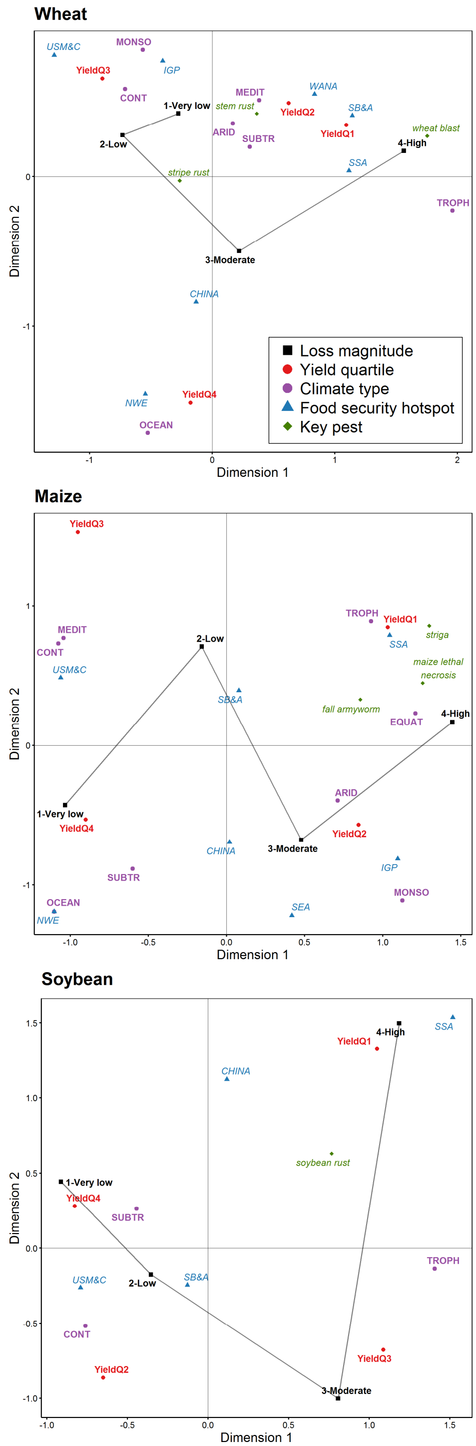
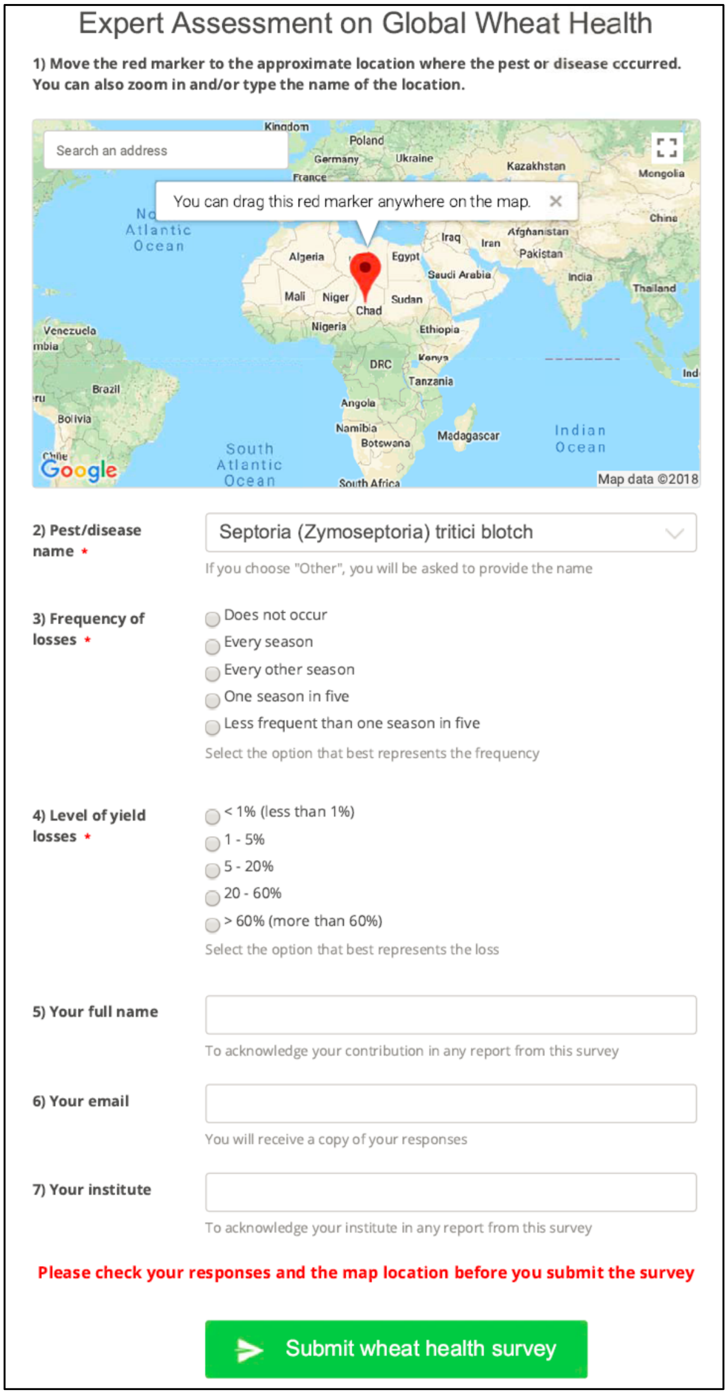


Supplementary Figure 3. Crop specific associations between losses, yield, climate, food security hotspots and key pests. Each panel is a correspondence analysis map based on the survey responses for that crop. Active variables (loss magnitude, yield quartiles, climate type) are in bold and supplemental variables (food security hotspot, key pests) are in italics. ARID=Arid; CONT=Humid continental; EQUAT=Equatorial; MEDIT= Mediterranean; MONSO= Monsoon; OCEAN=Oceanic; SUBTR=Subtropics; TROPH=Humid tropics. USM&C=US Midwest and Canada; SB&A=South Brazil, Paraguay, Uruguay and Argentina; NWE=Northwest Europe; WANA=West Asia and North Africa; SSA=Sub-Saharan Africa; CHINA=Mainland China; IGP=Indo-Gangetic Plain; SEA=Southeast Asia.


Expert Assessment on Global Wheat Health

1) Move the red marker to the approximate location where the pest or disease cccurred. You can also zoom in and/or type the name of the location.

2) Pest/disease name *

Septoria (Zymoseptoria) tritici blotch

If you choose "Other", you will be asked to provide the name

3) Frequency of losses *

- Does not occur
- Every season
- Every other season
- One season in five
- Less frequent than one season in five

Select the option that best represents the frequency

4) Level of yield losses *

- < 1% (less than 1%)
- 1 - 5%
- 5 - 20%
- 20 - 60%
- > 60% (more than 60%)

Select the option that best represents the loss

5) Your full name

To acknowledge your contribution in any report from this survey

6) Your email

You will receive a copy of your responses

7) Your institute

To acknowledge your institute in any report from this survey

Please check your responses and the map location before you submit the survey

Submit wheat health survey

Global Crop Health Survey
You are invited to contribute to a global survey on the losses caused by crop diseases and pests. If you would like to participate in this global effort, **please use the links on the left to submit information for one or more of the main staple crops**. The questionnaire has been devised to be simple and flexible, so that you would need as little of your time to provide inputs. If you have any queries about this survey, please **email** us.

Background
Quantification of the importance of crop diseases and pests is a necessary first step towards better understanding of crop health and its management. However, the information pertaining to the losses caused by plant diseases and pests in agriculture is fragmented, heterogeneous, and is very incomplete. Undertaking this survey is a project that has been considered for a long time. It has first been discussed by the Crop Loss Subject Matter Committee of the International Society for Plant Pathology during its first meeting in August 2013 in Beijing. Documenting the importance of crop diseases and pests is also one goal of several international research networks, such as AgMiP and MacSur.

About the survey
This survey is intended to help document crop losses in major world crops. As you will see, the information sought on each crop disease or pest (location, frequency and loss) is very simplified, in order to both reduce the time required to answering the questionnaire, and to generate homogeneous information across multiple diseases and pests of several crops.

The survey also asks you to provide your name, institute and e-mail address. Please note that providing this information is optional. However, providing this information will enable us to recognize your valuable contribution to this survey in future reports.

Hopefully, this survey will collect as many inputs from numerous contributors worldwide, on as many diseases and pests as possible. **The survey will end on 31 Jan 2017. If the survey is successful and we obtain a sufficient number of responses, we will generate a global crop health report which will be made public by 31 Apr 2017. The report will contain summarised crop health assessments, where individual contributions will not be presented, but your contribution will be explicitly acknowledged.**

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Sarah Pethybridge, Cornell University, USA
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Paul Esker, University of Costa Rica

Supplementary Figure 4. Screen capture of web-page of the online survey (http://globalcrophealth.org) for wheat, and accompanying explanatory text from the web-page.

Supplementary Table 1. List of contributors to the Global Survey on Crop Losses. Listed alphabetically by surname.

Name*	Country	Institution
Araz Abdullah	Australia	Curtin University, Centre for Crop and Disease Management
Adewale Adetayo	Nigeria	Ministry of Agriculture Ogun State Nigeria
Dante Adorada	Australia	University of Southern Queensland, Centre for Crop Health
Vanina Alemandri	Argentina	IPAVE CIAP INTA (Instituto Nacional de Tecnología Agropecuaria)
Shaukat Ali	USA	South Dakota State University
Thomas W. Allen	USA	Mississippi State University
Eduardo Alves	Brazil	Universidade Federal de Lavras
Lamia Aouini	The Netherlands	WUR (Wageningen University and Research)
Christos Athanassiou	Greece	University of Thessaly
Renuka Nilmini Attanayake	Sri Lanka	University of Kelaniya
Julián Ayala	Spain	AIMCRA (Asociación de Investigación para la Mejora del Cultivo de la Remolacha Azucarera)
Arun Balasubramaniam	India	Banaras Hindu University
Ranajit Bandyopadhyay	Nigeria	IITA (International Institute of Tropical Agriculture)
Biruta Bankina	Latvia	Latvia University of Agriculture
Robert Beiriger	USA	University of Florida
Samia Berraies	Tunisia	INRAT (National Institute of Agricultural Research of Tunisia)
Suma S. Biradar	India	University of Agricultural Sciences, Dharwad Karnataka
Leonardo Silva Boiteux	Brazil	Embrapa Vegetable Crops (Brazilian Agricultural Research Corporation)
Claude Bragard	Belgium	Université Catholique de Louvain
Toby Bruce	UK	Rothamsted Research
Adalberto Correa Cafe Filho	Brazil	Universidade de Brasilia
Nancy Castilla	Philippines	IRRI (International Rice Research Institute)
Xianming Chen	USA	USDA ARS
Angela Cherunya	Kenya	KALRO (Kenya Agriculture and Livestock Research Organization)
Godfree Chigeza	Nigeria	IITA (International Institute of Tropical Agriculture)
Il-Ryong Choi	Philippines	IRRI (International Rice Research Institute)
Michalakis Christoforou	Cyprus	Cyprus University of Technology
Glenda Clezy	Canada	Saskatchewan Pulse Growers
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Leila Maria Costamilan	Brazil	Embrapa Trigo (Brazilian Agricultural Research Corporation)
Eric Cother	Australia	New South Wales Department of Primary Industries
Gilles Couleaud	France	ARVALIS (French Arable Crops R&D Institute)
Henry Creissen	Ireland	Teagasc (The Agriculture and Food Development Authority)
Leonardo Crespo-Herrera	Mexico	CIMMYT (International Maize and Wheat Improvement Center)
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Anne Dorrance	USA	The Ohio State University
Daniel Dostaler	Canada	University Laval
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Susamoy Kundu	India	Bidhan Chandra Krishi Viswavidyalaya
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Concepcion Rubies Autonell	Italy	Department of Agricultural Sciences, Università di Bologna
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Abubacker Siddick	India	Hand in Hand India
Hamood Ahmed Siddiqui	Pakistan	PPSL
Richard W. Smiley	USA	Oregon State University
Damon Smith	USA	University of Wisconsin
Marcella Viana de Sousa	Brazil	Monsanto, Brazil
Gomathinayagam Subramanain	Guyana	University of Guyana
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W. Tadesse	Turkey	ICARDA (International Center for Agricultural Research in the Dry Areas
Oliver Boye Teekpeh	Liberia	Ministry of Agriculture, Liberia
Didier Tharreau	France	CIRAD (Agricultural Research for Development)
Kelly Tiller	Canada	Syngenta Canada Inc
Ruud Timmer	The Netherlands	WUR (Wageningen University and Research)
Vicki L. Tolmay	South Africa	Agricultural Research Council Small Grain Institute
Juan Manuel Tovar-Pedraza	Mexico	Universidad Autonoma Chapingo
Atma Nand Tripathi	India	ICAR India Institute of Vegetable Research IIVR, Varanasi UP
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Hugh Wallwork	Australia	SARDI (South Australian Research and Development Institute)
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Calum Wilson	Australia	University of Tasmania
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Yilin Zhou	China	Institute of Plant Protection of Chinese Academy of Agricultural Sciences
Xiaoyang Zhu	Canada	Ottawa Research and Development Centre

*An additional 31 responses were submitted anonymously.

Supplementary Table 2. Characterisation of pathogens and pests. Common and scientific names, emergence status, number of survey responses, extent and diversity.

Common name[*,†]	Latin or scientific name	Number of responses	Extent Code[‡]	Explanation - Extent	Diversity code[§]	Explanation - Diversity
Wheat						
Aphids[a]	*Sitobion avenae, Rhopalosiphum padi, Diuraphis noxia*[72]	16	L	Local: Long dispersal ability but local outbreaks associated with crop management.[72]	U	No deployed host plant resistance (HPRs).[72]
Aster Yellows[b]	*Aster yellows phytoplasma*[85]	1	L	Local: Wheat is not considered a main host. Several possible flying vectors with limited dispersal range.[85]	U	No major diversity factor reported.[85]
Barley yellow dwarf (BYD)[a]	BYD viruses[72,73,86]	14	G[‖]	General: Transmission by flying insects.[72,73]	U	No major diversity factor reported.[72,73]
Black Point (multiple pathogens)[b]	*Alternaria* spp., *Cochliobolus sativus, Cladosporium* spp., *Epicoccum* spp., *Fusarium* spp., *Stemphylium* spp., *Pyrenophora tritici-repentis*[87]	1	L	Local: Seed borne. Local dispersal.[87]	U	No major diversity factor reported.[87]
Heterodera avenae (Cereal cyst nematode)[b]	*Heterodera avenae*[88]	1	F	Focal: Soil borne.[88]	U	No major diversity factor reported.[88]
Crown and Root Rot[b]	*Fusarium* spp.[89]	5	G	General: Air borne dispersal of spores over long distances. Survival in residues.[89]	U	No major diversity factor reported.[89]
False armyworm[b]	*Leucania loreyi* Syn. *Mythimna loreyi*[90]	1	L	Local: Strong flying dispersal ability, although outbreaks are initiated from relatively limited (dense vegetation) areas.[90]	U	No major diversity factor reported.[90]
Fusarium head blight (FHB) – Scab[a]	*Fusarium* spp., *Microdochium* spp.[72,73]	41	G	General: Air borne dispersal of spores over long distances. Survival in residues.[72,73]	U	No (or limited) deployed HPRs.[72,73]
Fusarium seedling blight[b]	*Fusarium* spp., *Monographella nivalis*[91]	1	L	Local: Soil borne and seed borne with limited dispersal.[91]	U	No major diversity factor reported.[91]
(Grass) leaf miner[b]	*Agromyza ocularis*[92]	1	L	Local: Only local infestations reported.[92]	U	No major diversity factor reported. [92]
Heterodera filipjevi[b]	*Heterodera filipjevi*[93]	1	F	Focal: Soil borne.[93]	U	No major diversity factor reported.[93]
Leaf (brown) rust[a]	*Puccinia triticina*[72,73,94]	33	G	General: Air borne dispersal of spores over long distances.[72,73]	H	Deployed HPRs - many genes.[72,73]
Pratylenchus neglectus[b]	*Pratylenchus neglectus*[95]	1	F	Focal: Soil borne.[95]	U	No major diversity factor reported.[95]
Pratylenchus thornei[b]	*Pratylenchus thornei*[96]	3	F	Focal: Soil borne.[96]	U	No major diversity factor reported.[96]
Loose smut[b]	*Ustilago tritici*[97]	1	L	Local: Seed borne. Local dispersal.[97]	U	No major diversity factor reported.[97]
(Northern) armyworm[b]	*Mythimna separata*[98]	1	L	Local: Strong flying dispersal ability, although outbreaks are initiated from relatively limited (dense vegetation) areas.[98]	U	No major diversity factor reported.[98]
Powdery mildew[b]	*Blumeria graminis* f sp. *tritici*[99]	7	G	General: Air borne dispersal of spores over long distances.[99]	H	Deployed HPRs -many genes.[99]

Rhizoctonia root rot (bare patch)[b]	*Rhizoctonia solani* AG-8[100]	4	L	Local: Soil borne and limited dispersal - survival through sclerotia.[100]	U	No major diversity factor reported.[100]
Russian wheat aphid[b]	*Diuraphis noxia*[101]	1	G	General: Long-range flying insect.[101]	U	No major diversity factor reported.[101]
Sclerotium foot and root rot[b]	*Sclerotium rolfsii* Syn. *Athelia rolfsii*[72]	1	F	Focal: Soil borne.[72]	U	No major diversity factor reported.[72]
Tritici blotch[a]	*Zymoseptoria tritici*[72,73,102]	60	G	General: Rain splash and air borne dispersal of spores over moderate distances. Survival in residues.[72,73]	U¶	No deployed HPRs.[72,73]
Sharp eye spot[b]	*Ceratobasidium cereale*[103]	1	F	Focal: Soil borne.[103]	U	Resistances exist - limited deployment.[103]
Spot blotch[a]	*Cochliobolus sativus*[72,73,104]	9	G	General: Air borne dispersal of spores over moderate distances. Survival in residues.[72,73]	U	No major diversity factor reported.[1,3]
Nodorum blotch[a]	*Parastagonospora avenae* f. sp. *tritici, Parastagonospora (Phaeosphaeria) nodorum*[72,73,105]	21	G	General: Rain splash and air borne dispersal of spores over moderate distances. Survival in residues.[72,73]	U	No deployed HPRs.[72,73]
Stem (black) rust[a,106]	*Puccinia graminis* f. sp. *tritici*[72,73]	21	G	General: Air borne dispersal of spores over long distances.[72,73]	H	Deployed HPRs several genes.[72,73]
Stripe (yellow) rust[a,107]	*Puccinia striiformis* f. sp. *tritici*[72,73]	44	G	General: Air borne dispersal of spores over long distances.[72,73]	H	Deployed HPRs - many genes.[72,73]
Tan spot[a]	*Pyrenophora tritici-repentis*[72,73]	25	G	General: Air borne dispersal of spores over moderate distances. Survival in residues.[72,73]	U	No major diversity factor reported.[72,73]
Wheat Blast[b,108]	*Pyricularia graminis-tritici*[109,110]	6	L	Local: Seed borne. Moderate-distance aerial spore dispersal. Epidemics determined by coinciding environmental conditions and crop stage.[106]	U	No deployed HPRs.[106]
Wheat Soil-borne mosaic[b]	*Soilborne wheat mosaic virus* (SBWMV)[111]	2	F	Focal: Soil borne.[111]	U	No major diversity factor reported.[111]
(Wheat) spindle streak mosaic[b]	*Wheat spindle streak mosaic virus* (WSSMV)[112]	1	F	Focal: Soil borne. Transmitted by *Polymyxa graminis* [112]	U	No major diversity factor reported.[112]
Wheat streak mosaic[b]	*Wheat streak mosaic virus*[113]	1	L	Local: Transmitted by wind borne mites (wheat curl mite *Aceria tosichella*) over limited distances.[113]	U	No major diversity factor reported.[113]
Rice						
Aggregate sheath spot[b]	*Rhizoctonia oryzae-sativae*[114]	1	L	Local: Soil borne and limited dispersal - survival through sclerotia.[114]	U	No major diversity factor reported.[114]
Bacterial blight[a]	*Xanthomonas oryzae pv. oryzae*[74,115]	36	G	General: Dispersal through irrigation water and canals.[112]	H	Diversity of varieties with HPR - Many (efficient) resistances deployed.[112]
Bacterial panicle blight[b,116]	*Burkholderia glumae*[116]	7	L	Local: Seed borne. Local dispersal.[116]	U	No major diversity factor reported.[116]
Bacterial sheath rot[b]	*Acidovorax avenae, Pantoea ananatis, Burkholderia cepacia*[117]	1	L	Local: Seed borne. Local dispersal.[117]	U	No major diversity factor reported.[117]

Bakanae[b]	*Fusarium fujikuroi*[74]	2	L	Local: Seed borne and soil borne - Is also dispersed by ascospores (short distance).[74]	U	No major diversity factor reported.[74]
Black bug[b]	*Scotinophara coardata*[118]	1	L	Local: Poor flyer and local propagation. Population densities usually low.[118]	U	No major diversity factor reported.[118]
Blast (Leaf, neck, or panicle blast)[a]	*Pyricularia oryzae*[74,119]	52	G	General: air borne dispersal of conidia over moderate distances.[74]	H	Many resistances deployed; heavy chemical control in some countries.[74]
Brown plant hopper[a]	*Nilaparvata lugens*[1,75]	17	G	General: Insect flights over long distances.[1,75]	H	Partial resistances; differential effect of (inducing) pesticide campaigns.[1,75]
Brown spot[a]	*Cochliobolus miyabeanus*[74,120]	22	G	General: air borne dispersal of conidia over moderate distances. Survival in residues.[112]	U	No major diversity factor reported.[112]
False smut[b,121]	*Ustilaginoidea virens*[122]	5	G	General: Air borne dispersal of conidia over moderate distances. Survival in many different forms (incl. chlamydospores and sclerotia).[122]	H	Effects of hybrids in landscapes; partial resistances.[122]
Grassy stunt[b]	*Rice grassy stunt virus*[123]	4	L	Local: Transmission by flying vectors. Severe, however local outbreaks often associated with crop management.[123]	U	No major diversity factor reported.[123]
Hoja blanca[b]	*Rice hoja blanca virus*[74]	6	L	Local: Transmission by flying vectors. Sporadic-cyclic epidemics due to genetically variable vector capacity in the insect.[74,124]	U	No major diversity factor reported.[74,124]
Kernel smut[b]	*Tilletia barclayana*[74]	1	L	Local: Soil borne and limited dispersal.[74]	U	No major diversity factor reported.[74]
Leaf folder[b]	*Cnaphalocrocis medinalis*[75]	1	G	General: Moderate distance spread (flights).[75]	U	No major diversity factor reported.[75]
Narrow brown leaf spot[b]	*Cercospora janseana*[1,74]	1	G	General: Air borne dispersal of conidia over moderate distances. Survival in residues.[1,74]	U	No major diversity factor reported.[1,74]
Ragged stunt[a]	*Rice ragged stunt virus*[74,125]	7	L	Local: Transmission by flying vectors. Severe, however local outbreaks often associated with crop management.[74,125]	U	No major diversity factor reported.[74,125]
Rice sheath mite[b]	*Steneotarsonemus spinki*[126]	1	L	Local: Short-distance dipersal. Only local outbreaks reported.[126]	U	No major diversity factor reported.[126]
Rice tungro disease[a]	*Rice tungro bacilliform virus* and *Rice tungro spherical virus*[74,127]	23	L	Local: Transmission by flying vectors. Severe, however local outbreaks often associated with crop management.[74,127]	U	Partial resistances deployed; crop establishment synchrony in landscapes.[74,127]
Rice weevil[b]	*Sitophilus oryzae*[128]	1	L	Local: Poor flyer and local propagation. Population densities usually low.[128]	U	No major diversity factor reported.[128]

Sheath blight[a]	*Rhizoctonia solani*[74,129]	18	G	General: Dispersal through irrigation water and canals (sclerotia). Survival in soil and residues.[112]	U	No major diversity factor reported.[112]
Sheath rot[a]	*Sarocladium oryzae*[1,74]	12	L	Local: Seed borne and soil (straw residue) borne. Local dispersal.[1,74]	U	No major diversity factor reported.[1,74]
Stem borers[a]	*Scirpophaga incertulas, Chilo suppressalis, Sesamia inferens*[1,75]	20	G	General: Moderate to long distance flights.[1,75]	U	No major diversity factor reported.[1,75]
Stem rot[b]	*Sclerotium oryzae*[74]	1	L	Local: Soil borne and limited dispersal - survival through sclerotia.[74]	U	No major diversity factor reported.[74]
Stripe[b]	*Rice stripe virus*[130]	1	L	Local: Transmission by flying small brown planthopper vectors. Severe, however local outbreaks often associated with crop management.[130]	U	No major diversity factor reported.[130]
White grubs[b]	*Coleoptera: Scarabaeidae*[131]	1	L	Local: Population densities usually low. Long life cycle.[131]	U	No major diversity factor reported.[131]
Yellow mottle[b]	*Rice yellow mottle virus*[132]	4	G	General: Transmission by flying insects.[132]	U	No major diversity factor reported.[132]
Maize						
African black beetle[b]	*Heteronychus arator*[1,133]	1	L	Local: Poor flyer and local propagation. Population densities usually low.[1,133]	U	No indication of major crop/host variability.[1,133]
African boll worm[b]	*Helicoverpa armigera*[134]	1	L	Local: Strong flying dispersal ability, but infestations often spatially patchy and cyclical.[134]	U	No indication of major crop/host variability.[134]
African stem borer[a]	*Busseola fusca, Sesamia calamistris*[1,135]	5	L	Local: Strong flying dispersal ability, but infestations often spatially patchy and cyclical.[1]	U	No indication of major crop/host variability.[1]
Anthracnose leaf blight[b]	*Colletotrichum graminicola*[76,136]	1	L	Local: Soil borne and survival in crop residues. Short-distance aerial spore dispersal.[76]	U	No indication of major crop/host variability.[76]
Anthracnose stalk rot[b]	*Colletotrichum graminicola*[76,136]	2	L	Local: Soil borne and survival in crop residues.[76]	U	No indication of major crop/host variability.[76]
Asian corn borer[b]	*Ostrinia furnacalis*[137]	1	G	General: Long-range flying insect.[137]	U	No indication of major crop/host variability.[137]
Bacterial stalk rot[b]	*Dickeya zeae*[1,76]	1	G	General: Soil borne, but transmitted by soil and contaminated tools.[76]	U	Variability of hybrid susceptibility.[76]
Banded leaf and sheath blight[b]	*Rhizoctonia solani*[1,138]	2	L	Local: Soil borne and limited dispersal - survival through sclerotia.[138]	U	No deployed HPR.[138]
Brown stripe downy mildew[b]	*Sclerophthora rayssiae* var. *zeae*[1,76]	1	F	Focal: Soil borne. Epidemics associated with heavy rains in Terai (India-Nepal).[76]	H	Deployed HPRs and chemical control.[76]
Common rust[b]	*Puccinia sorghi*[139]	4	G	General: Air borne dispersal of spores over long distances.[139]	H	Deployed HPRs.[139]

Common smut[b]	*Ustilago maydis*[1,76]	3	L	Local: Soil borne and limited dispersal.[76]	H	Deployed HPRs.[76]
Corn stunt[b]	*Spiroplasma kunkelii*[1,140]	1	L	Local: Spiroplasma transmitted by leafhopper. Only limited epidemics reported.[140]	U	No major diversity factor reported.[140]
Crazy top[b]	*Sclerophthora macrospora*[76]	1	L	Local: Soil borne and limited dispersal.[76]	U	No major diversity factor reported.[76]
Cutworm[b]	*Agrotis ipsilon*[141]	1	L	Local: Strong flying dispersal ability, but infestations often spatially patchy and cyclical.[141]	U	No major diversity factor reported.[141]
Diabrotica (beetle and rootworms)[a]	*Diabrotica balteata, D. virgifera, D. longicornis, D. speciosa*[1,142]	4	G	General: Long-range flying insect.[1]	U	No major diversity factor reported.[1]
Diplodia ear and stem rot[a]	*Stenocarpella maydis*[1,76]	6	G	General: Air borne dispersal over moderate distances. Spread by infected seeds. Survival in residues.[1,76]	U	No major diversity factor reported.[1,76]
European stem borer[a]	*Ostrinia nubialis*[1,143]	4	G	General: Long-range flying insect.[1]	U	No major diversity factor reported.[1]
Eyespot[b]	*Kabatiella zeae*[144]	2	F	Focal: Rain splash and air borne dispersal of spores over moderate distances. Survival in residues. Low occurrence of epidemics reported.[1,144]	U	No major diversity factor reported.[1,144]
Fall armyworm[b,145]	*Spodoptera frugiperda*[146]	3	G	General: Long-range flying insect.[146]	U[#]	No deployed HPR, no wide scale chemical control.[146]
Fusarium and Gibberella (F&G) ear rots[a]	*Fusarium moniliforme (Gibberella fujikuroi), F. graminearum (Gibberella zeae)*[1,76,147]	18	G	General: Air borne dispersal of spores over moderate distances. Survival in residues.[1,76,147]	U	No major diversity factor reported.[1,76,147]
Fusarium and Gibberella (F&G) stalk rots[a]	*Fusarium moniliforme (Gibberella fujikuroi), F. graminearum (Gibberella zeae)*[1,76]	15	G	General: Air borne dispersal of spores over moderate distances. Survival in residues.[1,76]	U	No major diversity factor reported.[1,76]
Gray leaf spot[b]	*Cercospora zeae-maydis, C. zeina*[1,76]	3	G	General: Air borne dispersal of spores over moderate distances. Survival in residues.[76]	U	No major diversity factor reported.[76]
Head smut[b]	*Sphacelotheca reiliana* (syn. *Sporisorium relianum*)[1,76]	2	F	Focal: Soil borne.[76]	H	No major diversity factor reported.[76]
Maize lethal necrosis[b,148]	*Maize chlorotic mottle virus* and a virus of the *Potyviridae* family (e.g., *Wheat streak mosaic virus ; Maize dwarf mosaic virus ; Sugarcane mosaic virus*)[149]	2	L	Local: Dual virus infections transmitted by multiple vectors. Contaminated soil is infective. Local epidemics reported.[148,149]	U	No major diversity factor reported.[148,149]
Maize streak[a]	*Maize streak virus*[1,76]	9	G	General: Transmission by flying insects.[1,76]	U	No major diversity factor reported.[1,76]
Mal de Río Cuarto[b]	*Mal de Río Cuarto virus*[150]	1	G	General: Transmission by flying insects.[150]	U	No major diversity factor reported.[150]
Mediterranean corn borer[b]	*Sesamia nonagrioides*[1,151]	1	G	General: Long-range flying insect.[151]	U	No major diversity factor reported.[151]
Northern leaf blight[a]	*Exserohilum turcicum*[1,76]	16	G	General: Air borne dispersal of spores over long distances. Survival in residues.[1,76]	H	Deployed HPRs.[1,76]

Rajasthan downy mildew[b,☆]	*Peronosclerospora heteropogoni*[1,76,152]	1	L	Local: Soil borne and limited dispersal.[76]	H	Deployed HPRs.[76]
Root knot nematodes[b]	*Meloidogyne incognita, M. arenaria, M. javanica, M. hapla,* and *M. chitwoodi*[76]	1	F	Focal: Soil borne.[76]	U	No major diversity factor reported.[76]
Silk fly[b]	*Euxesta stigmatias*[1,153]	1	F	Focal: Localised outbreaks on sweet corn.[153]	H	No deployed HPR - on sweetcorn.[153]
Sorghum downy mildew[b,☆]	*Peronosclerospora sorghi*[1,76]	1	L	Local: Soil borne and limited dispersal.[76]	H	Deployed HPRs.[76]
Southern leaf blight[b]	*Bipolaris maydis*[154]	3	G	General: Air borne dispersal of spores over long distances. Survival in residues.[154]	H	Deployed HPRs.[154]
Southern rust[a]	*Puccinia polysora*[1,76]	13	G	General: Air borne dispersal of spores over long distances.[1,76]	H	Deployed HPRs.[1,76]
(Maize) Spotted stem borer[b]	*Chilo partellus*[155]	1	G	General: Long-range flying insect.[155]	U	No major diversity factor reported.[155]
Striga[b,156]	*Striga* spp. *(S. hermontica, asiatica)*[1,156]	2	L	Local: Soil borne and limited dispersal.[156]	U	No major diversity factor reported.[156]
Tar spot[b]	*Phyllachora maydis, Coniothyrium phyllachorae,* and *Monographella maydis*[1,76]	1	L	Local: Survival on volunteers and in crop residues. Short-distance aerial spore dispersal.[76]	U	No major diversity factor reported.[76]
White spot[b]	*Pantoea stewartii*[1,157]	2	L	Local: Transmission by flying vectors and seed borne. Severe, however local outbreaks often associated with crop management.[157]	H	Deployed HPRs.[157]
Potato						
Aphids[b]	*Myzus persicae*[158]	1	L	Local: Long-range dispersal ability but local outbreaks associated with crop management.[158]	U	No major diversity factor reported.[158]
Apical leaf curl[b]	*Potato apical leafcurl virus*[159,160]	1	F	Focal. Seems limited to Northern India.[159]	H	Strongly dependent of whitefly seasonal variations.[159]
Brown rot[b,161]	*Ralstonia solanacearum*[1,77]	8	F	Focal: Soil borne and transmitted by planting material.[77]	U	No major diversity factor reported.[77]
Canker and black scurf[b]	*Rhizoctonia solani*[1,77]	1	G	General: Soil-borne but very large host range. Spread via contaminated tools or plant parts.[77]	U	No major diversity factor reported.[77]
Colorado potato beetle[a]	*Leptinotarsa decemlineata*[1,162]	2	G	General: Long-range flying insect.[1]	U	No major diversity factor reported.[1]
Common scab[a]	*Streptomyces scabiei, Streptomyces* spp.[77,163]	15	F	Focal: Soil borne.[77]	U	No major diversity factor reported.[77]
Cyst nematode[a]	*Globodera rostochiensis, G. pallida*[77]	11	G	General: Soil borne, but transmitted by soil and contaminated tools.[77]	U	No major diversity factor reported.[77]
Early blight[a]	*Alternaria solani*[77]	27	G	General: Air borne dispersal of spores over moderate distances. Survival in residues.[77]	H	Fungicide protection widespread.[77]
Early dying/Verticillium wilt[a]	*Verticillium albo-atrum, V. dahlia, Pratylenchus penetrans*[77,164]	11	L	Local: Soil borne and limited dispersal - survival through sclerotia.[77]	U	No major diversity factor reported.[77]

Groundnut ringspot[b]	*Groundnut ringspot virus*[165]	1	L	Local: Transmitted by thrips: moderate to short distance dispersal.[165]	U	No major diversity factor reported.[165]
Late blight[a]	*Phytophthora infestans*[77]	63	G[**]	General: Air borne dispersal of spores over moderate distances. Survival in residues.[77]	H	Large variation in chemical protection (and pathogen diversity) .[77]
Leaf miner[b]	*Liriomyza huidobrensis*[1,166]	1	L	Local: Only local infestations reported.[166]	U	No major diversity factor reported.[166]
Leaf worm[b]	*Spodoptera* spp. [167]	1	L	Local: Strong flying dispersal ability, but infestations often spatially patchy and cyclical.[167]	U	No major diversity factor reported.[167]
Potato leafhopper[a]	*Empoasca fabae*[1]	3	L	Local: Long-range dispersal ability but local outbreaks associated with crop management.[1]	U	No major diversity factor reported.[1]
Powdery scab[a]	*Spongospora subterranea*[1,77]	6	F	Focal: Soil borne and transmitted by planting material.[77]	U	No major diversity factor reported.[77]
Slugs[b]	*Deroceras reticulatum, Arion hortensis*[168]	1	L	Local: Highly polyphagous but short range dispersal ability.[168]	U	No major diversity factor reported.[168]
Zebra chip[b]	*Candidatus* Liberibacter solanacearum[169]	1	L	Local: Transmission by flying vectors. Severe, however local outbreaks often associated with crop management.[169]	U	No major diversity factor reported.[169]
Soybean						
Alternaria leaf spot[b]	*Alternaria* spp.[78]	1	L	Local: Seed borne and survival in crop residues. Short-distance aerial spore dispersal.[78]	U	No documented heterogeneity (susceptibility, management) .[78]
Anthracnose[b]	*Colletotrichum truncatum*[1,78]	2	L	Local: Seed borne and survival in crop residues. Short-distance aerial spore dispersal.[78]	U	No HPR and limited chemical control (ever) used.[78]
Armyworm[a]	*Spodospora exigua, S. praefica*[78]	2	L	Local: Strong flying dispersal ability, but infestations often spatially patchy and cyclical.[78]	U	No HPR no systematic insecticide use.[78]
Brown spot[b]	*Septoria glycines*[170]	2	L	Local: Seed borne and survival in crop residues. Short-distance aerial spore dispersal.[170]	U	No HPR and limited chemical control (ever) used.[170]
Cercospora leaf blight[b]	*Cercospora kikuchii*[1,171]	3	L	Local: Seed borne and survival in crop residues. Short-distance aerial spore dispersal.[171]	U	No HPR and limited chemical control (ever) used.[171]
Charcoal rot[b]	*Macrophomina phaseolina*[1,172]	2	L	Local: Soil borne and limited dispersal - survival through sclerotia.[172]	U	No HPR.[172]
Cylindrocladium rot[b]	*Calonectria ilicicola (syn. Cylindrocladium parasiticum); Calonectria morganii (syn. Cylindrocladium scoparium)*[78,173]	3	F	Focal: Soil borne. Limited dispersal as microsclerotia in crop debris.[78]	U	No HPR - no Fungicide.[78]

Cyst nematode[a]	*Heterodera glycines*[1,78]	10	G	General: Soil borne, but transmitted by soil and contaminated tools.[78]	U	Limited use of HPRs.[78]
Downy mildew[b]	*Peronospora manshurica*[78]	1	L	Local: Seed borne and limited dispersal.[78]	H	Wide diversity of races.[78]
Frogeye leaf spot[b]	*Cercospora sojina*[78]	4	L	Local: Seed borne and survival in crop residues. Short-distance aerial spore dispersal.[78]	H	Resistances deployed.[78]
Fusarium wilt and rot[b]	*Fusarium oxysporum, F. glycines, F. proliferatum*[1,78]	1	L	Local: Soil borne and seed borne with limited dispersal.[78]	U	Limited use of HPRs.[78]
Phomopsis seed decay[b]	*Diaporthe phaseolorum* var. *sojae*; *Diaporthe longicolla*[1,174]	1	F	Focal: Soil borne and transmitted by infected seed.[174]	U	No documented heterogeneity (susceptibility, management).[174]
Phyllosticta leaf spot[b]	*Pleosphaerulina sojicola (*Syn. *Phyllosticta sojaecola)*[78,175]	1	G	General: Air borne dispersal of spores over moderate distances. Survival in residues.[78]	U	No documented heterogeneity (susceptibility, management).[78]
Phytophthora root and stem rot[a]	*Phytophthora sojae*[78,176]	14	G	General: Soil borne, but transmitted by soil and contaminated tools.[78]	U	Limited use/efficiency of HPRs and chemicals.[78]
Pythium damping-off[a]	*Pythium* spp. and *Globisporangium* spp.[1,78,177]	6	F	Focal: Soil borne.[78]	U	No documented heterogeneity (susceptibility, management).[78]
Reniform nematode[b]	*Rotylenchulus reniformis*[1,78]	1	F	Focal: Soil borne.[78]	U	No documented heterogeneity (susceptibility, management).[78]
Rhizoctonia root rot, web blight[a]	*Rhizoctonia solani*[78]	9	L	Local: Soil borne and limited dispersal - survival through sclerotia.[78]	U	No documented heterogeneity (susceptibility, management).[78]
Root knot nematode[b]	*Meloidogyne* spp.[1,78]	2	L	Local: Soil borne and limited dispersal.[78]	U	No documented heterogeneity (susceptibility, management).[78]
Soybean mosaic[a]	*Soybean mosaic virus*[78,178]	3	G	General: Transmission by flying insects.[78]	U	No documented heterogeneity (susceptibility, management).[78]
Soybean rust[a,179]	*Phakopsora pachyrhizi*[78,179]	30	G	General: Air borne dispersal of spores over long distances.[78,179]	H	Heterogeneity of HPR and fungicides.[78,179]
Spider mites[b]	*Tetranychus* spp.[180]	1	L	Local: Short-distance dipersal. Only local outbreaks reported.[180]	U	No documented heterogeneity (susceptibility, management).[180]
Stem canker[b]	*Diaporthe phaseolorum* var. *caulivora; D. phaseolorum* var. *meridionalis (Phomopsis* spp.)[181,182]	1	L	Local: Soil borne and limited dispersal.[181]	U	No documented heterogeneity (susceptibility, management).[181]
Sudden death[a]	*Fusarium virguliforme, F. tucumaniae*[78,183]	8	G	General: Air borne dispersal of spores over long distances. Survival in residues.[78]	U	limited use/efficiency of HPRs and chemicals.[78]
Target spot[b]	*Corynespora cassiicola*[184]	2	L	Local: Seed borne. Short-distance aerial spore dispersal.[184]	H	HPRs deployed.[184]
White mould[a]	*Sclerotinia sclerotiorum*[78]	15	G	General: Air borne dispersal over moderate distances. Wide host range. Soil borne survival.[78]	U	Limited use/efficiency of HPRs and chemicals.[78]

* Corresponds to two lists: a: pathogen or pest listed in the survey questionnaire; or b: pathogen or pest named by a respondent to the survey.

† Reference provided if this has been considered an emerging P&P or “key pest”.

‡ Extent: F=Focal, L=Local, G=General.

§ Diversity: H=Heterogeneous, U=Uniform.

‖ The extent code for barley yellow dwarf viruses in wheat was set as "global", except in SB&A (South Brazil, Paraguay, Uruguay and Argentina) , where it was set as "focal". This is because the disease loss reported occurs in limited areas in this region.

¶ The diversity code for tritici blotch in wheat was set as "uniform", except in NWE (Northwest Europe), where it was set as "heterogeneous". This reflects the fact that in this region, the disease is managed through regular use of fungicides.

The diversity code for fall armyworm in maize was set as heterogeneous for all American countries, where pesticides and host plant resistance are used, and set as uniform in all African countries.

☆ Rajasthan and sorghum downy mildews were combined into a single disease.

** The extent code for late blight in potato was set as "global" except in IGP (Indo-Gangetic Plain) and CHINA (mainland China), where it was set as "local", as disease loss reported corresponds to local losses in these regions.

Supplementary Table 3. Crop loss estimates. Losses by individual pests and pathogens globally and in food security hotspots.

Pathogen and pest per crop	Global		USM&C[*]		SB&A		NWE		WANA		SSA		CHINA		IGP		SEA	
	estYL[†]	N[‡]	estYL	N	estYL	N	estYL	N	estYL	N	estYL	N	estYL	N	estYL	N	estYL	N
Wheat	**21.47**	326	**17.91**	25	**21.54**	20	**24.91**	62	**10.14**	22	**25.68**	13	**28.1**	23	**16.57**	32		
Leaf rust	3.25	33	0.54	3	1.37	2	2.50	6	3.14	2	2.19		4.38	1	4.25	5		
FHB-scab	2.85	41	3.20	4	4.16	6	1.80	10					8.75	9	0	1		
Tritici blotch	2.44	60	2.10	3	2.14	2	5.51	15	0.97	16	5.36	1	2.10	2				
Stripe rust	2.08	44	0.82	4	0.03	1	5.82	8	2.80	2	4.96	2	2.16	3	1.44	8		
Spot blotch	1.67	9	1.04	1			0	1							7.29	4		
Tan spot	1.64	25	4.30	4	6.79	4	1.91	5										
Aphids	1.30	16	0.93				0.54	4			0.85	1	3.75	2	1.78	4		
Powdery mildew	1.07	7					2.19	2					3.27	3	0	1		
BYD	0.96	14	0.64	1	1.17	1	3.26	4	2.90	1	1.72	2	0.35	1				
Stem rust	0.90	21	0.10	2	0.53	1	0	1	0.33	1	8.89	4			0.03	2		
Nodorum blotch	0.90	21	2.10	2	0.31	1	0.11	5										
Crown and Root Rot	0.86	5	1.06										2.10	1				
Northern armyworm	0.37	1													1.73	1		
Sharp eye spot	0.26	1											1.25	1				
Rhizoctonia bare patch	0.24	4																
Pratylenchus thornei	0.21	3	0.15															
Wheat Soil-borne mosaic	0.18	2					1.28	1										
Aster Yellows	0.09	1	0.93	1														
Wheat Blast	0.07	6			3.52	1									0.02	2		
Wheat streak mosaic	0.05	1			1.51	1												
Pratylenchus neglectus	0.03	1																
Cereal cyst nematode	0.01	1																
Heterodera filipjevi	0.01	1																
Russian wheat aphid	0.01	1									0.66	1						
False armyworm	0.01	1									0.76	1						
Grass leaf miner	0.003	1									0.28	1						
Black Point	0.002	1													0.011	1		
Fusarium seedling blight	0.002	1													0.011	1		
Wheat spindle streak mosaic	0.002	1																
Sclerotium foot and root rot	0.001	1													0.004	1		
Loose smut	0.0001	1													0.0004	1		
Rice	**30.03**	246									**31.25**	13	**32.18**	13	**40.86**	37	**24.57**	93
Sheath blight	6.78	18									6.78		8.75	1	5.76	5	7.06	4
Stem borers	5.57	20									5.82	1	8.75	1	7.38	4	2.39	8
Blast	4.33	52									4.21	3	4.38	2	3.27	6	5.89	11
Brown spot	3.77	22									3.33	1	3.25		5.86	2	2.93	13
Bacterial blight	2.72	36									4.73	3	1.05	1	8.51	9	1.45	14
Leaf folder	1.92	1											2.10		2.10		2.10	1
Brown plant hopper	1.31	17											1.05	3	1.43	3	1.00	6
Bacterial panicle blight	0.87	7													1.87	1		
False smut	0.68	5											0.88	1	2.19	1		
Sheath rot	0.40	12									0.38		0.15	1	1.16	2	0.15	4

Ragged stunt	0.30	7									0.75	1			0.27	6
Stripe	0.27	1									0.90	1				
Rice tungro	0.27	23											0.43	4	0.54	18
Kernel smut	0.20	1											0.45			
Rice sheath mite	0.20	1											0.45			
Bacterial sheath rot	0.16	1													0.53	1
Yellow mottle	0.08	4							4.33	4						
Bakanae	0.06	2							0.13		0.18	1			0.01	1
Rice weevil	0.03	1							1.55	1						
Narrow brown leaf spot	0.03	1														
Grassy stunt	0.03	4													0.11	4
White grubs	0.02	1													0.06	1
Black bug	0.02	1													0.08	1
Hoja Blanca	0.01	6														
Stem rot	0.01	1														
Aggregate sheath spot	0.002	1														
Maize	**22.51**	138	**21.31**	30	**19.46**	6			**30.07**	28			**41.14**	14		
Fusarium and Gibberella (F&G) stalk rots	4.58	15	4.54	5	4.15				3.28	1			5.84	1		
Fall armyworm	2.85	3	4.34		4.34				6.25	2						
Northern leaf blight	2.68	16	1.64	4	2.63	1			1.02	1			2.46	1		
Fusarium and Gibberella (F&G) ear rots	2.38	19	1.18	3	0.99				0.49	2			4.52	2		
Anthracnose stalk rot	1.65	2	3.63	2												
Southern rust	1.15	13	0.19	3					1.40	1			7.87	1		
Diabrotica	0.98	4	2.03	2									3.83	1		
Gray leaf spot	0.94	3	2.01	1	2.07	1										
Common rust	0.75	4	0.21	2	0.61				2.50				2.46	1		
Bacterial stalk rot	0.64	1											1.18	1		
Southern leaf blight	0.55	3			0.50								2.46	1		
White spot	0.42	2			1.42	1										
Maize streak	0.37	9							3.90	7			3.05			
Corn stunt	0.35	1			1.78											
Tar spot	0.35	1														
Silk fly	0.27	1	0.60													
Diplodia rot	0.24	6	0.34	2	0.50				0.34							
European stem borer	0.22	4	0.42	2												
African stem borer	0.21	5							4.01	5						
Banded leaf and sheath blight	0.20	2											3.62	2		
Striga	0.16	2							3.12	2						
Sorghum and Rajasthan downy mildew	0.14	2											2.53	2		
Maize lethal necrosis	0.13	2							2.54	2						
Asian corn borer	0.11	1											0.20			
Common smut	0.06	3	0.09	1	0.24	1										
Brown stripe downy mildew	0.06	1											1.12	1		
Spotted stem borer	0.04	1							0.68	1						
Mal de Rio Cuarto	0.02	1			0.22	1										
Root knot nematodes	0.02	1							0.40	1						
Mediterranean corn borer	0.01	1														
Eyespot	0.01	2	0.09	1												

African boll worm	0.003	1									0.05	1						
Cutworm	0.003	1									0.05	1						
Anthracnose leaf blight	0.002	1	0.01	1														
African black beetle	0.002	1									0.03	1						
Crazy top	0.001	1			0.01	1												
Head smut	0.0004	2	0.001	1														
Potato	**17.22**	154	**8.05**	6			**9.8**	13	**12.55**	8	**10.8**	16			**21**	15		
Late blight	5.98	63	2.22	1			3.24	6	4.90	2	4.18	6			8.08	10		
Brown rot	3.10	8	0.16						3.75	1	3.87	4			3.65			
Early blight	2.59	27	1.47	1			1.33	2	1.83	1	1.64	1			2.08	1		
Cyst nematode	1.52	11					3.13	2	0.88	2	0	1						
Powdery scab	0.94	6	0.57	1			0.87		1.04		0.17	1			1.06	1		
Verticillium wilt	0.68	11	0.90	1							0	1						
Apical leaf curl	0.67	1													3.65	1		
Potato leafhopper	0.65	3	1.35	1							0.24	1			1.69			
Common scab	0.46	15	0.28	1			0.45	1	0.16	2	0.69	1			0.47	1		
Colorado potato beetle	0.24	2	1.10															
Leaf miner	0.20	1																
Slugs	0.08	1					0.63	1										
Leaf worm	0.05	1													0.33	1		
Canker and black scurf	0.03	1																
Aphids	0.02	1					0.15	1										
Groundnut ringspot	0.01	1																
Zebra chip	0.002	1																
Soybean	**21.4**	125	**25.27**	30	**32.44**	24					**10.98**	13						
Cyst nematode	4.24	10	9.31	5	5.24													
White mould	3.90	15	4.11	7	3.88	1												
Soybean rust	2.96	30	0.02	1	6.65	6					5.91	9						
Cercospora leaf blight	1.88	3	2.18		3.17	1												
Brown spot	1.32	2	0.84		2.94	1												
Charcoal rot	1.31	2	1.55		1.45	2					1.65							
Root knot nematode	1.18	2	0.84		2.33						1.83	1						
Phytophthora root & stem rot	0.94	14	0.58	6	1.89	2					0.61	1						
Sudden death	0.89	8	2.69	5	1.23	1												
Fusarium wilt and rot	0.67	1	0.84		0.90	1												
Rhizoctonia rot and blight	0.53	9	0.90	2	0.70	2					0.9	1						
Soybean mosaic	0.43	3	0.33															
Target spot	0.23	2	0.16		0.30													
Spider mites	0.20	1			0.29													
Frogeye leaf spot	0.19	4	0.42		0.26	1					0.08	1						
Phomopsis seed decay	0.18	1			0.73	1												
Anthracnose	0.12	2			0.23	1												
Reniform nematode	0.08	1	0.28															
Pythium damping-off	0.05	6	0.18	3	0.02													
Phyllosticta leaf spot	0.03	1			0.10	1												
Downy mildew	0.03	1	0.04		0.05	1												
Alternaria leaf spot	0.01	1			0.04	1												
Stem canker	0.01	1			0.04	1												

Cylindrocladium rot	0.001	3																
Armyworm	0.0002	2	0.001	1														

* Food security hotspot: USM&C=US Midwest and Canada; SB&A=South Brazil, Paraguay, Uruguay and Argentina; NWE=Northwest Europe; WANA=West Asia and North Africa; SSA=Sub-Saharan Africa; CHINA=Mainland China; IGP=Indo-Gangetic Plain; SEA=Southeast Asia.

† Crop loss estimate. Shaded columns indicate no reported P&Ps or insufficient responses to estimate a loss.

‡ Number of responses for the pest or pathogen globally or within a given hotspot.

Supplementary Table 4. Summary of analyses on contingency tables. Chi-square analyses and interpretations to examine different factors related to global crop losses.

Variables	Chi-square value	*d.f.*	*P* value	Comments on chi-square calculation	Interpretations of frequency distributions in contingency table
Analyses involving all crops globally					
loss magnitude × crop	57.683	12	< 0.001	Balanced expected values	Loss magnitudes in - Wheat: evenly distributed across categories, from very low to high - Rice: tended to be low or moderate, seldom high - Maize: generally very low or low - Potato: tended to be high, seldom low or very low - Soybean: tended to be low or very low
loss magnitude × food security hotspot[*]	165.203	24	<0.001	Balanced expected values	- NWE, SEA, USM&C: predominantly low yield losses, with infrequent high yield losses - CHINA: Predominantly moderate yield losses with infrequent high or very low yield losses - SB&A, WANA: wide range of yield losses including high yield losses - IGP: low yield losses were infrequent but high yield losses frequently reported - SSA: predominantly moderate and high yield losses
food security hotspot[*] × crop	596.619	32	<0.001	Balanced expected values	- Rice-dominated hotspot: SEA - Rice- and wheat- dominated hotspots: CHINA, IGP - Wheat-dominated hotspots: NWE, WANA - Wheat- and soybean- dominated hotspots: SB&A - Maize- and soybean- dominated hotspots: USM&C - Diverse, maize- dominated hotspots: SSA
loss magnitude × loss frequency	66.7	9	<0.001	Balanced expected values	Losses of very low magnitude are more frequently chronic, or rare; losses of low magnitudes are more frequently chronic or frequent; and losses of moderate or high magnitudes are more frequently rare or infrequent.
crop × loss frequency	35.4	12	<0.001	Balanced expected values	More chronic losses in maize and potato; less chronic losses in wheat
food security hotspot[*] × loss frequency	67.9	24	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant ($P < 0.001$) test with combined (Infrequent and Rare) frequency losses: More chronic losses in CHINA and IGP; less chronic losses in SB&A and SEA
Analyses involving wheat					
climate† × loss magnitude	50.620	18	<0.001	Balanced expected values	Loss magnitude associated with climate: moderate and high yield losses more frequent under SUBTR and TROPH
yield quartile × loss magnitude	57.897	9	<0.001	Balanced expected values	Loss magnitude associated with yield levels: Moderate-high yield losses more frequent at very low to low yield levels (YieldQ1-2), and very low to low yield losses more frequent at moderate - high yield levels (YieldQ3-4)
yield quartile × climate†	217.946	18	<0.001	Balanced expected values	Yield levels associated with climates: Highest yield levels associated with OCEAN, lowest yield levels associated with MEDIT, TROPH
food security hotspot[*] × loss magnitude	98.602	21	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant ($P < 0.01$) test with combined (Very low – Low) and (Moderate – High) yield losses: - Moderate-High yield losses more frequent: CHINA, SB&A, SSA - Very low-Low yield losses more frequent: USM&C, WANA
food security hotspot[*] × yield quartile	412.666	21	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant ($P < 0.01$) test with combined lowest quartiles (YieldQ1-2) and highest quartiles (YieldQ3-4) yield levels: - Higher yield levels predominant: CHINA, NWE, USM&C - Lower yield levels predominant: SB&A, WANA
Analyses involving rice					
climate† × loss magnitude	174.709	15	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant ($P < 0.01$) test with combined (Very low – Low) and (Moderate – High) yield losses: - Moderate-High yield losses more frequent: TROPH - Very low-Low yield losses more frequent: EQUAT, SUBTR
yield quartile × loss magnitude	30.266	9	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant ($P < 0.01$) test with combined (Very low – Low) and (Moderate – High) yield losses: Loss magnitude associated with yield: - High-Moderate yield losses associated with low yields (YieldQ1) - Low-Very low yield losses associated with highest yield (YieldQ4)
yield quartile × climate†	29.874	15	0.012	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant ($P < 0.01$) test with combined lowest quartiles (YieldQ1-2) and highest quartiles (YieldQ3-4) yield levels: - Higher yield levels predominant: EQUAT, MEDIT, SUBTR
food security hotspot[*] × loss magnitude	32.642	15	0.005	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant ($P < 0.01$) test with combined (Very low – Low) and (Moderate – High) yield losses. Loss magnitude is associated with hotspots: - Moderate-High yield losses dominant in the IGP, SSA - Very low - Low yield losses dominant in SEA - Large range of yield losses in CHINA

food security hotspot[*] × yield quartile	203.457	15	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined lowest quartiles (YieldQ1-2) and highest quartiles (YieldQ3-4) yield levels: - Moderate to high yields (YieldQ3-Q4) dominant: CHINA, SB&A, SEA - Very low to low yields (YieldQ1-Q2) dominant: IGP, SSA
Analyses involving maize					
climate† × loss magnitude	58.708	21	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined (Very low – Low) and (Moderate – High) yield losses: - Moderate-High yield losses more frequent: MONSO - Very low-Low yield losses more frequent: CONT, SUBTR
yield quartile × loss magnitude	45.454	9	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined (Very low – Low) and (Moderate – High) yield losses: - Moderate-High yield losses more frequent at lowest yield levels (YieldQ1-2) - Very low-Low yield losses more frequent at highest yield levels (YieldQ3-4)
yield quartile × climate†	163.112	21	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined lowest quartiles (YieldQ1-2) and highest quartiles (YieldQ3-4) yield levels: - Higher yield levels predominant: EQUAT, MEDIT, SUBTR - Wide range of yield levels (YieldQ1-2 to YieldQ3-4): MONSO, TROPH
food security hotspot[*] × loss magnitude	47.409	21	0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined (Very low – Low) and (Moderate – High) yield losses: - Moderate-High yield losses more frequent: IGP, SSA - Very low-Low yield losses more frequent: USM&C
food security hotspot[*] × yield quartile	211.964	21	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined lowest quartiles (YieldQ1-2) and highest quartiles (YieldQ3-4) yield levels: - Lower yield levels predominant: IGP, SSA - Higher yield levels predominant: USM&C
Analyses involving potato					
climate† × loss magnitude	48.536	18	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined (Very low – Low) and (Moderate – High) yield losses: - Moderate-High yield losses more frequent: CONT, MONSO, TROPH
yield quartile × loss magnitude	35.795	9	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined (Very low – Low) and (Moderate – High) yield losses: - Moderate-High yield losses more frequent at lowest yield levels (YieldQ1-2) - Very low-Low yield losses more frequent at highest yield levels (YieldQ3-4)
yield quartile × climate†	159.071	18	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined lowest quartiles (YieldQ1-2) and highest quartiles (YieldQ3-4) yield levels: - Higher yield levels predominant: ARID, MEDIT, OCEAN, TROPH - Lower yield levels predominant: CONT, MONSO
food security hotspot[*] × loss magnitude	37.843	21	0.013	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined (Very low – Low) and (Moderate – High) yield losses: - Moderate-High yield losses more frequent: IGP, SSA
food security hotspot[*] × yield quartile	144.125	21	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined lowest quartiles (YieldQ1-2) and highest quartiles (YieldQ3-4) yield levels: - Higher yield levels predominant: NWE - Lower yield levels predominant: IGP
Analyses involving soybean					
climate† × loss magnitude	27.672	6	<0.001	Balanced expected values	Loss magnitude associated with climate: moderate and high yield losses more frequent under TROPH compared to SUBTR and CONT
yield quartile × loss magnitude	44.642	9	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined (Very low – Low) and (Moderate – High) yield losses: - Moderate-High yield losses more frequent at lowest yield level (YieldQ1) - Very low-Low yield losses more frequent at highest yield levels (YieldQ3-4)
yield quartile × climate†	67.258	6	<0.001	Balanced expected values	Yield levels associated with climates: Highest yield levels associated with CONT, SUBTR, lowest yield levels associated with TROPH
food security hotspot[*] × loss magnitude	35.559	12	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined (Very low – Low) and (Moderate – High) yield losses: - Moderate-High yield losses more frequent: SSA - Very low-Low yield losses more frequent: USM&C
food security hotspot[*] × yield quartile	134.995	12	<0.001	Over one-fifth of cells with expected values smaller than five	Valid association re-analysed with a significant (*P* < 0.01) test with combined lowest quartiles (YieldQ1-2) and highest quartiles (YieldQ3-4) yield levels: - Higher yield levels predominant: USM&C

	- Lower yield levels predominant: SB&A, SSA

* Food security hotspots: USM&C=US Midwest and Canada; SB&A=South Brazil, Paraguay, Uruguay and Argentina; NWE=Northwest Europe; WANA=West Asia and North Africa; SSA=Sub-Saharan Africa; CHINA=Mainland China; IGP=Indo-Gangetic Plain; SEA=Southeast Asia.

† Climate: ARID=Arid; CONT=Humid continental; EQUAT=Equatorial; MEDIT= Mediterranean; MONSO= Monsoon; OCEAN=Oceanic; SUBTR=Subtropics; TROPH=Humid tropics.

Supplementary Table 5. Interpretations of correspondence analyses. Main statistical results and their interpretation.

Axes and variables	Statistical results	Interpretation*, [57,59,62]
Overall analysis†: crop and loss magnitude (supplemental: food security hotspot, and "key pests")		
Inertia accounted for by axes	Dimension 1: 17.09% Dimension 2: 16.15% Accumulated dimensions 1 and 2: 33.24%	An acceptable fraction of the information contained in the [crop x loss magnitude] contingency table is accounted for by the two first dimensions
Active variable 1: crop	Contribution to axes: Fairly large accumulated contributions from Maize (18%), Potato (35%), Rice (32%), and Soybean (13%), to the two first dimensions, but very small contribution of Wheat (0.1%). Contribution of axes to class description: Acceptable representations (accumulated squared cosines) of Maize (0.2), Potato (0.5), Rice (0.5), Soybean (0.2), but not of Wheat (less than 0.01) on these axes.	The two first dimensions provide an acceptable representation of crop classes, except Wheat.
Active variable 2: loss magnitude	Contribution to axes: Fairly large accumulated contributions of classes to the two first dimensions: 1-Very low (36.18%), 2- Low (9.18%), 3-Moderate (14.27%), and 4-High (40.37%). Contribution of axes to class description: Fairly large representation of classes on these axes: 1-Very low (0.48), 2- Low (0.17), 3-Moderate (0.24), and 4-High (0.56).	The two first dimensions provide an good representation of loss magnitude classes
Supplemental variable 1: food security hotspot‖	Contribution of axes to class description: Small squared cosines on dimensions 1 and 2, but larger than other dimensions. Squared cosines for SEA (axes 1 and 2) and for USM&C (axis 2) are larger.	Some associations may be interpreted as trends only.
Supplemental variable 2: "key pests"	Contribution of axes to class description: Very small squared cosines (smaller than 0.05). Squared cosines associated with Brown rot (dimension 1) and with Soybean rust (on dimension 2) are higher than for other key pest categories.	Some associations may be interpreted as trends only.
Wheat‡,§: loss magnitude, climate, and yield quartile (supplemental: food security hotspot and "key pests")		
Inertia accounted for by axes	Dimension 1: 14.32% Dimension 2: 13.18% Accumulated dimensions 1 and 2: 27.50%	An acceptable fraction of the information contained in the [loss magnitude x yield x climate] contingency table for Wheat records is accounted for by the two first dimensions
Active variable 1: climate¶	Contribution to axes: Large accumulated contributions from OCEAN (35%) and TROPH (18%), and fairly large contribution of CONT (10%), to the two first dimensions. Contribution of axes to class description: Acceptable representations (accumulated squared cosines) of CONT (0.2), MEDIT (0.1), MONSO (0.1), OCEAN (0.7), and TROPH (0.3) on these axes.	The two first dimensions account for, and provide an acceptable representation of, most climates for Wheat (except SUBTR).
Active variable 2: loss magnitude	Contribution to axes: Large accumulated contributions from 2-Low (13%) and 4-High (21%), fair contribution of 3-Moderate (6%), to the two first dimensions. Contribution of axes to class description: Acceptable representations (accumulated squared cosines) of 2-Low (0.3), 3-Moderate (0.1), and 4-High (0.4) on these axes.	The two first dimensions account for, and properly represent, Loss magnitude classes, except for 1-Very low losses.
Active variable 3: yield quartiles	Contribution to axes: Large accumulated contributions YieldQ1 (12%), YieldQ3 (24%), and YieldQ4 (35%), and fair contribution of YieldQ2 (11%), to the two first dimensions. Contribution of axes to class description: Good representations (accumulated squared cosines) of YieldQ1 (0.2), YieldQ2 (0.2), YieldQ3 (0.6), and YieldQ4 (0.8) on these axes.	The two first dimensions account for, and properly represent yield quartiles.
Supplemental variable 1: food security hotspot‖	Contribution of axes to class description:	NWE and USM&C are well represented by the two first dimensions.

	NWE (first dimension), and USM&C (dimension 2) are well accounted for. CHINA, IGP (dimension 1) and SB&A, SSA (dimension 2) are represented to some degree.	
Supplemental variable 2: “key pests”	Contribution of axes to class description: Squared cosine values for stem rust, stripe rust, wheat blast are small on all first five dimensions. Squared cosine value for wheat blast is higher on dimension 2.	Only wheat blast is reasonably accounted for by the two first directions.
Rice[‡]: loss magnitude, climate, and yield quartile (supplemental: food security hotspot and “key pests”)		
Inertia accounted for by axes	Dimension 1: 16.64% Dimension 2: 13.59% Accumulated dimensions 1 and 2: 30.23%	An acceptable fraction of the information contained in the [loss magnitude x yield x climate] contingency table for Rice records is accounted for by the two first dimensions
Active variable 1: climate[¶]	Contribution to axes: Large contributions from MEDIT and SUBTR to dimension 1, and from TROPH to dimension 2. Contribution of axes to class description: Acceptable (accumulated) representations (squared cosines) of CONT, MEDIT, MONSO, OCEAN and TROPH on these axes.	The two first dimensions account for, and provide an acceptable representation of, most climates for Rice (except ARID).
Active variable 2: loss magnitude	Contribution to axes: All levels of loss magnitude have some contribution to the two first dimensions. However, only 4-High has a large contribution. Contribution of axes to class description: Acceptable (accumulated) representations (squared cosines) 2-Low, 3-Moderate, and 4-High, but not of 1-Very low, on these axes.	The two first dimensions account for, and properly represent, loss magnitude classes, except for 1-Very low losses.
Active variable 3: yield quartile	Contribution to axes: Large contributions of YieldQ1, YieldQ3, and YieldQ4 to the two first dimensions. Contribution of axes to class description: Good representations (squared cosines) of all four yield quartiles on these axes.	The two first dimensions account for, and properly represent yield quartiles.
Supplemental variable 1: food security hotspot[‖]	Contribution of axes to class description: CHINA, IGP are represented on dimension 1, and SEA on dimension 2. SSA is represented on both dimensions.	CHINA, IGP, SEA, and (especially) SSA, are well represented by the two first dimensions.
Supplemental variable 2: “key pests”	Contribution of axes to class description: Squared cosine values for Bacterial panicle blight and False smut are small on all first five dimensions.	Key diseases and pests are not well accounted for by the two first directions. Direction 1 provides some description of Bacterial panicle blight.
Maize[‡,§]: loss magnitude, climate, and yield quartile (supplemental: food security hotspot and “key pests”)		
Inertia accounted for by axes	Dimension 1: 17.30% Dimension 2: 13.29% Accumulated dimensions 1 and 2: 30.59%	An acceptable fraction of the information contained in the [loss magnitude x yield x climate] contingency table for Maize records is accounted for by the two first dimensions
Active variable 1: climate[¶]	Contribution to axes: Fairly large contributions from CONT, MONSO, TROPH (dimension 1), CONT, MONSO, SUBTR, TROPH (dimension2) to the two first dimensions. Contribution of axes to class description: Acceptable representations (squared cosines) of climates on these axes, except for EQUAT.	The two first dimensions account for, and provide an acceptable representation of, most climates for Maize (except EQUAT).
Active variable 2: loss magnitude	Contribution to axes: Large contributions from 1-Very low and 4-Very high to dimension 1; large contributions of 2-Low and 3-Moderate to dimension 2. Contribution of axes to class description: Good representations (squared cosines) of all 4 classes on these axes.	The two first dimensions account for, and properly represent, loss magnitude classes.
Active variable 3: yield quartiles	Contribution to axes: Fairly large accumulated contributions of each quartile to the two first dimensions. Contribution of axes to class description: Good representations (squared cosines) of all quartiles on these axes.	The two first dimensions account for, and properly represent yield quartiles.
Supplemental variable 1: food security hotspot[‖]	Contribution of axes to class description: Fair representation of CHINA (dim. 1), IGP (dim. 1 and 2), NWE (dim. 1 and 2), SSA (dim. 1 and 2) and USM&C (dim. 1 and 2). Poor representation of SB&A, SEA.	Hotspots are well represented except SB&A and SEA.

Supplemental variable 2: "key pests"	Contribution of axes to class description: Squared cosine values for Maize key pests and diseases are small on all first five dimensions. Squared cosine values on dimension 1 are however higher compared to all other dimensions.	Dimension 1 provides some accounting of Striga, Maize lethal necrosis, and fall armyworm.
Potato[‡,§]: loss magnitude, climate, and yield quartile (supplemental: food security hotspot and "key pests")		
Inertia accounted for by axes	Dimension 1: 16.60% Dimension 2: 14.81% Accumulated dimensions 1 and 2: 31.41%	An acceptable fraction of the information contained in the [loss magnitude x yield x climate] contingency table for Potato records is accounted for by the two first dimensions
Active variable 1: climate[¶]	Contribution to axes: Fairly large contributions from MONSO, OCEAN (dimension 1), CONT, OCEAN, TROPH (dimension2) to the two first dimensions. Contribution of axes to class description: Acceptable representations (squared cosines) of Climates on these axes, except for ARID and SUBTR.	The two first dimensions account for, and provide an acceptable representation of, most climates for Potato (except ARID and SUBTR).
Active variable 2: loss magnitude	Contribution to axes: fairly large contributions from 1-Very low and 4-Very high to dimension 1. Contribution of axes to class description: Good representations (squared cosines) of 1-Very low, 2-Low, and 4-High on direction 1 only.	Only direction 1 accounts for, and properly represent, loss magnitude classes, except 3-Moderate.
Active variable 3: yield quartiles	Contribution to axes: Fairly large accumulated contributions of each quartile to the two first dimensions. Contribution of axes to class description: Good representations (squared cosines) of all quartiles on these axes.	The two first dimensions account for, and properly represent yield quartiles.
Supplemental variable 1: food security hotspot[‖]	Contribution of axes to class description: Fair representation of IGP (dim. 1), NWE (dim. 1 and 2), and SSA (dim. 2). Poor representation of CHINA, SB&A, USM&C, WANA.	Only some hotspots well represented: IGP, NWE, SSA.
Supplemental variable 2: "key pests"	Contribution of axes to class description: Fair representation (squared cosine) of brown rot on dimension 2.	Dimension 2 provides some accounting of Brown rot.
Soybean[‡,§]: loss magnitude, climate, and yield quartile (supplemental: food security hotspot and "key pests")		
Inertia accounted for by axes	Dimension 1: 27.11% Dimension 2: 15.72% Accumulated dimensions 1 and 2: 42.83%	An acceptable fraction of the information contained in the [loss magnitude x yield x climate] contingency table for Soybean records is accounted for by the two first dimensions
Active variable 1: climate[¶]	Contribution to axes: Fairly large contributions from CONT and TROPH to dimension1. Contribution of axes to class description: Good representations (squared cosines) of Climates, especially on dimension 1.	The two first dimensions account for, and provide an acceptable representation of, most climates for Potato. (Note: only 3 climates reported).
Active variable 2: loss magnitude	Contribution to axes: fairly large contributions from 1-Very low, 3-Moderate, and 4-Very high to dimension 1; and from 1-Very low and 4-Very high to dimension 2. Contribution of axes to class description: fair accumulated representations (squared cosines) of all classes along both directions.	Directions 1 and 2 account for, and properly represent classes of loss magnitude.
Active variable 3: yield quartiles	Contribution to axes: Fairly large accumulated contributions of each quartile to the two first dimensions. Contribution of axes to class description: Good representations (squared cosines) of all quartiles on these axes.	The two first dimensions account for, and properly represent yield quartiles.
Supplemental variable 1: food security hotspot[‖]	Contribution of axes to class description: Fair representation of SSA (dim. 1 and 2) and USM&C (dim. 1). CHINA and SB&A poorly represented on these axes.	Only some hotspots well represented: SSA and USM&C. CHINA and SB&A poorly represented.
Supplemental variable 2: "key pests"	Contribution of axes to class description: Fair representation (squared cosine) of soybean rust on both dimensions.	Dimensions 1 and 2 properly represent soybean rust.

* Interpretation of correspondence analyses is based on a number of criteria, which are summarised here. First is the amount of inertia accounted by axes. A large accumulated inertia accounted for by the considered axes implies a proportionally large representation of the information contained in the original contingency table(s). In

the following analyses, the two first axes were deemed to represent a satisfactory fraction of this information. Second is the inertia accounted by each of the classes (categories) representing the modalities of a given variable. The larger the inertia of an individual class, the larger its importance, which increases with the squared distance of this class from the origin of factorial axes. A quantitative measure is provided by the (relative, on a 0-100% scale) contribution of each classes of a given variable in accounting for the inertia of each axis, and, reciprocally, by the (relative, on a 0-1 scale) representation of each class by a given axis (labelled Squared-Cosine in outputs). Third is the proximity between two classes of the variables considered. Proximity of two classes on the graph suggests association. However, the significance of such association is proportional to the (squared) distance to the origin of axes. Two graphically proximate different classes, which are at a large distance from the origin of axes may indicate very strong, significant associations; however, proximity of two classes on, or in close proximity to the origin of the factorial axes has little or no significance. These interpretations pertaining to associations can be specifically tested with chi-square tests.

† Overall correspondence analysis: Active variables are crop (five classes: Wheat, Rice, Maize, Potato, Soybean) and loss magnitude (four classes: 1-Very low, 2-Low, 3-Moderate, and 4-High); supplementary variables are food security hotspot and emerging pathogens and pests, P&P or “key pests”.

‡ Crop specific analysis: For each crop, active variables are loss magnitude, climate, and yield quartiles; supplementary variables are food security hotspot and emerging pathogens and pests, P&P or “key pests”.

§ Some climate categories were represented only by a few individuals (less than 4% of the population) in wheat, maize, potato, and soybean. Individuals from these climate categories were removed prior to analyses in order to provide robust results: 4 individuals from EQUAT were removed for wheat; 1 individual removed from EQUAT for maize; 4 individuals from EQUAT were removed for potato; 8 individuals from ARID (1), EQUAT (2), MEDIT (1), and MONSO (4) for soybean.

‖ Food security hotspots: USM&C=US Midwest and Canada; SB&A=South Brazil, Paraguay, Uruguay and Argentina; NWE=Northwest Europe; WANA=West Asia and North Africa; SSA=Sub-Saharan Africa; CHINA=Mainland China; IGP=Indo-Gangetic Plain; SEA=Southeast Asia.

¶ Climate: ARID=Arid; CONT=Humid continental; EQUAT=Equatorial; MEDIT= Mediterranean; MONSO= Monsoon; OCEAN=Oceanic; SUBTR=Subtropics; TROPH=Humid tropics.

Supplementary Table 6. Outputs of correspondence analyses.

Overall correspondence analysis						
Active variables: Crop and loss magnitude						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	Maize	-0.5328	1.0967	-0.1603	1.8748	-0.1518
	Potato	1.6612	-0.2005	0.483	0.5419	0.4574
	Rice	-0.6885	-0.9965	0.4646	0.2463	0.44
	Soybean	-0.2724	1.0665	1.0881	-1.5904	1.0304
	Wheat	0.0648	-0.0265	-0.9281	-0.6257	-0.8789
	1-Very low	-0.7211	1.4728	-0.6487	0	0.6143
	2-Low	-0.4869	-0.2344	0.7934	0	-0.7513
	3-Moderate	0.154	-0.6746	-0.7671	0	0.7264
	4-High	1.758	0.6495	0.4656	0	-0.4409
Contributions to axes		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	Maize	3.312	14.8492	0.3399	49.0444	0.3399
	Potato	35.9285	0.5539	3.4453	4.5734	3.4453
	Rice	9.8598	21.8568	5.092	1.5091	5.092
	Soybean	0.7839	12.7198	14.1925	31.9686	14.1925
	Wheat	0.1158	0.0204	26.9303	12.9045	26.9303
	1-Very low	6.682	29.4996	6.1339	0	6.1339
	2-Low	7.3742	1.8084	22.2128	0	22.2128
	3-Moderate	0.6697	13.5974	18.8472	0	18.8472
	4-High	35.2741	5.0947	2.8061	0	2.8061
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	Maize	0.046	0.195	0.0042	0.57	0.0037
	Potato	0.509	0.0074	0.043	0.0542	0.0386
	Rice	0.157	0.3288	0.0715	0.0201	0.0641
	Soybean	0.0107	0.1646	0.1713	0.3659	0.1536
	Wheat	0.0021	3.00E-04	0.4236	0.1925	0.3799
	1-Very low	0.0944	0.3939	0.0764	0	0.0685
	2-Low	0.1405	0.0325	0.373	0	0.3345
	3-Moderate	0.0121	0.232	0.3001	0	0.2691
	4-High	0.4886	0.0667	0.0343	0	0.0307
Supplementary variable: Food security hotspot*						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CHINA	-0.2459	-0.4126	-0.4017	-0.0099	-0.2086
	IGP	0.1579	-0.3463	-0.0046	0.2395	-0.1486
	NWE	0.0981	-0.0037	-0.7672	-0.2271	-0.4695
	SB&A	0.1503	0.5544	0.2301	-0.6357	0.1142
	SEA	-0.7576	-0.8814	0.5401	0.2441	0.3602
	SSA	0.4719	0.3206	0.1831	0.4284	0.0808
	USM&C	-0.4687	0.8195	0.2231	-0.0424	-0.0699
	WANA	0.356	0.4222	-0.7607	-0.3143	-0.302
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CHINA	0.0029	0.0081	0.0077	0	0.0021
	IGP	0.0027	0.0132	0	0.0063	0.0024
	NWE	9.00E-04	0	0.0532	0.0047	0.0199

SB&A	0.0014	0.0192	0.0033	0.0252	8.00E-04
SEA	0.061	0.0826	0.031	0.0063	0.0138
SSA	0.0204	0.0094	0.0031	0.0168	6.00E-04
USM&C	0.0223	0.0681	0.005	2.00E-04	5.00E-04
WANA	0.004	0.0056	0.0181	0.0031	0.0029
Supplementary variable: Emerging pathogens and pests, P&P or "key pests"					
Coordinates	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
Bacterial panicle blight	-0.485	-1.1443	0.5144	0.2463	0.3874
Brown rot	2.4566	0.1531	0.7924	0.5419	0.1307
fall armyworm	0.5774	1.1545	-0.1001	1.8748	-0.2153
False smut	-0.6613	-1.3228	0.3051	0.2463	0.6084
maize lethal necrosis	0.3539	0.9593	-0.295	1.8748	-0.0095
soybean rust	0.3019	1.1223	1.1183	-1.5904	0.9986
stem rust	0.1273	0.2199	-1.0711	-0.6257	-0.728
striga	0.3539	0.9593	-0.295	1.8748	-0.0095
stripe rust	0.0386	-0.2404	-0.6987	-0.6257	-1.1212
wheat blast	1.0771	0.1607	-0.8284	-0.6257	-0.9843
Squared cosines	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
Bacterial panicle blight	0.0017	0.0093	0.0019	4.00E-04	0.0011
Brown rot	0.0492	2.00E-04	0.0051	0.0024	1.00E-04
fall armyworm	0.001	0.0041	0	0.0107	1.00E-04
False smut	0.0022	0.0089	5.00E-04	3.00E-04	0.0019
maize lethal necrosis	3.00E-04	0.0019	2.00E-04	0.0071	0
soybean rust	0.0029	0.0394	0.0391	0.0791	0.0312
stem rust	4.00E-04	0.001	0.0249	0.0085	0.0115
striga	3.00E-04	0.0019	2.00E-04	0.0071	0
stripe rust	1.00E-04	0.0027	0.0227	0.0182	0.0585
wheat blast	0.0071	2.00E-04	0.0042	0.0024	0.0059
Wheat correspondence analysis					
Active variables: Climate†, loss magnitude and yield quartile					
Coordinates	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
ARID	0.3566	0.1679	0.9815	1.9853	0.7586
CONT	0.5873	-0.7106	-0.4641	-0.0539	-1.1318
MEDIT	0.5121	0.3836	1.3365	-1.2024	0.0864
MONSO	0.8479	-0.5659	-0.9761	-0.7462	2.0027
OCEAN	-1.7152	-0.5252	0.1181	0.1408	0.1941
SUBTR	0.1995	0.3072	-0.6345	0.2913	-0.3907
TROPH	-0.2282	1.9595	-0.6486	-0.0907	0.2871
1-Very low	0.4238	-0.2764	0.7128	1.2443	-0.9023
2-Low	0.2778	-0.7311	-0.1677	-0.0752	0.5253
3-Moderate	-0.4997	0.2194	0.0463	-0.7192	-0.3988
4-High	0.1726	1.5634	-0.569	0.6743	0.8753
YieldQ1	0.3459	1.0948	1.6057	-0.1687	-0.0011
YieldQ2	0.4926	0.625	-1.0343	-0.0471	-0.3946
YieldQ3	0.6567	-0.8953	0.1823	-0.045	0.2613
YieldQ4	-1.5131	-0.1751	-0.0698	0.2004	0.0889
Contributions to axes	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5

		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	ARID	0.7125	0.1717	6.4271	31.4382	4.9752
	CONT	3.9279	6.2492	2.9205	0.0471	22.5049
	MEDIT	2.5593	1.5607	20.7563	20.0894	0.1124
	MONSO	3.2488	1.5726	5.1257	3.5816	27.9646
	OCEAN	32.4335	3.3048	0.1831	0.3113	0.6409
	SUBTR	0.4676	1.2046	5.6308	1.4191	2.7666
	TROPH	0.2166	17.3464	2.0822	0.0487	0.5288
	1-Very low	1.6877	0.7805	5.6852	20.7175	11.8059
	2-Low	1.5066	11.3401	0.6534	0.1571	8.3126
	3-Moderate	5.3697	1.1252	0.0549	15.8362	5.2778
	4-High	0.2314	20.6453	2.9963	5.031	9.1869
	YieldQ1	1.0381	11.3004	26.6309	0.3516	0
	YieldQ2	3.8155	6.6753	20.0289	0.0496	3.7772
	YieldQ3	8.0278	16.2175	0.7366	0.0537	1.9608
	YieldQ4	34.7573	0.5058	0.0881	0.8679	0.1853
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	ARID	0.0135	0.003	0.1026	0.4199	0.0613
	CONT	0.0839	0.1228	0.0524	7.00E-04	0.3116
	MEDIT	0.0528	0.0296	0.3599	0.2913	0.0015
	MONSO	0.0605	0.027	0.0802	0.0469	0.3376
	OCEAN	0.6876	0.0645	0.0033	0.0046	0.0088
	SUBTR	0.0101	0.0239	0.1018	0.0215	0.0386
	TROPH	0.004	0.2954	0.0324	6.00E-04	0.0063
	1-Very low	0.0346	0.0147	0.0978	0.2982	0.1568
	2-Low	0.039	0.2698	0.0142	0.0029	0.1393
	3-Moderate	0.1464	0.0282	0.0013	0.3032	0.0932
	4-High	0.0046	0.3767	0.0499	0.0701	0.1181
	YieldQ1	0.021	0.21	0.4516	0.005	0
	YieldQ2	0.0898	0.1446	0.3961	8.00E-04	0.0576
	YieldQ3	0.2028	0.377	0.0156	0.001	0.0321
	YieldQ4	0.808	0.0108	0.0017	0.0142	0.0028
Supplementary variable: Food security hotspot*						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CHINA	-0.8391	-0.1314	-0.249	0.1909	-0.4264
	IGP	0.7734	-0.403	-0.667	-0.1575	1.6387
	NWE	-1.4547	-0.5451	0.1341	0.0537	0.0908
	SB&A	0.4095	1.1423	-1.3584	0.387	-0.3017
	SSA	0.0404	1.115	-0.647	0.3888	0.6097
	USM&C	0.8125	-1.288	-0.1548	0.0243	-0.5533
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CHINA	0.0542	0.0013	0.0048	0.0028	0.014
	IGP	0.057	0.0155	0.0424	0.0024	0.2557
	NWE	0.5046	0.0709	0.0043	7.00E-04	0.002
	SB&A	0.0111	0.0864	0.1222	0.0099	0.006
	SSA	1.00E-04	0.0523	0.0176	0.0064	0.0156
	USM&C	0.0556	0.1396	0.002	0	0.0258
Supplementary variable: Emerging pathogens and pests, P&P or "key pests"						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5

	stem rust	0.423	0.3644	-0.4425	-0.0404	-0.2431
	stripe rust	-0.0264	-0.2645	-0.0958	-0.2254	0.4842
	wheat blast	0.2728	1.755	-1.4333	-0.0626	0.4183
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	stem rust	0.0125	0.0093	0.0137	1.00E-04	0.0041
	stripe rust	1.00E-04	0.0111	0.0015	0.008	0.0371
	wheat blast	0.0012	0.0486	0.0324	1.00E-04	0.0028
Rice correspondence analysis						
Active variables: Climate†, loss magnitude and yield quartile						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	ARID	-1.2063	1.4038	-1.7456	1.77	2.5375
	EQUAT	-0.5564	-0.8836	1.7844	0.6829	0.6087
	MEDIT	1.9792	0.6461	0.1846	2.1167	-0.0408
	MONSO	-0.2145	-0.3997	-0.4168	-0.1441	-0.3763
	SUBTR	1.646	0.6345	0.1985	-0.6291	0.421
	TROPH	-0.9667	1.8233	0.9577	-0.9603	-0.0668
	1-Very low	1.1384	0.0988	-0.2277	-0.1725	-1.3904
	2-Low	0.0017	-0.4025	0.3421	0.6177	0.0798
	3-Moderate	-0.1353	0.1686	-0.4105	-0.7795	0.6783
	4-High	-1.3848	1.6334	0.3843	0.4616	-1.7569
	YieldQ1	-1.1259	1.6467	0.1849	0.4823	-0.1942
	YieldQ2	-0.4393	-0.5446	-1.2093	0.2836	-0.1449
	YieldQ3	-0.3449	-0.6065	0.7536	-0.4732	0.0716
	YieldQ4	1.3921	0.4542	0.0538	0.1046	0.1368
Contributions to axes		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	ARID	3.2317	5.3588	9.1504	11.7603	25.3199
	EQUAT	1.8565	5.7322	25.8154	4.7266	3.9337
	MEDIT	10.4392	1.3622	0.1228	20.1831	0.0078
	MONSO	1.4617	6.2128	7.459	1.115	7.9623
	SUBTR	19.855	3.612	0.3904	4.9034	2.2999
	TROPH	4.3585	18.9827	5.7837	7.2703	0.0369
	1-Very low	8.6333	0.0796	0.4671	0.335	22.8058
	2-Low	1.00E-04	4.8456	3.8655	15.7548	0.2755
	3-Moderate	0.366	0.6958	4.5548	20.5301	16.2806
	4-High	6.8141	11.6083	0.7096	1.2799	19.4204
	YieldQ1	9.2905	24.331	0.3389	2.8812	0.4896
	YieldQ2	2.6149	4.9187	26.7875	1.8416	0.5035
	YieldQ3	2.2449	8.502	14.4969	7.1439	0.1713
	YieldQ4	28.8336	3.7582	0.0583	0.275	0.4927
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	ARID	0.0135	0.003	0.1026	0.4199	0.0613
	CONT	0.0839	0.1228	0.0524	7.00E-04	0.3116
	MEDIT	0.0528	0.0296	0.3599	0.2913	0.0015
	MONSO	0.0605	0.027	0.0802	0.0469	0.3376
	OCEAN	0.6876	0.0645	0.0033	0.0046	0.0088
	SUBTR	0.0101	0.0239	0.1018	0.0215	0.0386
	TROPH	0.004	0.2954	0.0324	6.00E-04	0.0063
	1-Very low	0.0346	0.0147	0.0978	0.2982	0.1568

	2-Low	0.039	0.2698	0.0142	0.0029	0.1393
	3-Moderate	0.1464	0.0282	0.0013	0.3032	0.0932
	4-High	0.0046	0.3767	0.0499	0.0701	0.1181
	YieldQ1	0.021	0.21	0.4516	0.005	0
	YieldQ2	0.0898	0.1446	0.3961	8.00E-04	0.0576
	YieldQ3	0.2028	0.377	0.0156	0.001	0.0321
	YieldQ4	0.808	0.0108	0.0017	0.0142	0.0028
Supplementary variable: Food security hotspot[*]						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CHINA	1.6739	0.6611	0.1501	-0.5657	0.7745
	IGP	-0.5768	-0.1237	-1.0116	0.315	0.3579
	SB&A	0.9916	0.7665	0.3779	-1.1441	0.0258
	SEA	-0.1772	-0.3642	0.3135	-0.1625	-0.2534
	SSA	-1.2942	2.1601	0.9937	-0.5978	-0.3452
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CHINA	0.1563	0.0244	0.0013	0.0179	0.0335
	IGP	0.0589	0.0027	0.1812	0.0176	0.0227
	SB&A	0.0246	0.0147	0.0036	0.0327	0
	SEA	0.0191	0.0806	0.0598	0.016	0.039
	SSA	0.0935	0.2603	0.0551	0.0199	0.0066
Supplementary variable: Emerging pathogens and pests, P&P or "key pests"						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	Bacterial panicle blight	-0.7796	0.6307	0.6513	0.2116	0.5918
	False smut	0.0022	-0.3997	-1.0046	-0.1976	0.1291
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	Bacterial panicle blight	0.0178	0.0117	0.0124	0.0013	0.0103
	False smut	0	0.0033	0.0209	8.00E-04	3.00E-04
Maize correspondence analysis						
Active variables: Climate[†], loss magnitude and yield quartile						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	ARID	0.7118	-0.3952	0.0852	1.6524	-0.2998
	CONT	-1.0777	0.7275	-0.5937	0.1736	0.6119
	EQUAT	1.2086	0.2296	3.2876	3.2532	6.6471
	MEDIT	-1.0432	0.7672	-0.5699	0.2809	-0.2165
	MONSO	1.1267	-1.1121	-1.7845	-0.7137	0.8018
	OCEAN	-1.1031	-1.1922	1.2699	-0.7694	1.4748
	SUBTR	-0.6008	-0.8852	0.4114	-0.325	-1.0062
	TROPH	0.9249	0.8871	0.5951	-0.5062	-0.2437
	1-Very low	-1.0331	-0.4273	0.119	-0.502	0.4516
	2-Low	-0.1585	0.7065	-0.1548	0.1979	-0.5953
	3-Moderate	0.4782	-0.6773	0.2081	0.8444	0.2819
	4-High	1.4458	0.167	-0.229	-1.6446	0.3623
	YieldQ1	1.0316	0.8443	1.2311	-0.0696	0.2606
	YieldQ2	0.8451	-0.5677	-0.7945	0.1131	-0.2067
	YieldQ3	-0.9518	1.5253	-1.0722	0.276	0.4617
	YieldQ4	-0.9016	-0.5304	0.4505	-0.1659	-0.1332
Contributions to axes		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	ARID	3.1011	1.2446	0.0695	30.3614	1.1445

	CONT	9.7283	5.7718	4.6189	0.4584	6.5227
	EQUAT	0.4706	0.0221	5.4476	6.1938	29.6013
	MEDIT	3.1559	2.2223	1.473	0.4157	0.2827
	MONSO	5.7262	7.2632	22.4709	4.1737	6.0302
	OCEAN	2.7442	4.1738	5.6895	2.4251	10.2008
	SUBTR	3.2565	9.204	2.3891	1.7309	18.9926
	TROPH	9.3708	11.2233	6.068	5.0993	1.3532
	1-Very low	11.0032	2.4511	0.2285	4.7187	4.3723
	2-Low	0.4211	10.8893	0.6284	1.1918	12.3481
	3-Moderate	2.7991	7.313	0.8291	15.8558	2.0225
	4-High	10.7751	0.1872	0.4227	25.3273	1.4069
	YieldQ1	8.9148	7.775	19.8602	0.0737	1.183
	YieldQ2	9.8943	5.8135	13.6807	0.3218	1.2313
	YieldQ3	5.5453	18.5442	11.0084	0.8468	2.7139
	YieldQ4	13.0934	5.9016	5.1155	0.8056	0.5942
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	ARID	0.0809	0.0249	0.0012	0.4359	0.0144
	CONT	0.2696	0.1228	0.0818	0.007	0.0869
	EQUAT	0.0107	4.00E-04	0.0789	0.0772	0.3225
	MEDIT	0.0759	0.0411	0.0227	0.0055	0.0033
	MONSO	0.1433	0.1396	0.3595	0.0575	0.0726
	OCEAN	0.065	0.076	0.0862	0.0316	0.1162
	SUBTR	0.0919	0.1995	0.0431	0.0269	0.2577
	TROPH	0.2797	0.2573	0.1158	0.0838	0.0194
	1-Very low	0.3222	0.0551	0.0043	0.0761	0.0616
	2-Low	0.0152	0.3018	0.0145	0.0237	0.2143
	3-Moderate	0.0869	0.1743	0.0164	0.2709	0.0302
	4-High	0.2741	0.0037	0.0069	0.3547	0.0172
	YieldQ1	0.2471	0.1655	0.3518	0.0011	0.0158
	YieldQ2	0.3233	0.1459	0.2857	0.0058	0.0193
	YieldQ3	0.1446	0.3715	0.1835	0.0122	0.034
	YieldQ4	0.4618	0.1599	0.1153	0.0156	0.0101
Supplementary variable: Food security hotspot*						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CHINA	0.0191	-0.6933	-0.4105	-0.1084	-1.0854
	IGP	1.0962	-0.8129	-1.3653	0.0122	0.2418
	NWE	-1.1031	-1.1922	1.2699	-0.7694	1.4748
	SB&A	0.0791	0.3918	-0.3416	-0.2739	-0.5663
	SEA	0.4174	-1.2198	-1.711	-0.8905	0.9677
	SSA	1.0447	0.7866	1.1327	-0.1104	0.2335
	USM&C	-1.0619	0.4834	-0.4215	0.0797	0.4403
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CHINA	0	0.0218	0.0077	5.00E-04	0.0536
	IGP	0.1357	0.0746	0.2105	0	0.0066
	NWE	0.065	0.076	0.0862	0.0316	0.1162
	SB&A	3.00E-04	0.007	0.0053	0.0034	0.0146
	SEA	0.0013	0.0109	0.0214	0.0058	0.0068
	SSA	0.2778	0.1575	0.3266	0.0031	0.0139

	USM&C	0.3132	0.0649	0.0493	0.0018	0.0539
Supplementary variable: Emerging pathogens and pests, P&P or "key pests"						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	fall armyworm	0.8567	0.3288	0.9887	-1.1004	-0.0306
	maize lethal necrosis	1.2561	0.4459	0.5584	-0.7145	0.0973
	striga	1.2976	0.8546	1.2629	-0.7882	0.3134
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	fall armyworm	0.0163	0.0024	0.0217	0.0269	0
	maize lethal necrosis	0.0232	0.0029	0.0046	0.0075	1.00E-04
	striga	0.0248	0.0107	0.0235	0.0091	0.0014
Potato correspondence analysis						
Active variables: Climate†, loss magnitude and yield quartile						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	ARID	0.4362	-0.0085	-0.3212	0.2665	1.1148
	CONT	-0.4467	-0.6529	-0.505	-0.023	-1.1028
	MEDIT	0.6949	0.4959	-1.3869	0.8234	0.6054
	MONSO	-1.7143	-0.6657	0.6282	0.1818	1.3411
	OCEAN	1.4238	-0.9256	1.2338	0.0715	-0.2193
	SUBTR	-0.1052	0.0785	-0.1223	-2.0207	0.2289
	TROPH	-0.1336	1.8441	0.784	0.1837	-0.3681
	1-Very low	1.1821	-0.7002	0.3527	1.2988	1.1057
	2-Low	0.5146	0.1448	0.0905	-1.0868	-0.159
	3-Moderate	0.1399	0.069	-0.6562	0.5865	-0.4369
	4-High	-1.1512	-0.0472	0.6956	0.0423	0.4481
	YieldQ1	-0.7748	2.3714	2.6275	1.8591	-1.9002
	YieldQ2	-0.8144	-0.4968	-0.2643	0.0036	-0.1062
	YieldQ3	0.3091	1.3515	-0.4667	-0.3117	0.4752
	YieldQ4	1.1955	-0.7021	0.5527	0.0498	-0.0216
Contributions to axes		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	ARID	1.1461	5.00E-04	0.9124	0.6882	13.0343
	CONT	2.6047	6.2368	4.8854	0.0112	27.6361
	MEDIT	3.071	1.7527	17.9494	6.9334	4.0577
	MONSO	15.7393	2.6593	3.1011	0.2846	16.7662
	OCEAN	13.5706	6.4267	14.9527	0.055	0.5606
	SUBTR	0.0519	0.0324	0.1029	30.768	0.4272
	TROPH	0.1434	30.6139	7.2447	0.4358	1.8948
	1-Very low	5.6124	2.2069	0.7334	10.8945	8.548
	2-Low	3.9891	0.354	0.1811	28.6052	0.6627
	3-Moderate	0.3536	0.0964	11.4205	9.997	6.0045
	4-High	17.2989	0.0326	9.2683	0.0375	4.5627
	YieldQ1	1.0046	10.547	16.9544	9.3009	10.5191
	YieldQ2	15.097	6.2947	2.3339	5.00E-04	0.4466
	YieldQ3	1.1831	25.3508	3.9587	1.9349	4.8686
	YieldQ4	19.1344	7.3953	6.001	0.0533	0.0108
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	ARID	0.0259	0	0.0141	0.0097	0.1695
	CONT	0.0701	0.1498	0.0896	2.00E-04	0.4273
	MEDIT	0.07	0.0357	0.279	0.0983	0.0532

		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	MONSO	0.3509	0.0529	0.0471	0.0039	0.2147
	OCEAN	0.3119	0.1318	0.2342	8.00E-04	0.0074
	SUBTR	0.0011	6.00E-04	0.0015	0.4203	0.0054
	TROPH	0.0034	0.6478	0.1171	0.0064	0.0258
	1-Very low	0.1215	0.0426	0.0108	0.1467	0.1063
	2-Low	0.1135	0.009	0.0035	0.5062	0.0108
	3-Moderate	0.011	0.0027	0.2422	0.1935	0.1073
	4-High	0.4656	8.00E-04	0.17	6.00E-04	0.0705
	YieldQ1	0.0207	0.1939	0.2381	0.1192	0.1245
	YieldQ2	0.55	0.2047	0.0579	0	0.0093
	YieldQ3	0.0313	0.5981	0.0713	0.0318	0.0739
	YieldQ4	0.5197	0.1792	0.1111	9.00E-04	2.00E-04
Supplementary variable: Food security hotspot[*]						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CHINA	-1.0255	-0.4172	0.2812	-1.161	0.7196
	IGP	-1.181	-0.5572	0.2352	0.3307	1.2017
	NWE	1.5526	-0.9239	1.201	0.0364	-0.2728
	SB&A	0.2667	0.8648	-0.6424	-2.085	0.355
	SSA	0.047	0.7235	1.0516	0.9414	-0.1731
	USM&C	0.746	-0.8394	0.1662	-0.2138	-0.7532
	WANA	0.3241	0.3107	-0.9341	0.5402	1.0256
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CHINA	0.0142	0.0024	0.0011	0.0182	0.007
	IGP	0.155	0.0345	0.0061	0.0121	0.1605
	NWE	0.2288	0.081	0.1369	1.00E-04	0.0071
	SB&A	0.001	0.0101	0.0056	0.0587	0.0017
	SSA	2.00E-04	0.0539	0.1138	0.0912	0.0031
	USM&C	0.0232	0.0294	0.0012	0.0019	0.0236
	WANA	0.0059	0.0054	0.0492	0.0164	0.0593
Supplementary variable: Emerging pathogens and pests, P&P or "key pests"						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	Brown rot	-0.6554	1.1729	1.3524	0.4148	-0.2236
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	Brown rot	0.0242	0.0775	0.103	0.0097	0.0028
Soybean correspondence analysis						
Active variables: Climate[†], loss magnitude and yield quartile						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CONT	-0.7605	-0.5173	1.1755	-1.0211	0.8108
	SUBTR	-0.4432	0.2624	-0.3932	0.5111	-0.2811
	TROPH	1.4053	-0.1365	-0.0831	-0.2562	-0.0382
	1-Very low	-0.9126	0.4431	-1.1817	-0.0549	0.6361
	2-Low	-0.3544	-0.1754	0.6626	0.031	-0.8967
	3-Moderate	0.8065	-1.0017	-0.3601	0.1325	0.6906
	4-High	1.1853	1.4966	0.5401	-0.2275	0.4911
	YieldQ1	1.0491	1.3287	0.7278	0.6422	0.299
	YieldQ2	-0.65	-0.8626	0.6226	1.4323	0.6039
	YieldQ3	1.0866	-0.6775	-0.5911	-0.346	-0.5093
	YieldQ4	-0.8272	0.2807	-0.1951	-0.6787	-0.0656

		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
Contributions to axes		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CONT	5.2419	4.1825	23.0931	20.0084	14.6417
	SUBTR	4.7992	2.9002	6.9639	13.5095	4.7429
	TROPH	24.9036	0.4053	0.1607	1.7527	0.0452
	1-Very low	8.5337	3.468	26.384	0.0653	10.1879
	2-Low	2.3758	1.0035	15.3147	0.0385	37.379
	3-Moderate	6.9207	18.408	2.5445	0.3957	12.472
	4-High	8.8576	24.351	3.3921	0.6909	3.7365
	YieldQ1	8.2406	22.791	7.3141	6.5365	1.6447
	YieldQ2	3.4968	10.6169	5.9151	35.9428	7.4174
	YieldQ3	13.9568	9.3566	7.6177	2.9959	7.5368
	YieldQ4	12.6733	2.5169	1.3	18.0638	0.1958
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CONT	0.1415	0.0655	0.3381	0.2551	0.1608
	SUBTR	0.2214	0.0776	0.1742	0.2944	0.089
	TROPH	0.7435	0.007	0.0026	0.0247	5.00E-04
	1-Very low	0.238	0.0561	0.399	9.00E-04	0.1156
	2-Low	0.0874	0.0214	0.3054	7.00E-04	0.5594
	3-Moderate	0.1951	0.301	0.0389	0.0053	0.1431
	4-High	0.2226	0.3548	0.0462	0.0082	0.0382
	YieldQ1	0.2134	0.3423	0.1027	0.0799	0.0173
	YieldQ2	0.0924	0.1628	0.0848	0.4488	0.0798
	YieldQ3	0.4071	0.1583	0.1205	0.0413	0.0895
	YieldQ4	0.4594	0.0529	0.0256	0.3093	0.0029
Supplementary variable: Food security hotspot*						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CHINA	0.116	1.1254	0.8479	1.1559	-0.9958
	SB&A	-0.1288	-0.2463	-0.1543	1.1948	-0.0735
	SSA	1.5173	1.5348	0.8871	0.2644	0.6071
	USM&C	-0.7922	-0.2628	0.7069	-0.8252	0.5244
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	CHINA	1.00E-04	0.0109	0.0062	0.0115	0.0085
	SB&A	0.0043	0.0157	0.0061	0.3684	0.0014
	SSA	0.2389	0.2444	0.0817	0.0073	0.0382
	USM&C	0.2164	0.0238	0.1723	0.2348	0.0948
Supplementary variable: Emerging pathogens and pests, P&P or "key pests"						
Coordinates		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	soybean rust	0.7663	0.6298	-0.0219	0.1395	0.1086
Squared cosines		Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
	soybean rust	0.1678	0.1133	1.00E-04	0.0056	0.0034

* USM&C=US Midwest and Canada; SB&A=South Brazil, Paraguay, Uruguay and Argentina; NWE=Northwest Europe; WANA=West Asia and North Africa; SSA=Sub-Saharan Africa; CHINA=Mainland China; IGP=Indo-Gangetic Plain; SEA=Southeast Asia.

† ARID=Arid; CONT=Humid continental; EQUAT=Equatorial; MEDIT= Mediterranean; MONSO= Monsoon; OCEAN=Oceanic; SUBTR=Subtropics; TROPH=Humid tropics.

Supplementary Note 1. Email sent by Serge Savary, Vice-President of the ISPP and Chair of the ISPP Subject Matter Committee on Crop Losses to the members of the ISPP.

Dear Colleague,

This e-mail is sent to you as a member of the ISPP, to invite you to contribute to a global survey on the losses caused by crop diseases and pests. If you would like to participate in this global effort, please use the following link

https://globalcrophealth.org/

which will provide you with information about this project, and which take you directly to the survey questionnaire. The questionnaire has been devised to be simple and flexible, so that you would need as little of your time to provide inputs. This is a global effort, which is undertaken under the aegis of the ISPP. We cannot possibly have reached all potential contributors to this survey. Please feel free to circulate this message to colleagues.

The questionnaire will be open for 3 months. We would be very glad if you could respond to this questionnaire as soon as you possibly can within the coming 3 months (i.e., before end of January, 2017). Any results that can yield analyses will be reported with due recognition of contributors to the survey.

For further queries please e-mail to: (survey@globalcrophealth.org)

Sincerely,

S. Savary, Chair, ISPP Crop Loss Subject Matter Committee, Centre INRA de Toulouse, France

A. Nelson, ITC, University of Twente, The Netherlands

L. Willocquet, Centre INRA de Toulouse, France

Sarah Pethybridge, Cornell University

Asimina Mila, North Carolina State University

Paul Esker, University of Costa Rica

Supplementary Note 2. Note published in the ISPP Newsletter of November 2016[49], republished with permission of the ISPP, announcing the conduct of the survey to the total membership of the ISPP.

ISPP Launches a Global Crop Loss Survey

Quantification of the importance of crop diseases and pests is a necessary first step towards better understanding of crop health and its management. However, the information pertaining to the losses caused by plant diseases and pests in agriculture is fragmented, heterogeneous, and is very incomplete. ISPP has been considering undertaking a survey on crop losses for a long time. Documenting the importance of crop diseases and pests is also one goal of several international research networks, such as AgMiP and MacSur. This project has first been discussed by the Crop Loss Subject Matter Committee of the International Society for Plant Pathology during its first meeting in August 2013 in Beijing.

With this article (and a message which should also be sent to you by ISPP), you are invited to contribute to this survey. If you would like to participate in this global effort**, please use the link below:**

http://globalcrophealth.org/

This link will direct you to a survey questionnaire. The questionnaire has been devised to be simple and flexible, so that you would need as little of your time to provide inputs. If you have any queries about this survey, please **email** us.

About the survey

This survey is intended to help document crop losses in major world crops. The information sought on each crop disease or pest (location, frequency and loss) is very simplified, in order to both reduce the time required to answering the questionnaire, and to generate homogeneous information across multiple diseases and pests of several crops.

At this stage, the survey focuses on five major crops worldwide: wheat, rice, potato, soybean, and maize. It might be expanded to other crops in the future. For each of these five crops, up to 10 pests and diseases have been listed. These are only suggestions, and the survey forms provide opportunity to submit information on other pests and diseases as well. Common names and scientific names of suggested pathogens and pests are tabulated below.

The survey asks contributors to provide their name, institute and e-mail address. Providing this information is optional. However, this will enable the recognition of contributions in future reports.

Hopefully, this survey will collect as many inputs from numerous contributors worldwide, on as many diseases and pests as possible. **The survey will end on 31 Jan 2017. If the survey is successful in eliciting a sufficient number of responses, a report will be made public by 31 Apr 2017, where the detail of individual contributions will not be presented, but where contributions will be explicitly acknowledged.**

Thanking everyone for your support in this effort,

S. Savary, INRA, Centre INRA de Toulouse, France ; Chair, Crop Loss Subject Matter Committee of the ISPP;

A. Nelson, ITC, University of Twente, The Netherlands;

L. Willocquet, INRA, Centre INRA de Toulouse, France ;

Sarah Pethybridge, Cornell University, USA;

Asimina Mila, North Carolina State University, USA;

Paul Esker, University of Costa Rica.

Lists of pests and diseases for the web-based survey of global crop health assessment

Potato

Disease or pest: common name	Scientific (Latin) name
Late blight	Phytophthora infestans
Cyst nematode	Globodera rostochiensis, G. pallida
Early blight	Alternaria solani
Early dying/Verticillium wilt	Verticillium albo-atrum, V. dahlia, Pratylenchus penetrans
Colorado potato beetle	Leptinotarsa decemlineata
Potato leafhopper	Empoasca fabae
Potato spindle tuber viroid	
Common scab	Streptomyces scabies
Powdery scab	Spongospora subterranea
Other	

Maize

Disease or pest: common name	Scientific (Latin) name
Northern corn leaf blight	Exserohilum turcicum, Setosphaeria turcica
Southern rust	Puccinia polysora
Maize streak	Maize streak virus
African stem borer	Busseola fusca, Sesamia calamistris
European stem borer	Ostrinia nubialis
Diabrotica beetle and rootworm	Diabrotica balteata, D. virgifera, D. longicornis, D. speciosa
Diplodia ear and stem rot	Diplodia frumenti
Fusarium and Gibberella stalk rots	Fusarium moniliforme, F. graminearum
Fusarium and Gibberella ear rots	Fusarium moniliforme, F. graminearum
Other	

Soybean

Disease or pest: common name	Scientific (Latin) name
White mold	Sclerotinia sclerotiorum
Soybean rust	Phakopsora pachyrhizi
Cyst nematode	Heterodera glycines
Sudden death	Fusarium virguliforme, F. tucumaniae, Heterodera glycines
Armyworm	Spodospora exigua, S. praefica
Phytophthora root and stem rot	Phytophthora sojae
Rhizoctonia root rot, web blight	Rhizoctonia solani
Pythium damping-off	Pythium spp.
Soybean mosaic	Soybean mosaic virus
Other	

Wheat

Disease or pest: common name	Scientific (Latin) name
Septoria (Zymoseptoria) tritici blotch	Zymoseptoria tritici
Stagonospora nodorum blotch	Stagonospora avenae f. sp. tritici, Parastagonospora (Phaeosphaeria) nodorum
Leaf (brown) rust	Puccinia triticina
Stem (black) rust	Puccinia graminis f. sp. tritici
Stripe (yellow) rust	Puccinia striiformis f. sp. tritici
Fusarium head blight – Scab	Fusarium spp., Microdochium spp.
Tan spot	Pyrenophora tritici-repentis
Spot blotch	Cochliobolus sativus
Barley yellow dwarf (BYD)	BYD viruses
Aphids	Sitobion avenae, Rhopalosiphum padi, Diuraphis noxia
Other	

Rice

Disease or pest: common name	Scientific (Latin) name
Bacterial blight	Xanthomonas oryzae pv. oryzae
Leaf, neck, or panicle blast	Pyricularia oryzae
Sheath blight	Rhizoctonia solani
Rice tungro	RTB virus and RTS virus
Ragged stunt	RRS virus
Brown spot	Cochliobolus miyabeanus
Sheath rot	Sarocladium oryzae
Stem borers	Scirpophaga incertulas, Chilo suppressalis, Sesamia inferens
Brown plant hopper	Nilaparvata lugens
Other	

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