Production Constraints and Opportunities for Six Priority GCP Food Crops in Farming Systems with High Poverty

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12 regional focal persons + 670 panelists provided information

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Project G4008.36:
Getting the focus right: Food crops and smallholder constraints
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Focus

- To generate information to support existing projects and identify areas for future investment, the GCP commissioned a study of production constraints and opportunities for important GCP food crops in priority farming systems with high degrees of poverty.

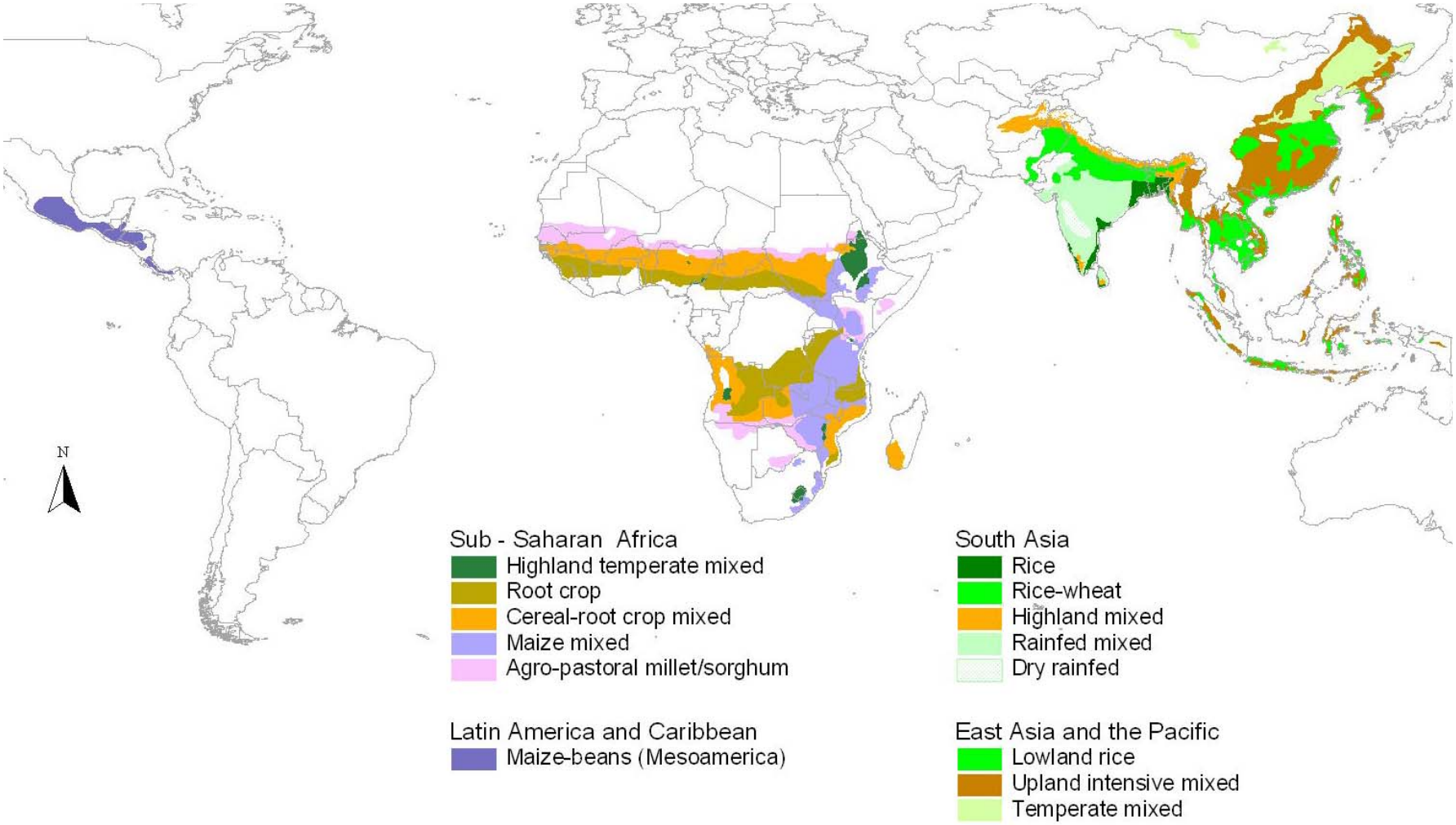
- Surveyed wheat, rice, sorghum, cassava, cowpea and chickpea, grown in 14 broad farming systems with large numbers of stunted children, drought incidence and large production areas of food crops (Hyman et al 2008).

- Developed from earlier pilot study on maize constraints (Gibbon et al 2007).

- The farming systems are located in South and East Asia, sub Saharan Africa (and one in Latin America).

Map of farming systems that are high priority for GCP and surveyed in constraints study

Feature: 1. high levels of poverty (child stunting), 2. high incidence of drought, 3. large areas of food crops



Methods

- Selected 41 target crop x farming system combinations: crop on > 3% arable area or > 100000 ha planted in system
- Applying a modified "**Delphi**" method (Dalkey 1969), three **rounds of survey** April 2008-March 2009 with 670 **"expert" panelists** familiar with the crops and systems
- Panelists included geneticists, plant breeders, plant protectionists, agronomists (soil and water), extensionists/training, input suppliers, farmers – public, private, NGO, international sectors
- Identified important **Abiotic, Biotic, Management-related** and **Socio-economic constraints** to crop production for each crop x farm system
- Estimated **yield losses** and frequency of occurrence associated with important constraints that contribute to:
- **Smallholder farm yield gap**, defined (Evenson et al 1996) as

"*Highest achieved yield on farm – Average yield on farm* "

- Constraint interactions, system effects, income effects described
- Panelists also proposed **solutions** to the most severe constraints
- Detailed data obtained for 38 crop x system combinations; 14 systems.

Yield gaps

- Large smallholder farm yield gaps identified for most crops and farming systems
  - significant scope for improvement of farm yields if severe constraints can be identified and alleviated
- Yield gap varied by crop:

Smallest for rice (mean 60% of current farm grain yields)

Mid size for wheat and cassava (70-100%)

Larger for sorghum and the legumes (often around double current farm yields, or more)

- Gaps by farming system were:

Larger in marginal, dryer farming systems, particularly in Sub-Saharan Africa

Smallest in the high input and yield systems of East Asia

Constraint areas

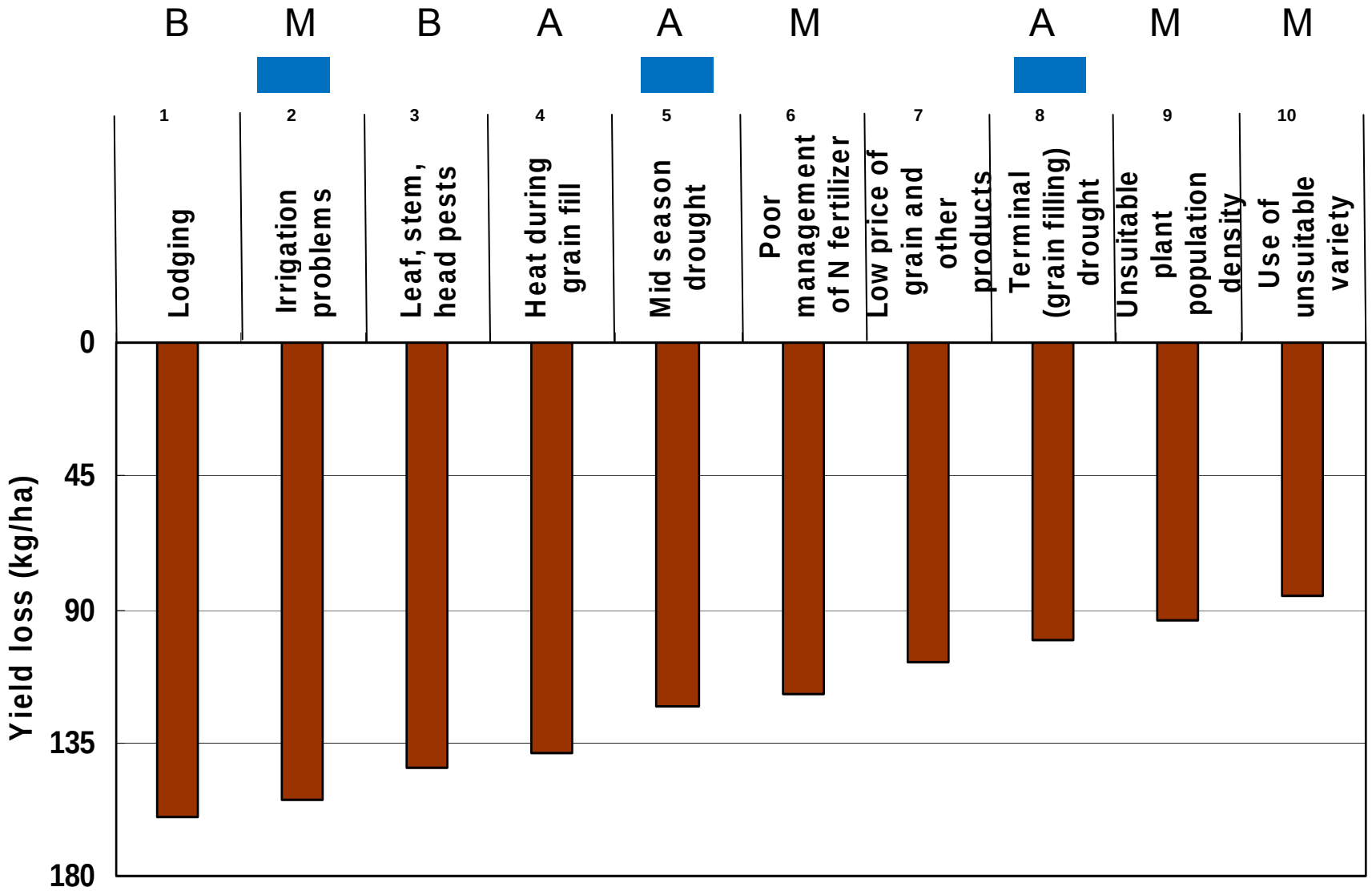
- Abiotic, biotic, management and socio-economic constraints all important contributors to yield gaps
  - Abiotic and management constraints more important for wheat
  - Socio-economic and management issues for rice and cassava
  - Abiotic constraints for sorghum
  - Biotic constraints for cowpea and chickpea
- Many severe specific constraints reported for each crop x system – Focused on the 24 most-severe (6 constraints x 4 categories)
- Most severe constraints were considered to be getting worse (i.e. in more fields and more years)
- Combined yield losses from the ten most severe constraints identified contributed 45% (cassava) to 56% (chickpea) of yield gap
- Groups of related constraints often dominated, e.g. poor management, high cost and deficiency of N fertilizer, and soil fertility depletion were widely reported for the cereals, as were drought stress and poor water management. Specific biotic constraints and the high cost of their control often dominated the legumes.

Example results: Wheat smallholder farm yield gaps and yield loss breakdown

Region and Farming system	**Highest** smallholder **farm yield** (t/ha)	**Average** smallholder **farm yield** (t/ha)	Smallholder **yield gap** (t/ha)	**Yield losses** by constraint category (Percent of total yield gap)			
				Socio-Economic	Abiotic	Biotic	Management-related
Sub Saharan Africa							
Highland Temperate Mixed	4.14	2.02	2.12	28	20	19	32
South Asia							
Highland Mixed	3.80	2.05	1.76	23	30	21	27
Rice-Wheat	4.81	2.46	2.38	20	28	20	31
Rainfed Mixed	4.96	2.39	2.54	20	28	22	28
Dry Rainfed	5.32	2.16	3.10	23	30	18	30
East Asia Pacific							
Lowland Rice	8.18	5.12	3.06	20	29	20	30
Upland Intensive Mixed	7.81	3.99	3.82	24	30	17	29
Temperate Mixed	8.74	5.84	3.13	20	34	20	27
Crop Mean	5.97	3.25	2.74	22	29	20	29

Most severe Constraints by yield loss across categories:

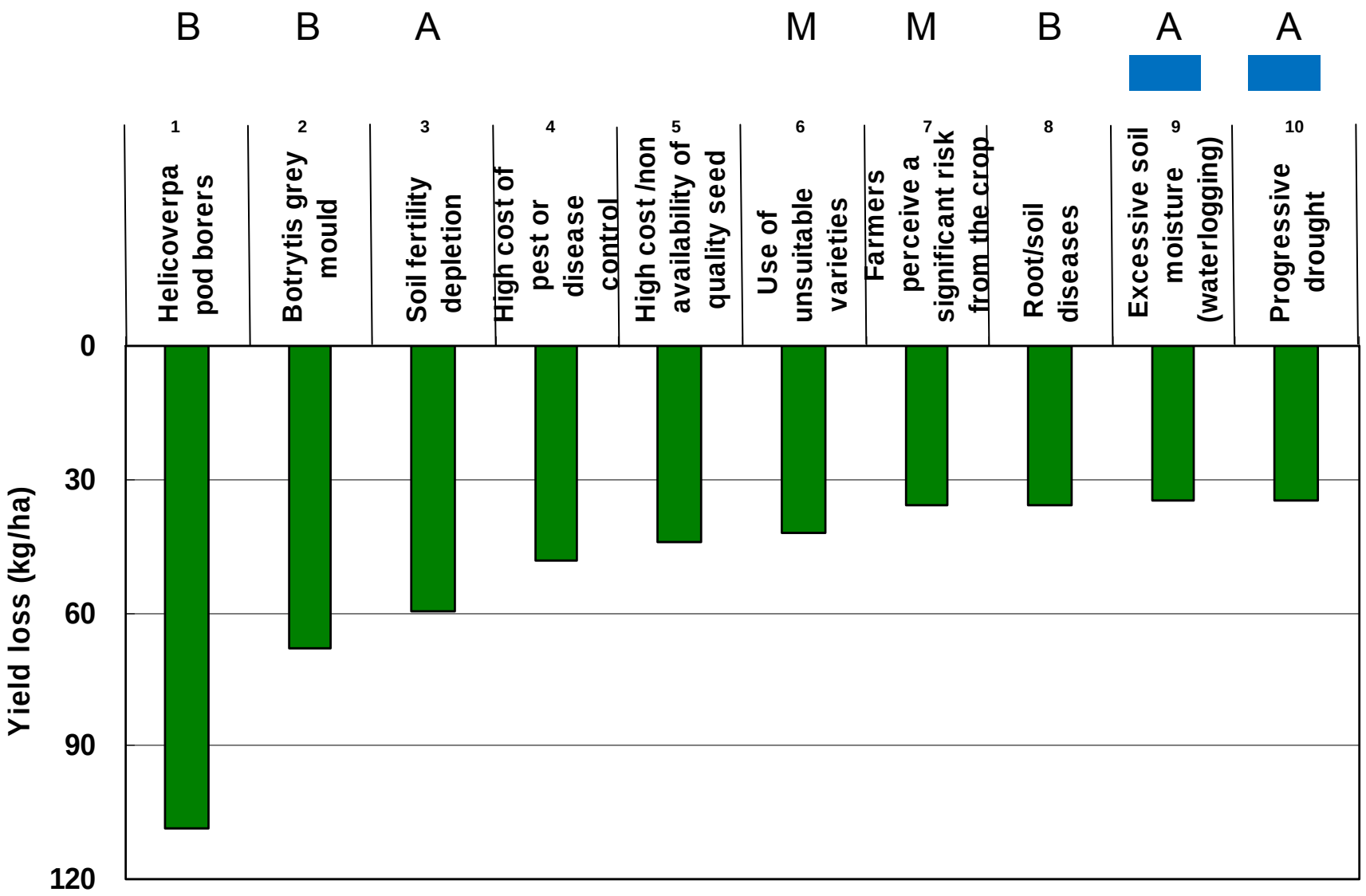
Wheat in East Asia Temperate Mixed System



A = Abiotic B = Biotic M = Management = drought or water management related

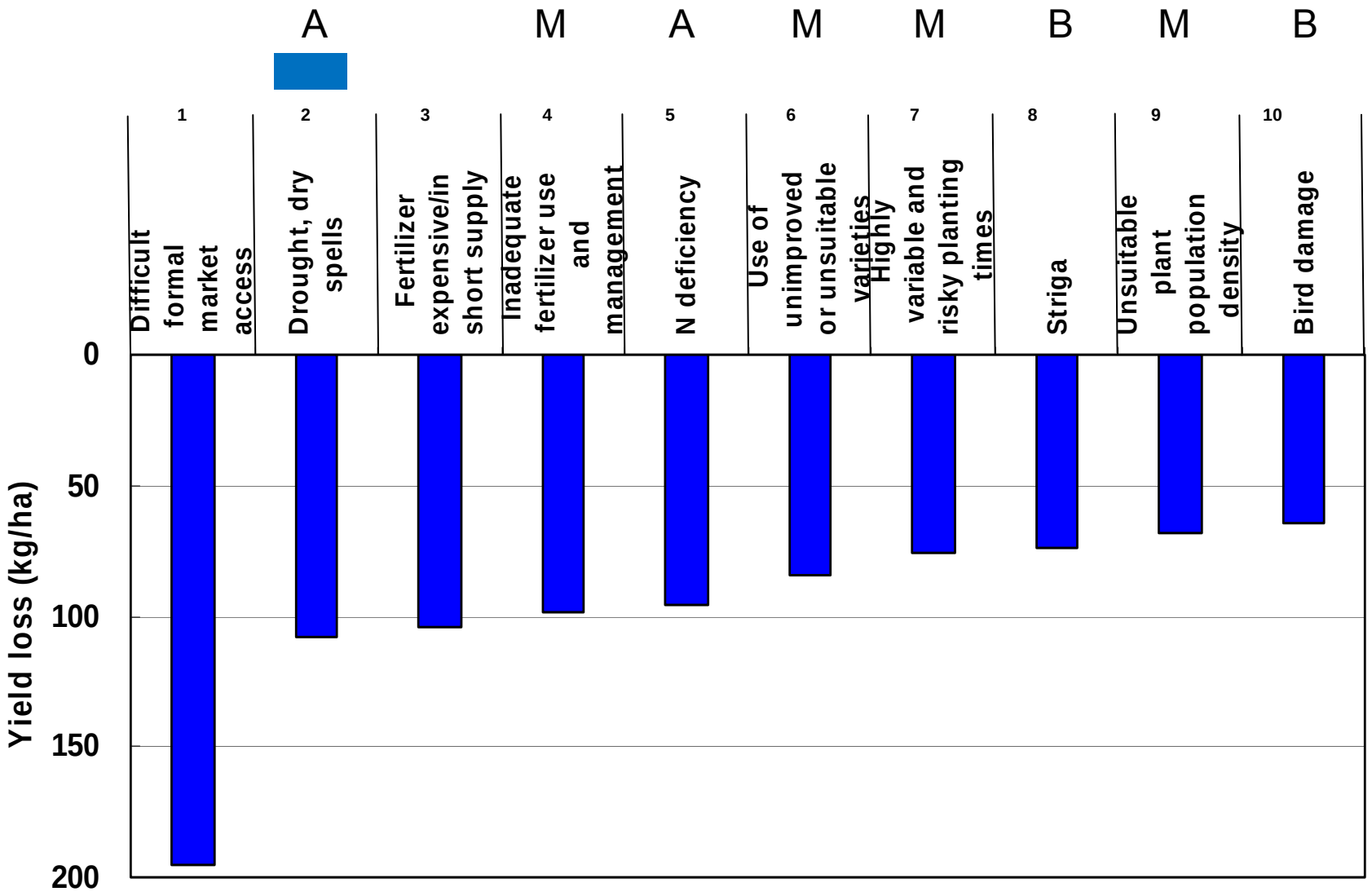
Most severe Constraints by yield loss across categories:

Chickpea in South Asia Rice-Wheat System



Most severe Constraints by yield loss across categories:

Sorghum in Sub-Saharan Africa Agropastoral Millet/Sorghum System



Overall most severe constraint areas across farming systems, by crop (based on size of estimated yield loss)

Crop	Constraint area	Crop	Constraint area
Wheat	• Deficiency, high cost & poor management of N fertilizer • **Grain filling drought stress** • **Mid season drought** • **Irrigation management**	**Cowpea**	• Pod, leaf, stem and flower insect pests • High cost of pest control • Unsuitable varieties/poor seed
Rice	• Deficiency, high cost & poor management of N fertilizer • Soil fertility depletion • Leaf, stem and head pests and diseases • Weed competition • **Water management**	**Chickpea**	• *Helicoverpa* pod borer • *Botrytis* grey mould • High cost of pest and disease control • Soil fertility depletion • Fertilizer input and management
Sorghum	• *Striga* • Weed competition • Soil resource degradation • Soil fertility management • **Drought at various stages**	**Cassava**	• Marketing problems • Lack of finance • Weed competition • African cassava mosaic virus • Poor varieties/planting materials

Solutions to severe constraints

- Respondents identified many variety/germplasm opportunities to address the most important constraints for each crop x system, and provided ideas on policy/socio-economic and crop management solutions.
- Proposed solutions to severe biotic and abiotic constraints often involved development and deployment of improved germplasm with tolerance or resistance to various pests, diseases, nutrient and water stresses
  - especially common for wheat or rice, particularly in Asia.
- Many of the solutions for sorghum, cowpeas, cassava and chickpea involved interactions, synergies and systems thinking.
- Some germplasm suggestions incorporated systems perspectives, e.g. need for earlier maturing genotypes to better fit intensifying cropping systems,
  - with rice or chickpea in South Asia.
- Importance of linking germplasm solutions to effective deployment of seed of new varieties and awareness of variety characteristics among farmers clear.
- Some management and policy-related interventions also emphasized integration and sequencing of several components for success in addressing the problems.

Uses of outputs

- GCP can use the important constraints and suggestions on varietal, germplasm or genetic solutions to help:
  - Justify current investments in particular thrusts with these crops for the farming systems
  - Decide priority traits x crop x system on which to support new research.

- Further debate between some key panelists − perhaps in the form of a workshop − on how to rationalize and prioritize the many constraints and solutions, and then to use them in priority setting, could be useful for the GCP?

- Some of the ideas on management and policy-related constraints and interventions will also be helpful to guide the wider agricultural research and development community.

Expanding the Approach?

- More-detailed surveys may be helpful in certain complex crop x farming systems, e.g. with rice in some Asian systems with 2+ rice seasons or where disaggregation of a severe constraint may be helpful (e.g. pod, leaf, stem and flower insect pests with cowpea).

- There were many concerns about systems effects and interactions, particularly with crops that are usually intercropped (cowpea) or have several functions/uses (sorghum, cowpea, cassava).
  - Implies a need to move beyond a focus on yield losses per unit land area and on single crops in future assessments.

- These methods may be usefully expanded to survey system productivity losses and opportunities, in say a few priority African systems, where several of the crops are all important.

Accessing the Results and Data?

1. Comprehensive report and annexes (± 450 p)

MS Word electronic, August 09

Downloadable from Briefing on GCP SP5 webpage, Oct 09?
[Includes maize constraints report and data]

Limited CDs and paper copies, Oct-Nov 09

2. Overview journal article
[+ Regional article(s) proposed]

Drafts being edited, July-Sept 09

3. Data archive at CIMMYT, and registry at GCP

Complete data (+metadata) available in MS Access and Excel files, July + Sept 09