Soybean Ancestors as Sources of Tolerance to Ozone and other Abiotic Stresses

2011 Soybean Breeders' and Plant Physiologists' Workshop

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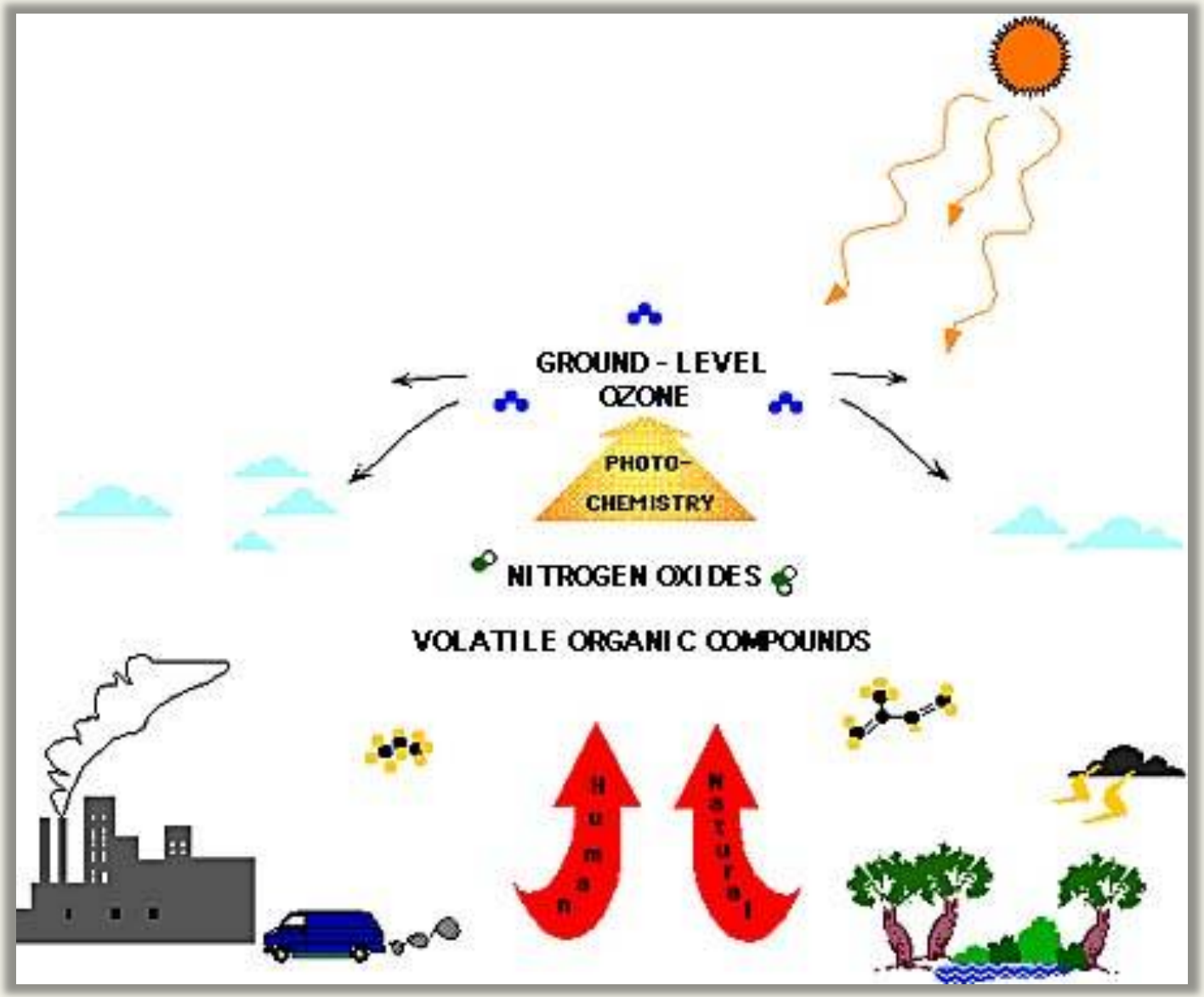
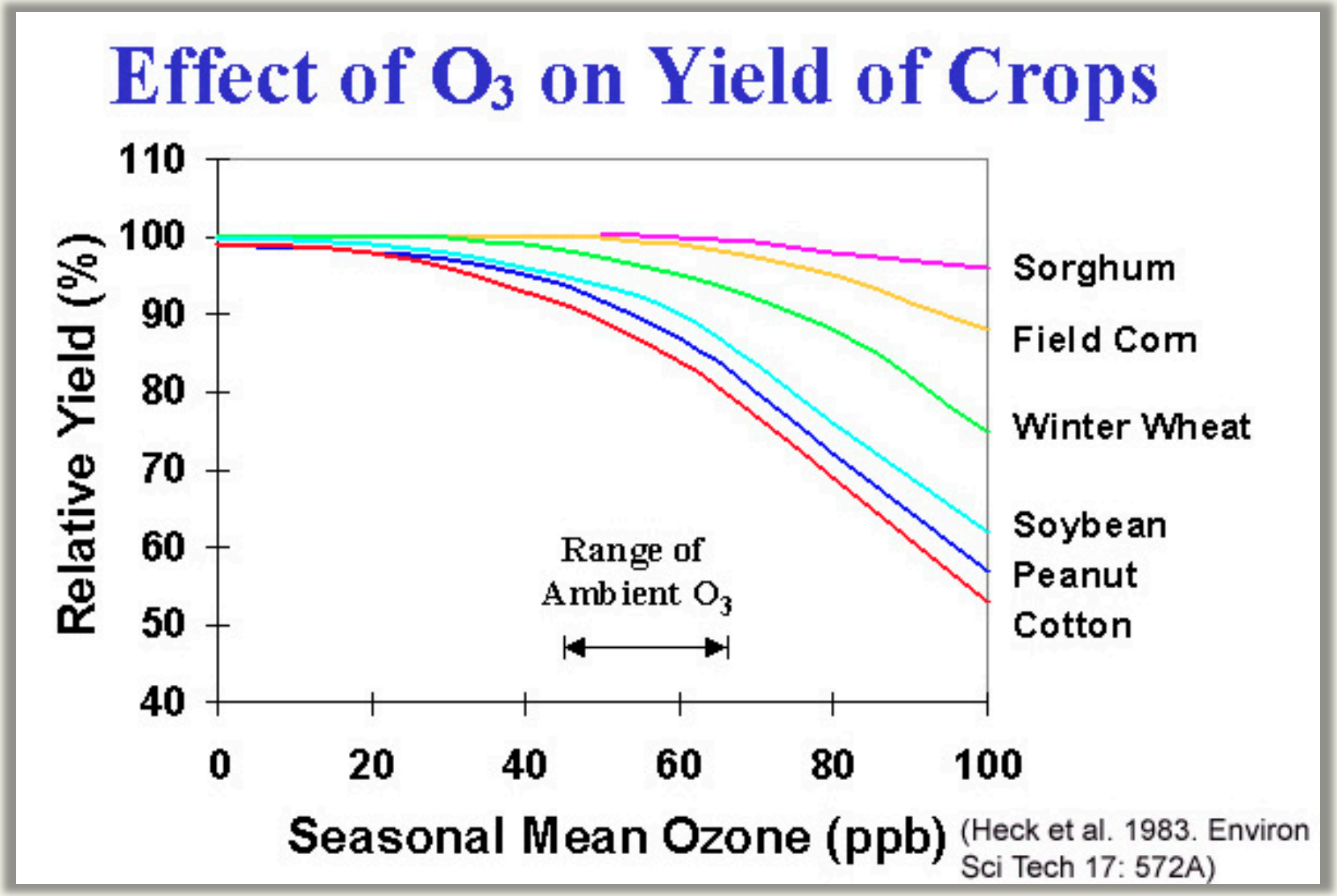
Topics to be addressed

1. Brief overview of ozone air pollution
2. Is ambient ozone a concern for soybean breeders and growers?
3. Germplasm that could contribute to development of cultivars with enhanced tolerance to ozone and other abiotic stresses

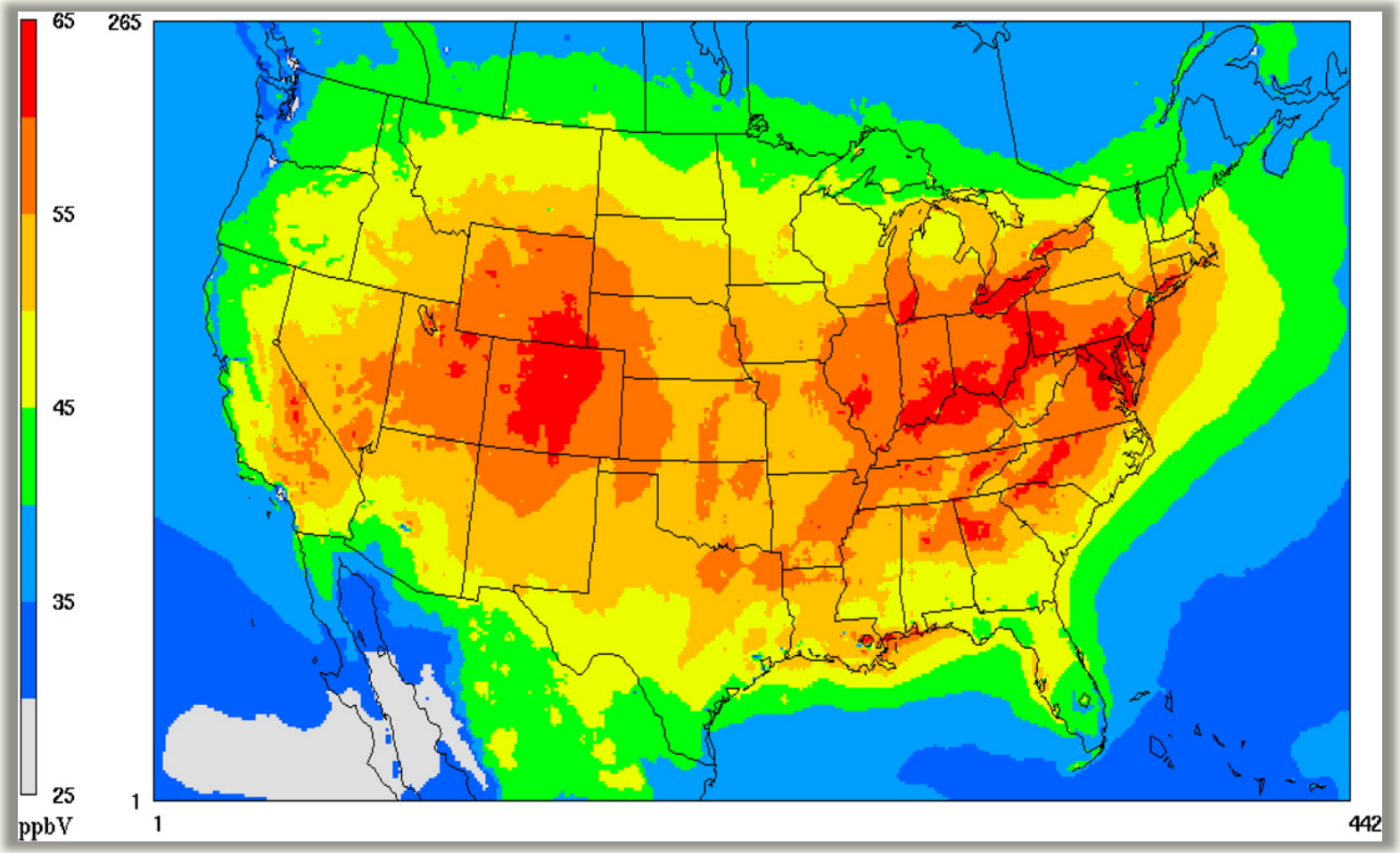
Ozone is a “secondary pollutant” formed in both urban and rural areas



National Crop Loss Assessment Network (NCLAN) with Open-Top Chambers



Ambient ozone can be high enough to impact crop yield



Seasonal mean of ambient ozone concentrations between 09:00 and 16:00 h over the continental United States from 1 July to 31 September 2005 (Tong et al. 2007Atmos. Environ. 41:8772). Areas shown in brown, orange and red can experience significant crop yield loss and damage to ecosystem function from ambient ozone.

Fishman et al. 2010 Atmospheric Environment 44: 2248-2256

- Modeled ambient ozone and soybean yield in the mid-west during 2002-2006 and provided evidence for 10% yield loss

- Supported conclusions of NCLAN (open-top chambers) studies

- Identified need for ozone-tolerant cultivars, particularly in view of SoyFACE studies that predict an additional 20% yield loss by 2050 as ambient ozone levels rise

Thirty soybean ancestors representing 92% of the genetic base in North American soybean screened for ozone tolerance in the greenhouse.

(Burkey and Carter 2009 Field Crops Research 111:207-217)

Low Ozone Control	Six days 1.5 x Ambient Ozone	
		Fiskeby III
		PI88788

Fiskeby soybeans as a source of tolerance to a diverse set of abiotic stresses

Selected Plant Introductions	Common Name	Ozone Foliar Injury (%)
PI 438477	**Fiskeby 840-7-3**	**5**
PI 438471	**Fiskeby III**	**9**
PI 548352	**Jogun**	**13**
PI 548311	**Capital**	**26**
PI 548379	**Mandarin (Ottawa)**	**40**
PI 88788 [SCN resistance]		**49**

Fiskeby soybeans
- Developed in Sweden
- Used in Canada as source of cold tolerance
- Not a significant contributor to pedigree of US soybeans

Fiskeby tolerant to a broad range of abiotic stresses
- Salt (Tommy Carter)
- Aluminum (Tommy Carter)
- Drought (Jim Orf)
- Iron deficiency chlorosis (Jim Orf)

Formation of the “Fiskeby” team

Project to map stress tolerance genes and investigate potential linkages between abiotic stresses

Fiskeby III (tolerant) x Mandarin Ottawa (sensitive)

↓

> 200 random inbred lines (RILs)

↓

DNA markers for RILs– Raleigh & Beltsville
(Amy Burton, Kent Burkey, Tommy Carter, Perry Cregan)
Phenotype RILs for ozone, salt and aluminum in Raleigh greenhouses
(Amy Burton, Kent Burkey, Tommy Carter)
Phenotype RILs for drought and iron deficiency chlorosis in Minnesota fields
(Jim Orf)

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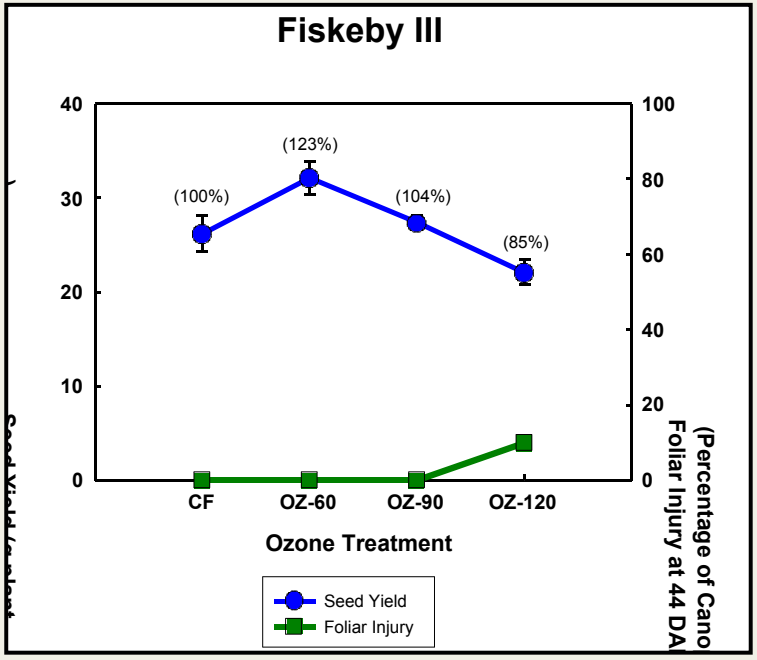
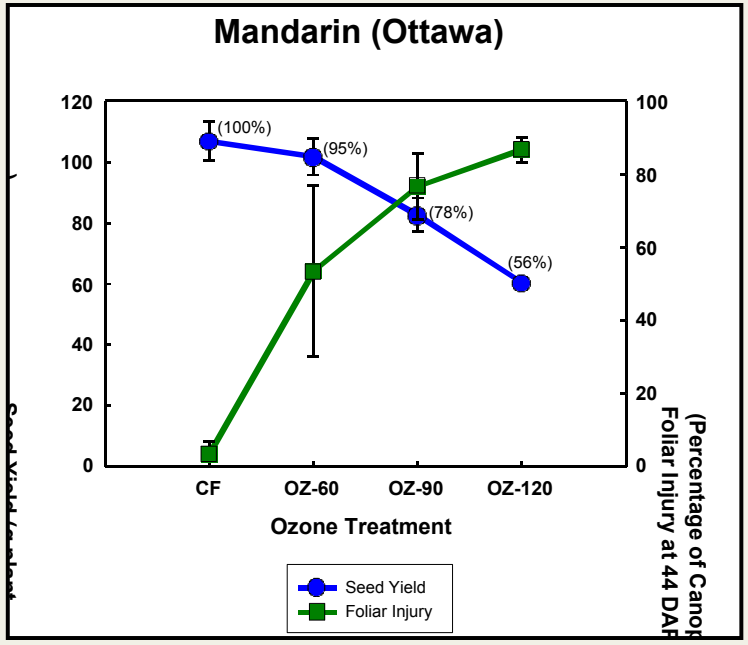
Map tolerance genes for 5 abiotic stresses

Ozone-induced foliar injury is associated with yield loss in soybean ancestors





Current and Future Directions

Mapping Project

- •Map abiotic stress tolerance genes to specific chromosome regions
- •Look for potential cross tolerance between five stresses
- •Develop strategies for transferring tolerance genes
- •Investigate physiological and molecular basis for unusually broad stress tolerance in Fiskeby soybeans

Cultivar Development

- •Move Fiskeby stress tolerance genes into adapted, high-yielding cultivars
- •Potential to combine Fiskeby tolerance genes with other unique stress tolerant germplasm

Some final thoughts and conclusions…

- Consider ozone as a factor in long term planning for adapting crops to abiotic stress associated with climate change

- Fiskeby soybeans appear to be a unique source of tolerance to a broad range of abiotic stresses

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