ILSI Japan ERA Workshop

Agronomic characterization for ERA of GM maize: Transportability across regions

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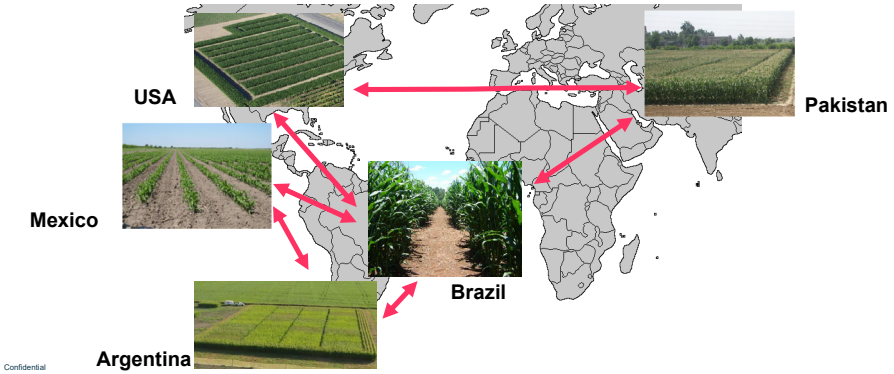
Objectives

- Share the results of agronomic characterization of genetically modified (GM) maize performed in five regions (Argentina, Brazil, Mexico, Pakistan, and the USA) from 2004 to 2014
- Assess the transportability of agronomic characterization data across the tested regions



Agronomic characterization practices

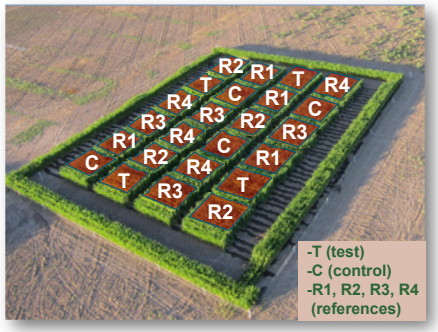
Commonly required for environmental risk assessment (ERA) of GM crops. Contributes to assessments pest/weed potential

A GM crop is compared to a conventional control for agronomic characteristics in replicated and randomized trials (RCBD)

- Conventional control of similar genetic background to the test(s)
- Commercial references

At each site, the GM crop and control are grown under:

- Comparable environmental conditions (*e.g.*, soil, temperature, precipitation)
- Comparable agronomic practices (*e.g.*, planting, tillage, irrigation, pest control)



Materials

NK603 maize

- Herbicide tolerant (*cp4 epsps*)
- Commercialized since 2001

MON 89034 maize

- Lepidopteran insect protected (*cry1A.105*, *cry2Ab2)*
- Commercialized since 2010

MON 89034 × NK603 maize

- Breeding stack (*cry1A.105*, *cry2Ab2, cp4 epsps)*
- Commercialized since 2010

Non-GM Maize NK603
(after herbicide application)

Non-GM Maize MON 89034
(under lepidopteran pest pressure)

Methods

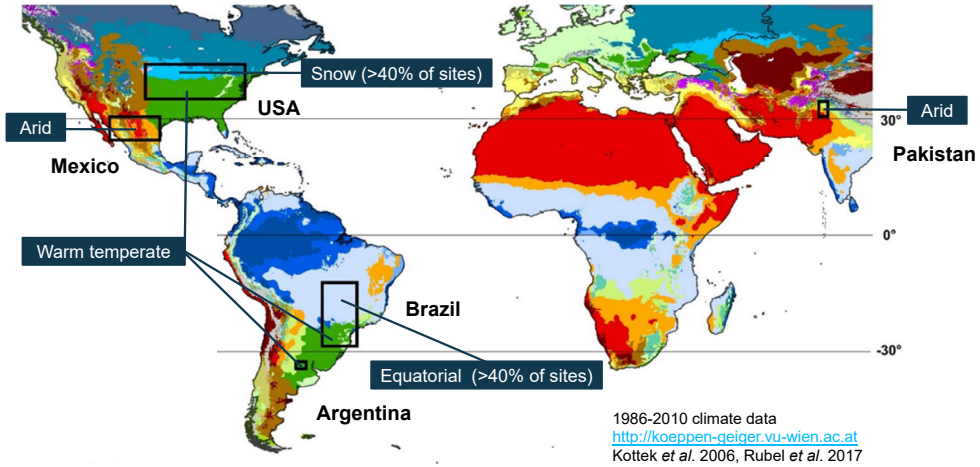
Data sources across GM products

- Tested environments:
  - Argentina, Brazil, Mexico, Pakistan, USA
  - 2004-2014 seasons
- 25 studies
- 104 sites
- 22 genetic backgrounds including temperate, subtropical, and tropical maize

Characteristics

- Early and final stand
- 50% pollen shed and 50% silking
- Ear height
- Plant height
- Seed loss
- Lodging (root and stalk)
- Grain moisture
- Grain yield

Field trials were conducted in diverse climate zones



1986-2010 climate data
http://koeppen-geiger.vu-wien.ac.at
Kottek *et al.* 2006, Rubel *et al.* 2017

NK603 agronomic characteristics varied among regions, but test and control were comparable

Characteristic	Argentina		Brazil		Mexico		Pakistan		USA	
	NK603	Control	NK603	Control	NK603	Control	NK603	Control	NK603	Control
Early stand, plants/ha	84,300	83,000	59,000	61,000	91,900	90,600	92,200	89,300	84,500	84,100
Final stand, plants/ha	71,800	71,000	56,100	57,100	69,300	69,800	73,000	73,100	71,100	71,400
50% pollen shed, DAP	60.7	60.3	58.3	59.2	75.0	75.9	–	–	65.0	64.7
50% silking, DAP	61.3	60.7	56.5	57.5	76.4*	77.7	–	–	64.6*	64.3
Ear height, m	0.83	0.82	1.21	1.27	0.96	0.94	1.05	1.05	1.06	1.04
Plant height, m	1.87	1.85	2.27	2.37	1.98	1.96	2.25	2.27	2.33	2.31
Seed loss, ears/100 plants	0.1	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.2	0.3
Root lodging, %	4.5	4.7	0.7	0.0	0.7	0.9	4.8	3.7	1.6	2.9
Stalk lodging, %	11.8	12.6	1.9	2.2	1.2	0.8	4.3	5.6	3.8	3.5
Grain moisture, %	20.7	20.1	17.9	17.3	19.3	19.7	17.6	17.9	18.7	18.6
Grain yield, t/ha	7.8	7.8	10.5	9.8	9.5	9.5	9.7	9.9	12.0	12.0

* Analysis was done by Mixed model ANOVA (P<0.05)

- Agronomic characteristics varied among regions. However, within regions, the great majority of comparisons between NK603 and the control did not result in significant differences
- Results from each region were consistent with no increase in weed potential for NK603
  - 50% silking differences were within the reference ranges (data not shown)

MON 89034 agronomic characteristics varied among regions, but test and control were comparable

Characteristic	Argentina		Brazil		USA	
	MON 89034	Control	MON 89034	Control	MON 89034	Control
Early stand, plants/ha	81,800	83,000	60,600	61,000	83,600	84,100
Final stand, plants/ha	69,300	71,000	56,900	57,100	71,100	71,400
50% pollen shed, DAP	60.7	60.3	59.1	59.2	64.9	64.7
50% silking, DAP	61.4	60.7	57.7	57.5	64.6*	64.3
Ear height, m	0.80	0.82	1.31	1.27	1.03	1.04
Plant height, m	1.82	1.85	2.42	2.37	2.31	2.31
Seed loss, ears/100 plants	0.0	0.0	–	–	0.2	0.3
Root lodging, %	5.6	4.7	–	–	1.9	2.9
Stalk lodging, %	8.0	12.6	–	–	3.0	3.5
Grain moisture, %	20.8	20.1	18.5	17.3	18.8	18.6
Grain yield, t/ha	8.8*	7.8	11.1*	9.8	12.1	12.0

* Analysis was done by Mixed model ANOVA (P<0.05)

- Agronomic characteristics varied among regions. However, within regions, the great majority of comparisons between MON 89034 and the control did not result in significant differences
- Results from each region were consistent with no increase in weed potential for MON 89034
  - 50% silking and grain yield differences were within the reference ranges (data not shown)
  - Grain yield differences may have resulted from intended lepidopteran pest protection of the MON 89034 event

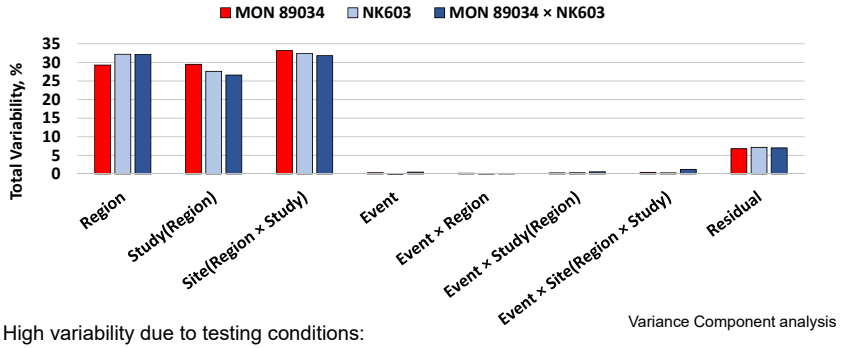
MON 89034 × NK603 agronomic characteristics varied among regions, but test and control were comparable

Characteristic	Argentina		Brazil		Mexico		Pakistan	
	MON 89034 × NK603	Control	MON 89034 × NK603	Control	MON 89034 × NK603	Control	MON 89034 × NK603	Control
Early stand, plants/ha	79,500	83,000	57,600*	61,000	85,300	90,600	–	–
Final stand, plants/ha	69,100	71,000	53,600*	57,100	69,800	69,800	72,100	73,100
50% pollen shed, DAP	61.0	60.3	59.3	59.2	74.8	75.9	71.8	71.8
50% silking, DAP	61.3	60.7	57.7	57.5	76.9	77.7	73.6	73.8
Ear height, m	0.83	0.82	1.25	1.27	0.98*	0.94	1.08	1.05
Plant height, m	1.85	1.85	2.31	2.37	1.99	1.96	2.24	2.27
Seed loss, ears/100 plants	0.0	0.0	–	–	0.0	0.2	0.0	0.0
Root lodging, %	6.8	4.7	–	–	1.6	0.9	3.0	3.7
Stalk lodging, %	11.0	12.6	–	–	0.3	0.8	5.6	5.6
Grain moisture, %	20.1	20.1	17.6	17.3	20.0	19.7	17.7	17.9
Grain yield, t/ha	8.5	7.8	10.0	9.8	10.3*	9.5	10.9*	9.9

* Analysis was done by Mixed model ANOVA (P<0.05)

- Agronomic characteristics varied among regions. However, within regions, the great majority of comparisons between MON 89034 × NK603 and the control did not result in significant differences
- Results from each region were consistent with no increase in weed potential for MON 89034 × NK603
  - Early stand, final stand, ear height, and grain yield differences were within the reference ranges (data not shown)
  - Grain yield differences may have resulted from intended lepidopteran pest protection of the MON 89034 event

Percentages of variability due to event and event interactions are low



Variance Component analysis

High variability due to testing conditions:
- Region, Study (Region) and Site(Region x Study)

Low variability due to event and event interactions:
- MON 89034, NK603, MON 89034 x NK603

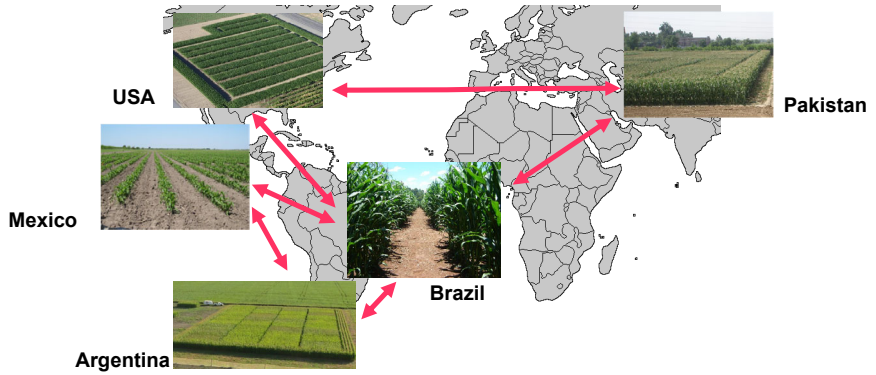
Summary

Conclusion of no increase of pest/weed potential on GM corns were consistent across diverse regions

- Similarity of Agronomic characterization was confirmed between GM corns and controls within regions was confirmed (great majority of comparisons not significant)
- Minimal event by region interactions for each GM product (<1% of total variability)

Conclusions

- Outcome of no increase of pest/weed potential on MON 89034, NK603 and MON 89034 × NK603 were consistent across multiple global regions
- The results support transportability of agronomic characterization data across different regions regardless of climate zone similarity



Thank you