Research Implementation with the MasAgro Program and Climate Change Research at CIMMYT

Ivan Ortiz-Monasterio

October 12, 2016

CIMMYT

Through collaborative research, partnerships and training, CIMMYT works throughout the developing world to improve livelihoods and foster more productive, sustainable farming.

OSS develops high-yield, disease-resistant, semi-dwarf wheat and shuttle breeding

Norman Borlaug is awarded the Nobel Peace Prize

CIMMYT scientists win the World Food Prize

1940s | 1950s | 1960s | 1970s | 1980s/1990s | 2000s | 2010s

The Office of Special Studies (OSS) is created

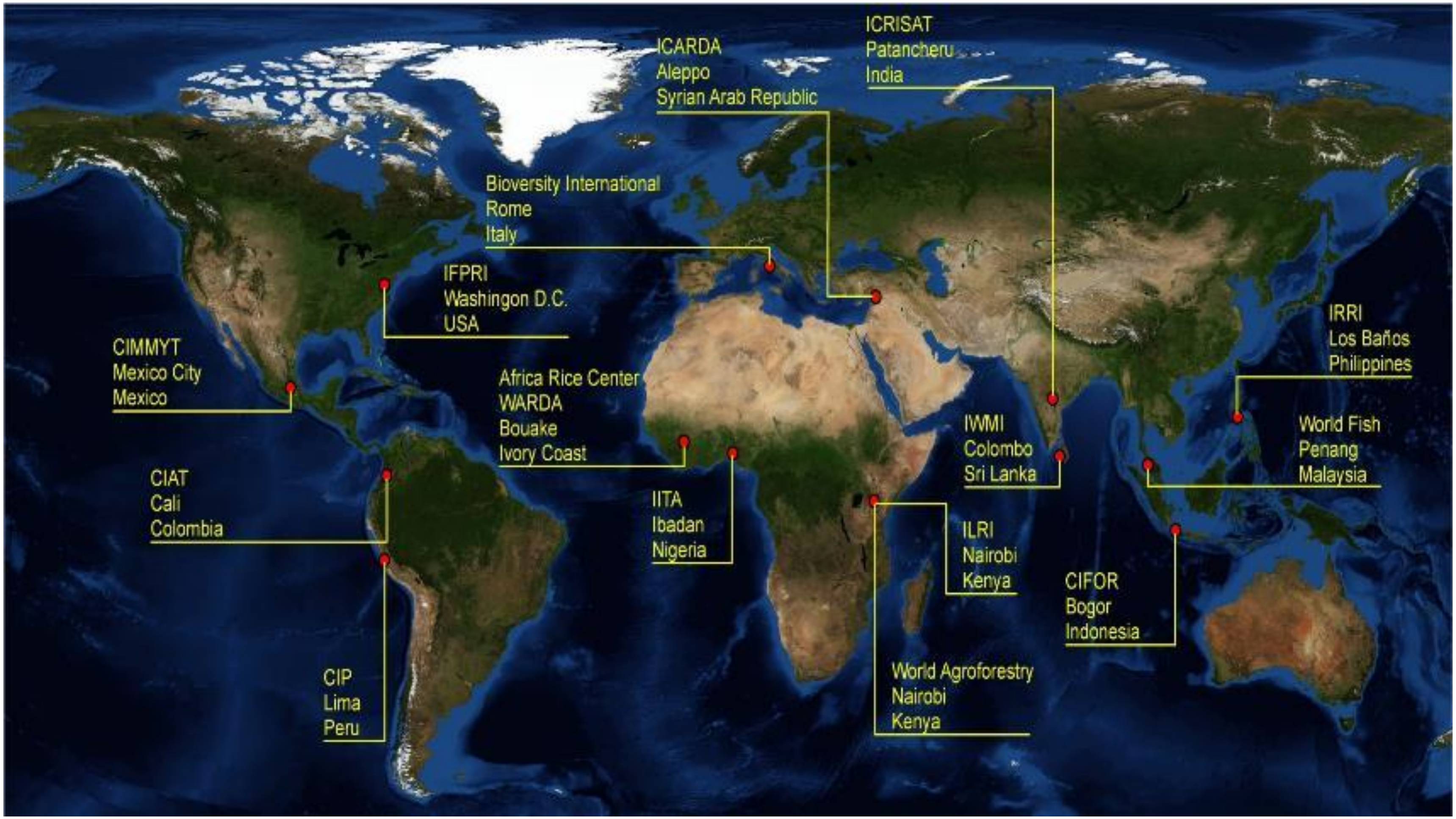
The Green Revolution in India and Pakistan

CIMMYT is officially founded

The Wellhausen-Anderson Plant Genetic Resources Center opens

CIMMYT responds to the food price crisis and expands globally

CIMMYT is Part of the CGIAR



1966 - 2016 CIMMYT
turning research into impact

Capacity Building

50,000 days training given each year.

Technical courses

Farmers' days

Workshops

PhD/MSc students

More than 10,000 scientific and professional alumni around the world.

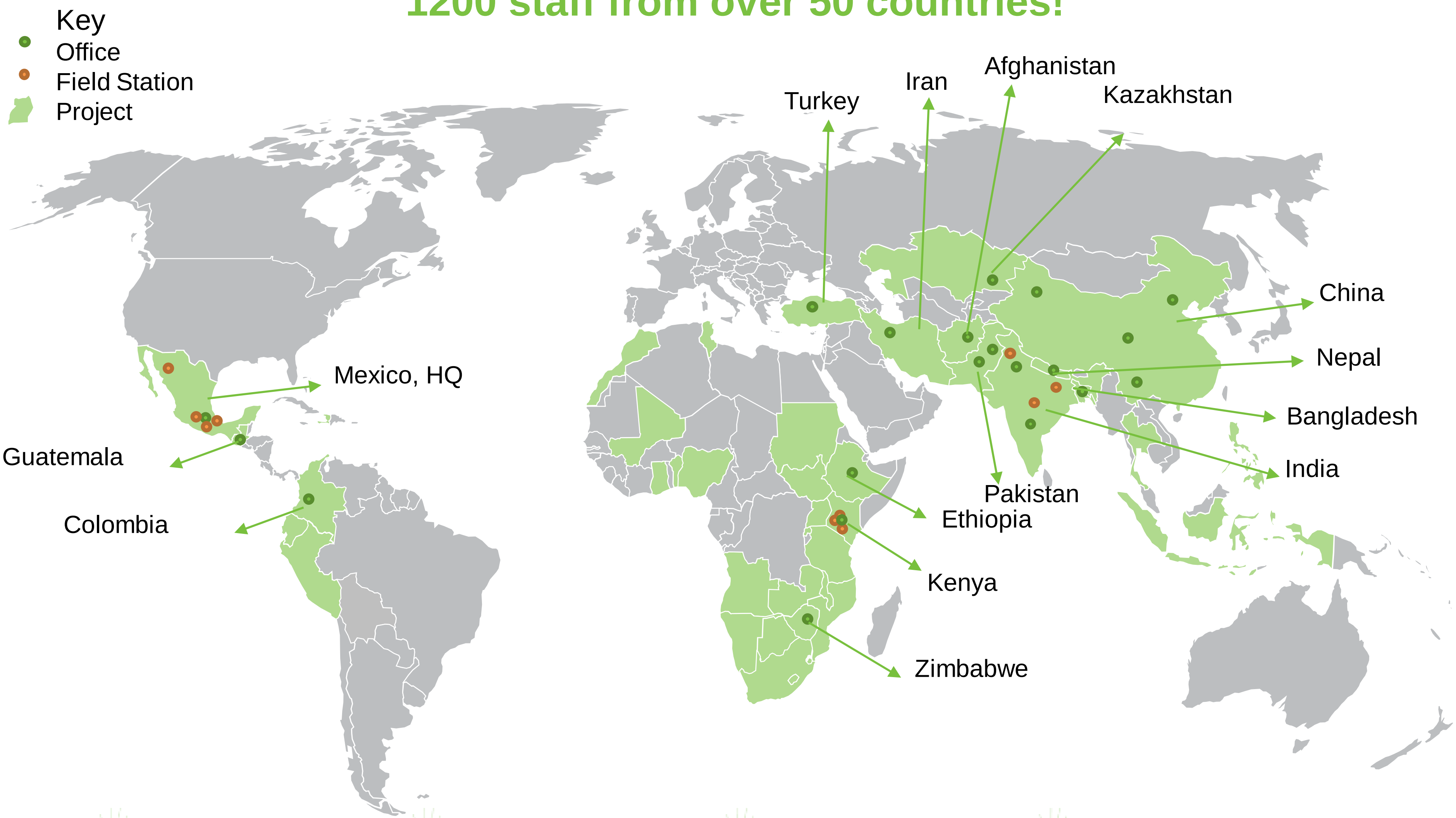
Basic Wheat Improvement Course, Ciudad Obregón, Mexico, March 2015

Farmers Mela, Jabalpur, India, September 2014

1966 - 2016 CIMMYT
turning research into impact

CIMMYT Around the World

1200 staff from over 50 countries!



Scientific Excellence

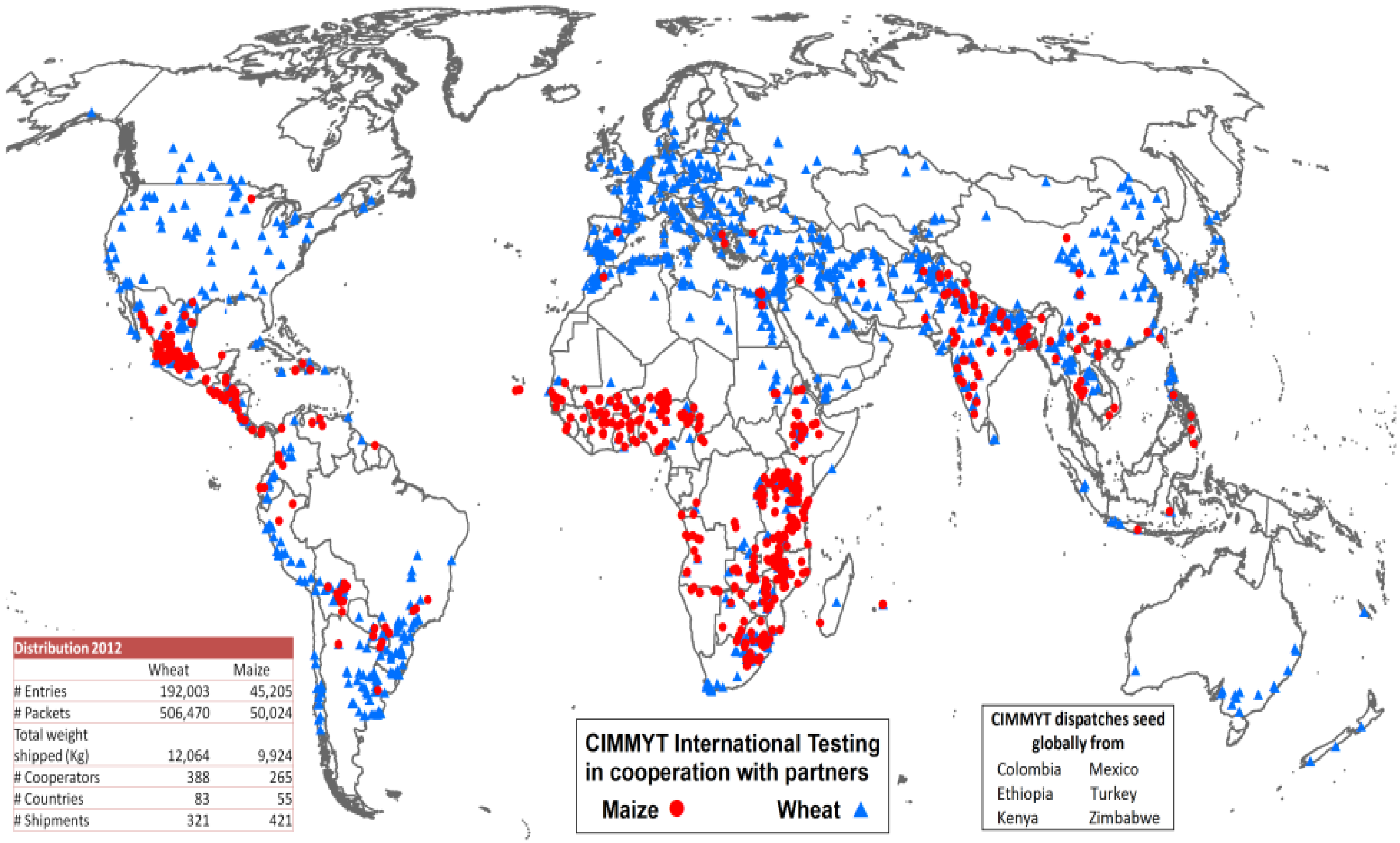
Genetic Resources
- Genebank & Bioinformatics
- Genetic resources, informatics, biometrics, seed health and distribution

Maize and Wheat Programs
- Improved Germplasm
- Breeding, phenotyping, seed systems

Sustainable intensification
- Conservation agriculture
- Agronomy, soil sciences, precision agriculture, mechanization

Socioeconomics
- Foresight, Targeting & Impact Assessment
- Socioeconomics & geographic information systems

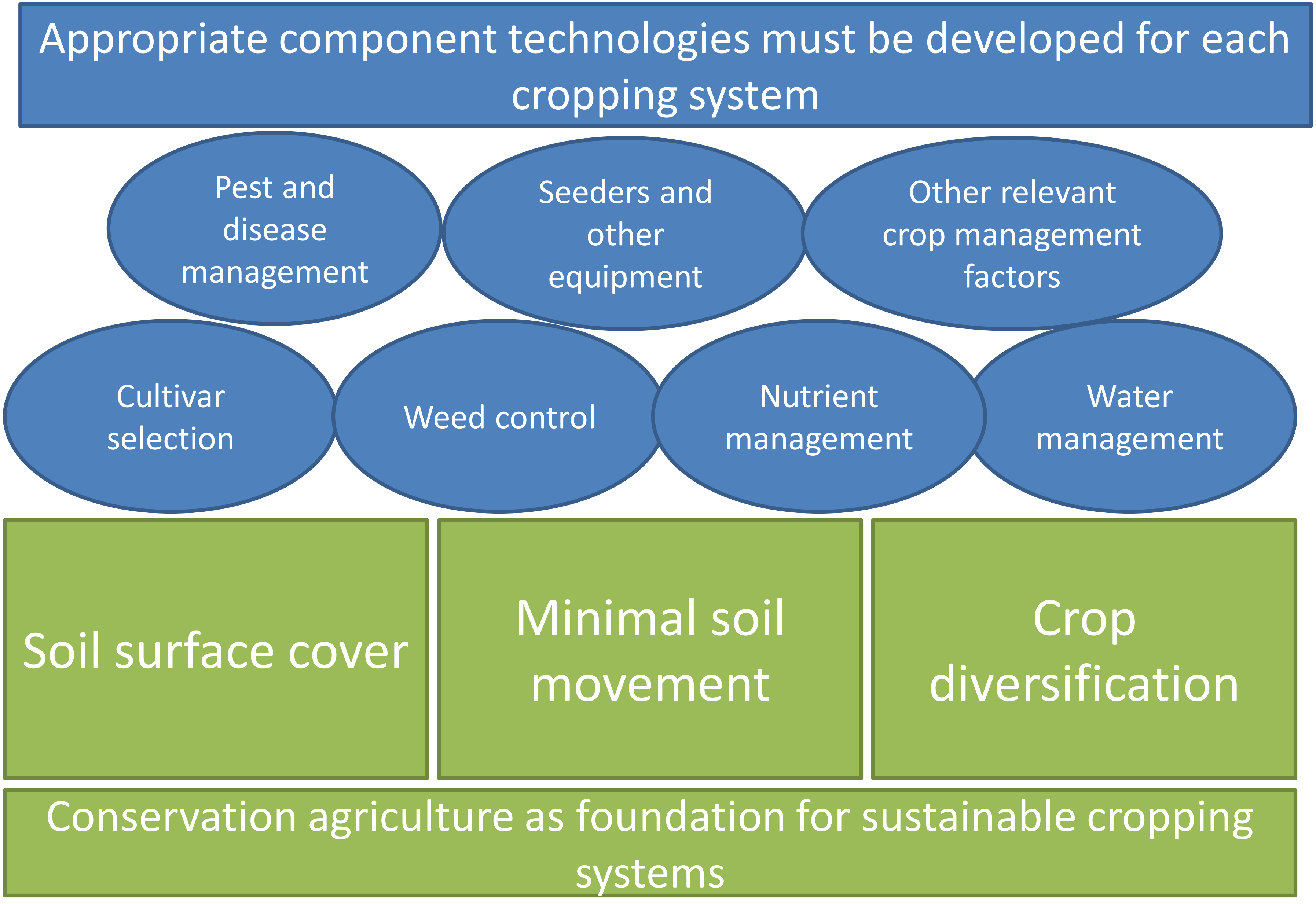
Global Seed Distribution Network



Distribution 2012

	Wheat	Maize
# Entries	192,003	45,205
# Packets	506,470	50,024
Total weight shipped (Kg)	12,064	9,924
# Cooperators	388	265
# Countries	83	55
# Shipments	321	421

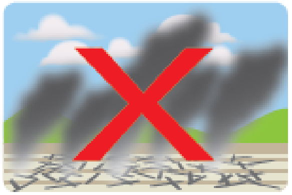
1966 - 2016 CIMMYT
turning research into impact


Appropriate component technologies must be developed for each cropping system
Pest and disease management
Seeders and other equipment
Other relevant crop management factors
Cultivar selection
Weed control
Nutrient management
Water management
Soil surface cover
Minimal soil movement
Crop diversification
Conservation agriculture as foundation for sustainable cropping systems

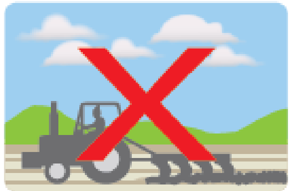
Strategic systems research

based on long-term and component technology trials in contrasting agro-ecological environments

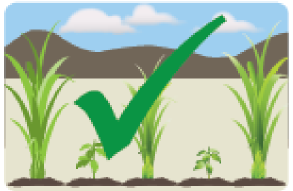
Conservation Agriculture Basic Principles



Residue retention
(no burning)



Zero tillage



Crop rotation

Conservation Agriculture Advantages:

- Savings in production costs
- Higher profitability
- Soil conservation
- CO_2 emission reductions
- Less water consumption
- Climate Change mitigation

* FAO. Basic data on Conservation Agriculture
http://www.fao.org/news/story/es/item/9962/icode/

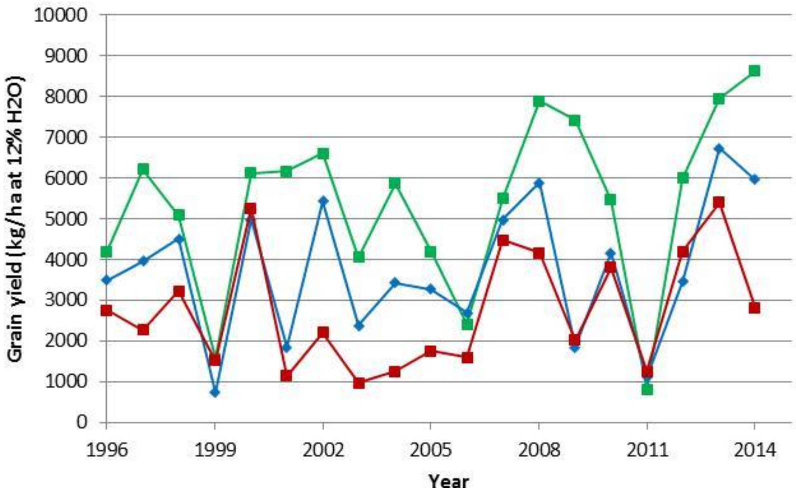
50%
average reduction in
farm work

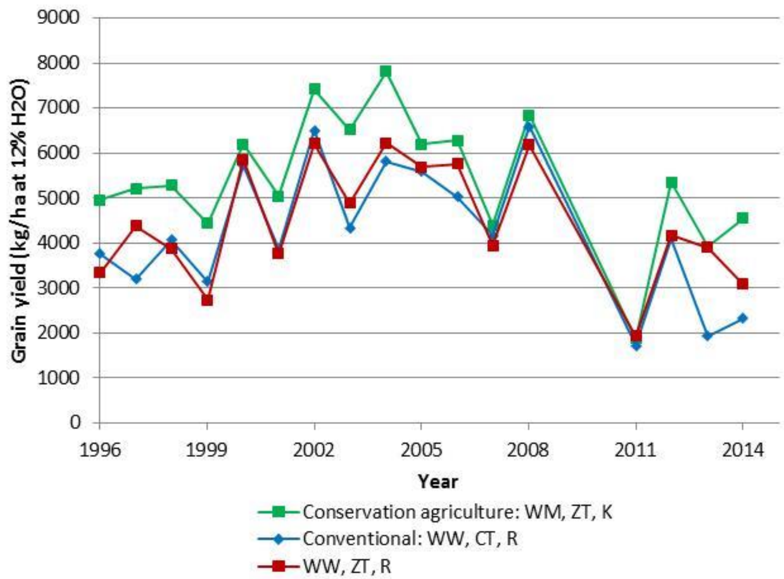
70%
drop in
fossil fuel consumption

0.5
ton/ha
CO_2 sequestration

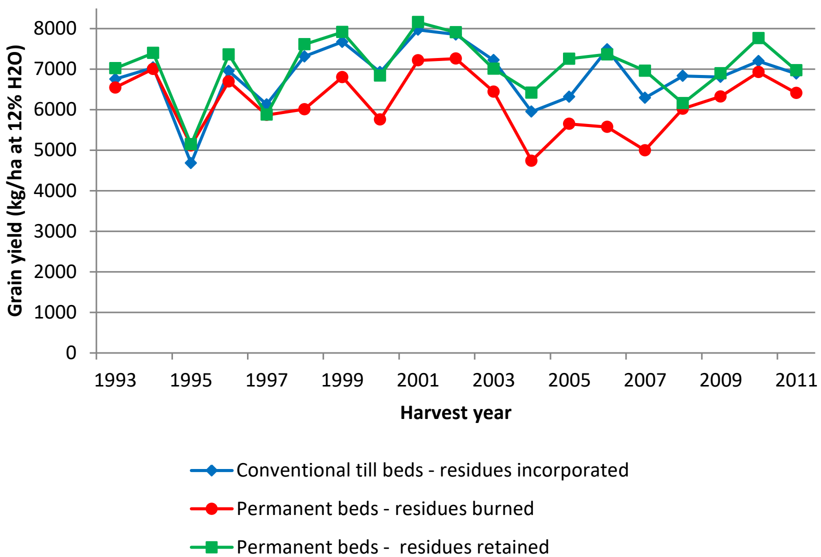
LTT: yield results

El Batan: rainfed maize and wheat



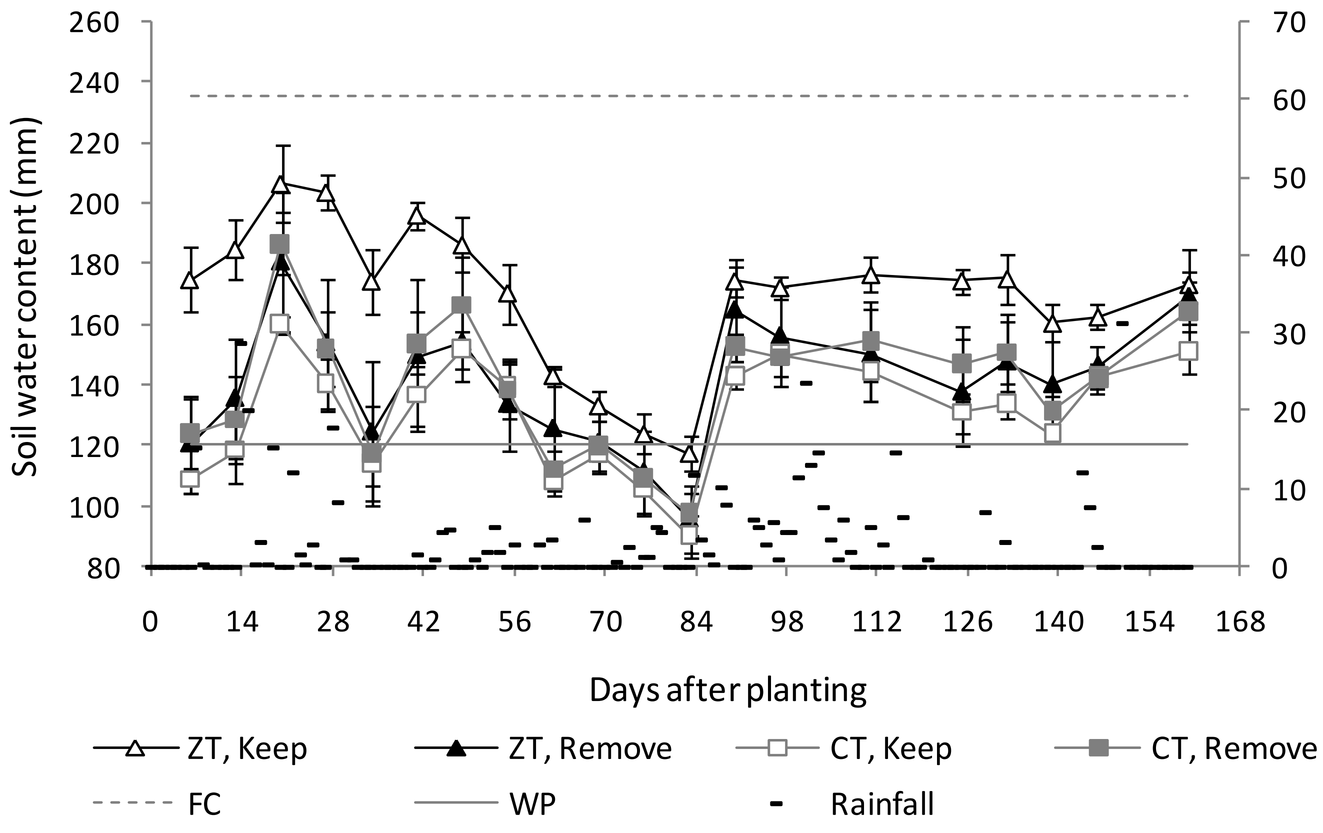


Ciudad Obregón: irrigated wheat



Rainfed conditions in central Mexico

- Soil water content (0-60 cm) in 2009 season (with severe drought 30-83 days after planting)



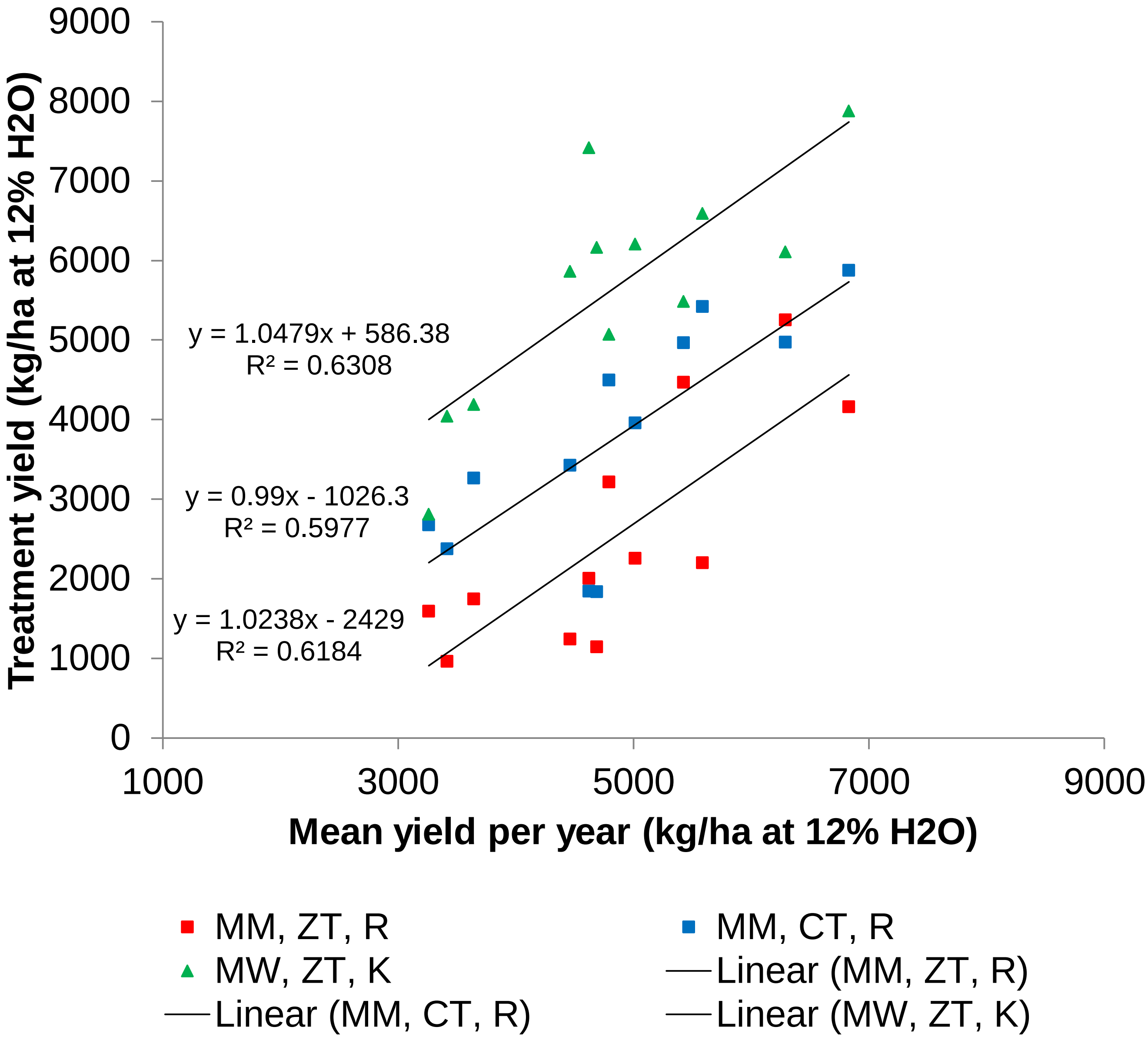
Rainfed conditions in central Mexico

- Maize yield (t ha^{-1} at 12% H_2O)

Management practice	2008		2009		1997-2009	
ZT, Keep	7.88 (0.20)	a	7.42 (0.63)	a	5.65 (0.02)	a
ZT, Remove	5.65 (1.26)	a	3.63 (0.30)	b	4.43 (0.27)	b
CT, Keep	6.65 (0.11)	a	2.71 (0.17)	b	4.59 (0.05)	b
CT, Remove	7.18 (0.96)	a	3.28 (0.67)	b	4.31 (0.23)	b

Conservation agriculture

Farmer practice



Verhulst et al., 2011

Componentes e **Impacto** del Programa **MasAgro** en México

CIMMYT MR

MasAgro
Modernización Sustentable de la Agricultura Tradicional

Investigación sobre la composición genética de las semillas para aprovechar la biodiversidad

Investigación para elevar el potencial de rendimiento del trigo

Desarrolla y distribuye semillas de maíz (criollos, variedades e híbridos) y fortalece las capacidades de la industria semillera nacional

Investigación y desarrollo colaborativo de tecnologías sustentables, adaptación, entrenamiento y extensionismo para fortalecer los sistemas de innovación agrícola

SAGARPA
SECRETARÍA DE AGRICULTURA, GANADERÍA, DESARROLLO RURAL, PESCA Y ALIMENTACIÓN

CIMMYT
International Maize and Wheat Improvement Center

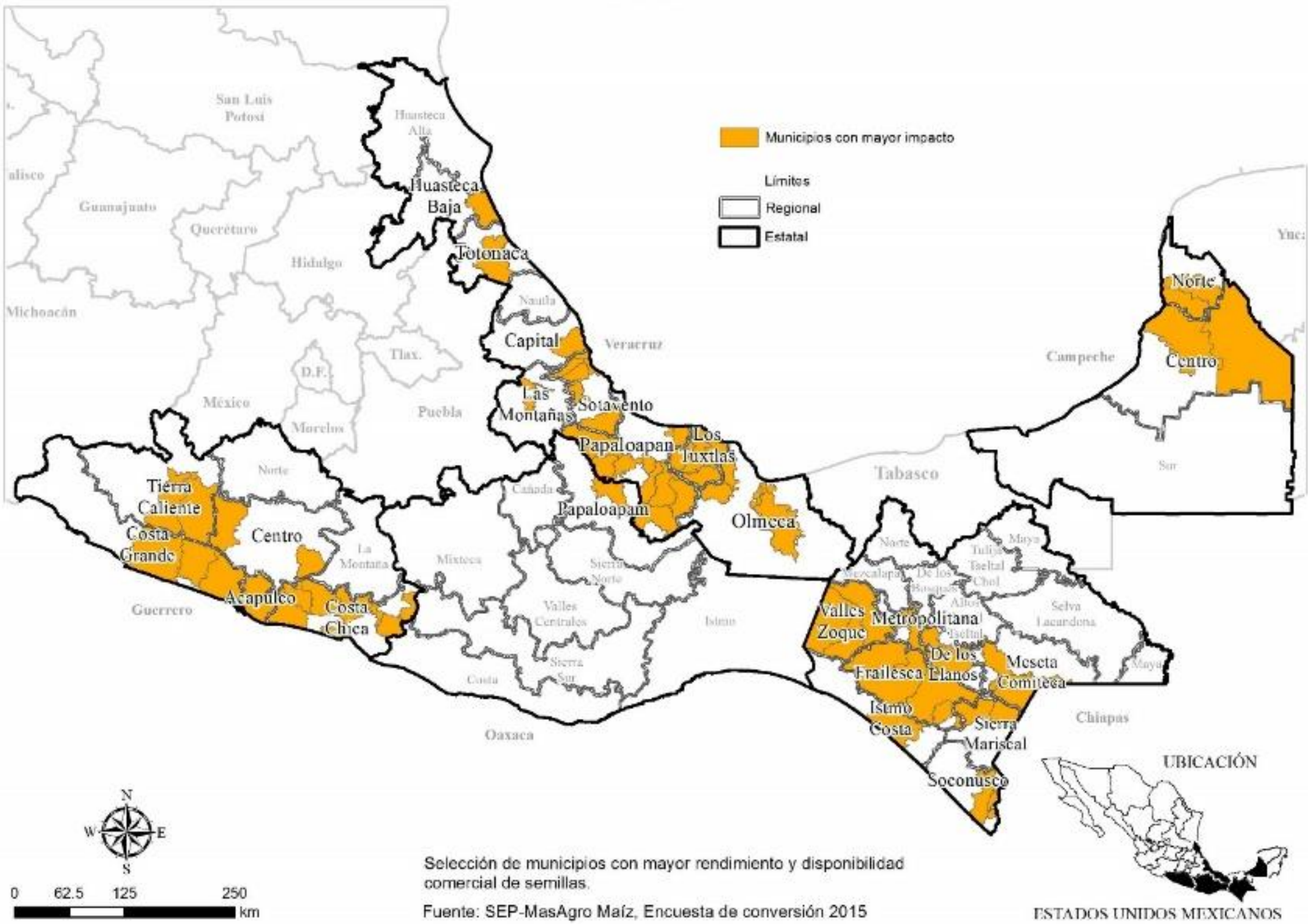
Oportunidad: biodiversidad

MasAgro Biodiversidad aprovecha los recursos genéticos del maíz y del trigo para beneficio de México.

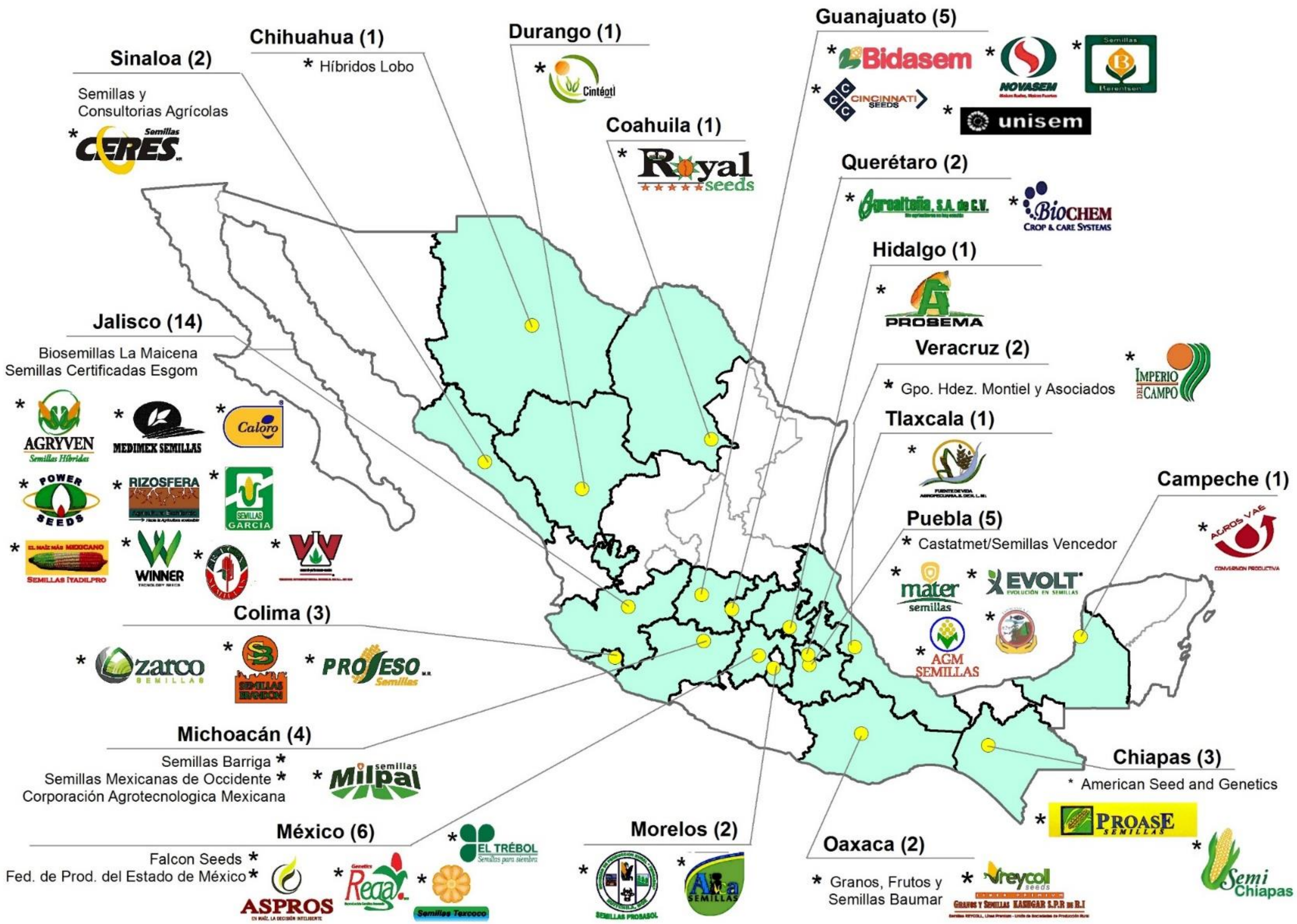
CIMMYT

Oportunidad: duplicar el uso de semilla mejorada

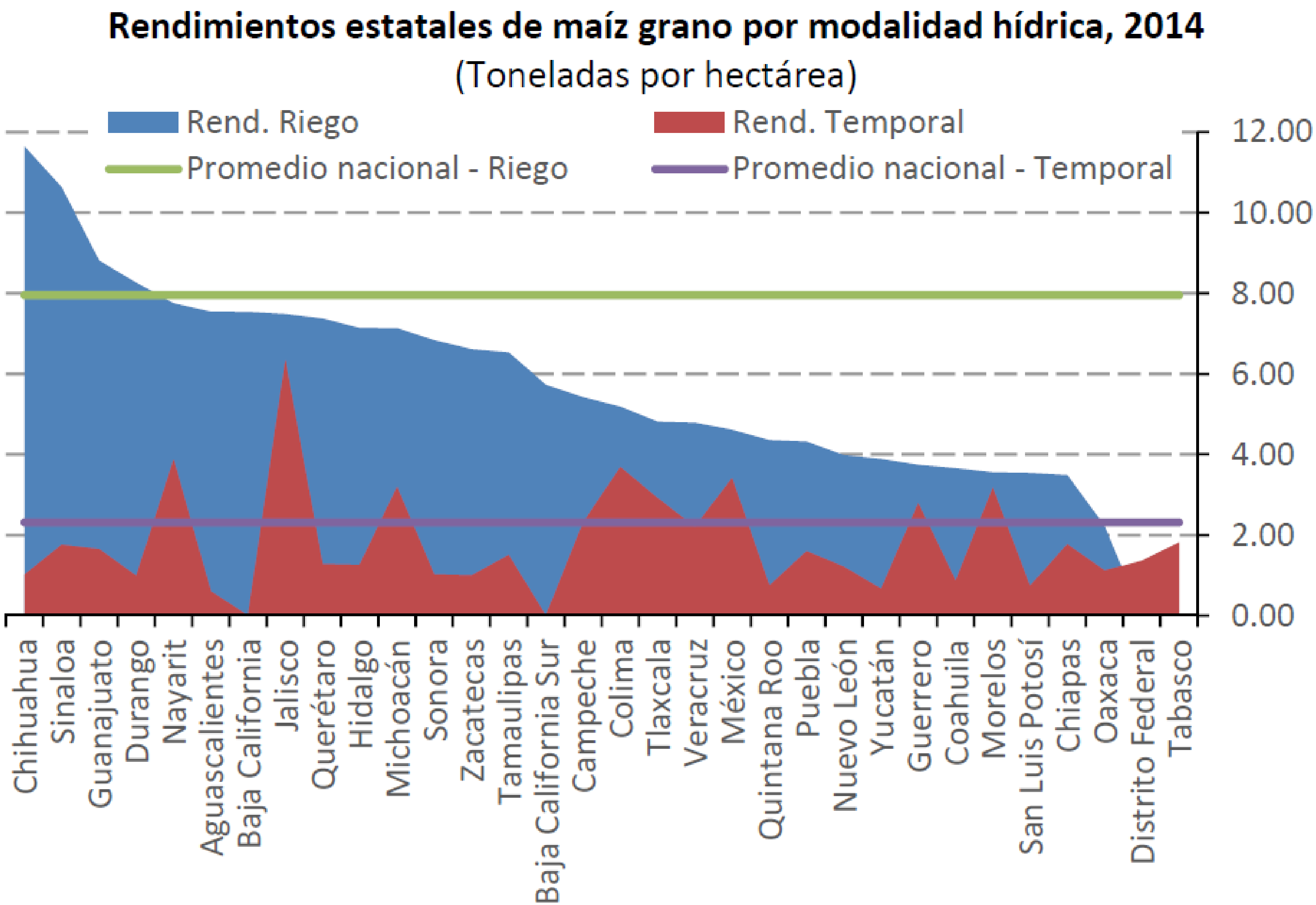
Regiones y municipios donde se puede tener mayor impacto con los híbridos
690,500 ha



Fortalezas: 56 compañías en 18 estados



Reto: cerrar brechas de productividad



Fuente: SIAP-SAGARPA.

Cultivar semillas mejoradas sin agronomía es como correr un auto deportivo en terracería.

CIMMYT

Tecnologías para una Intensificación Sustentable

- Variedades adaptadas de Maíz y Trigo
- Herramientas de diagnóstico para Nitrógeno, Fósforo y Potasio
- Fertilización Integral
- Agricultura de Conservación
- Maquinaria inteligente
- Tecnología post-cosecha
- Tecnificación de riego
- Tecnologías de la información y la comunicación para la agricultura (ICT4Ag)
- Diversificación y acceso a mercados
- Otras herramientas y tecnologías (control integral de plagas, crédito y seguros agrícolas…)

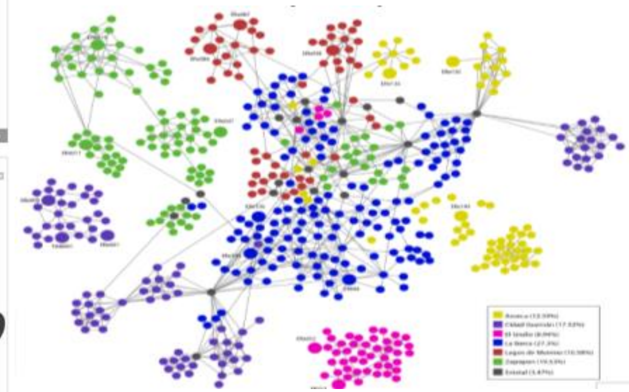




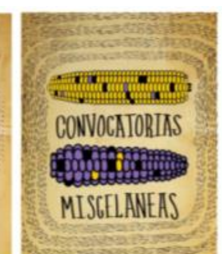

Investigación orientada a innovación e impacto

Captura de datos, sistematización, análisis y monitoreo / Bitácora electrónica, Conservation Earth y otras herramientas M&E

Redes de innovación */Mapeo de nodos de innovación*



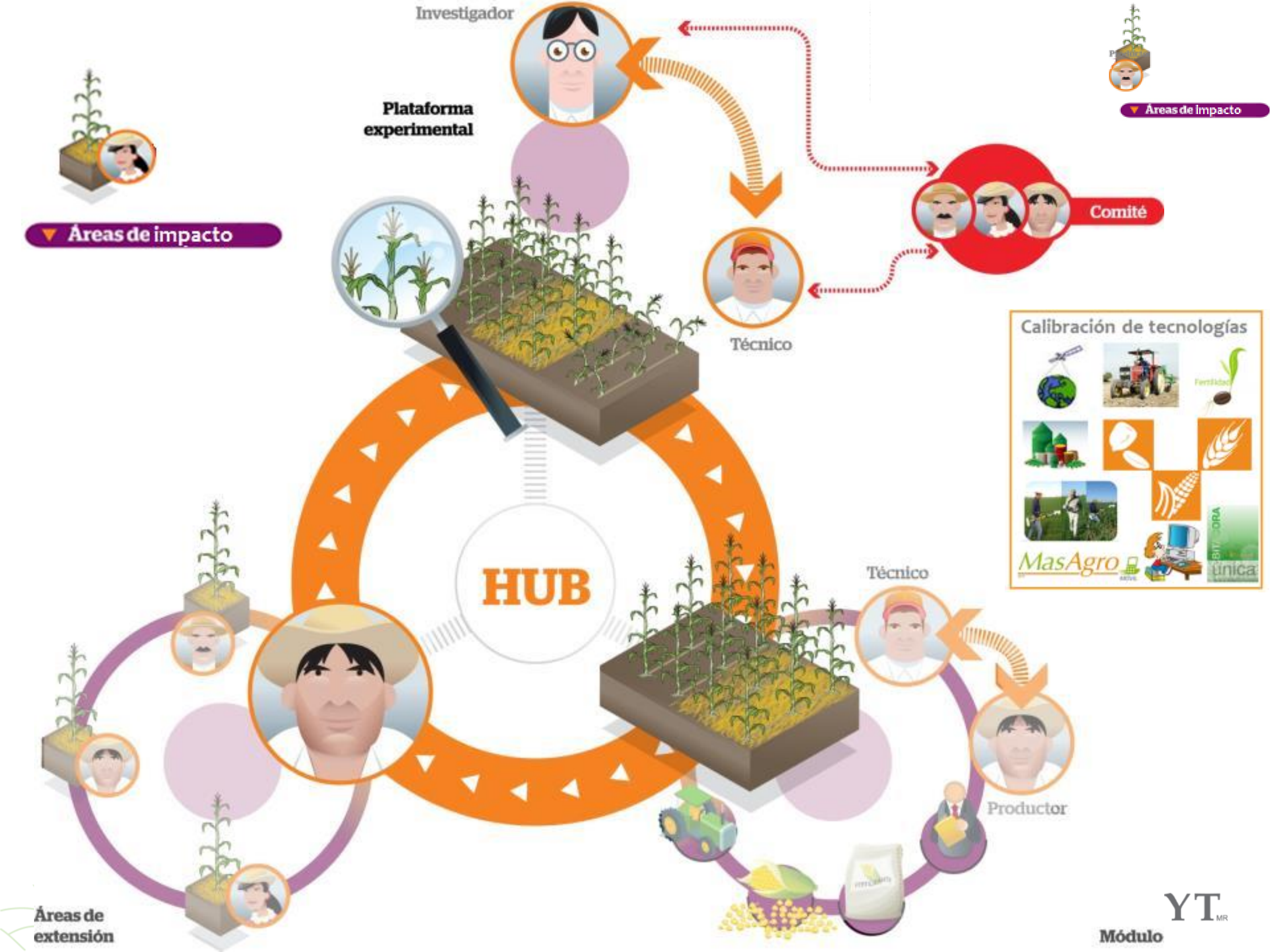
Capacitación y herramientas/ Agricultura Sustentable, Producción de cultivos, Fertilidad,Poscosecha,



DoctorMaíz DoctorTrigo

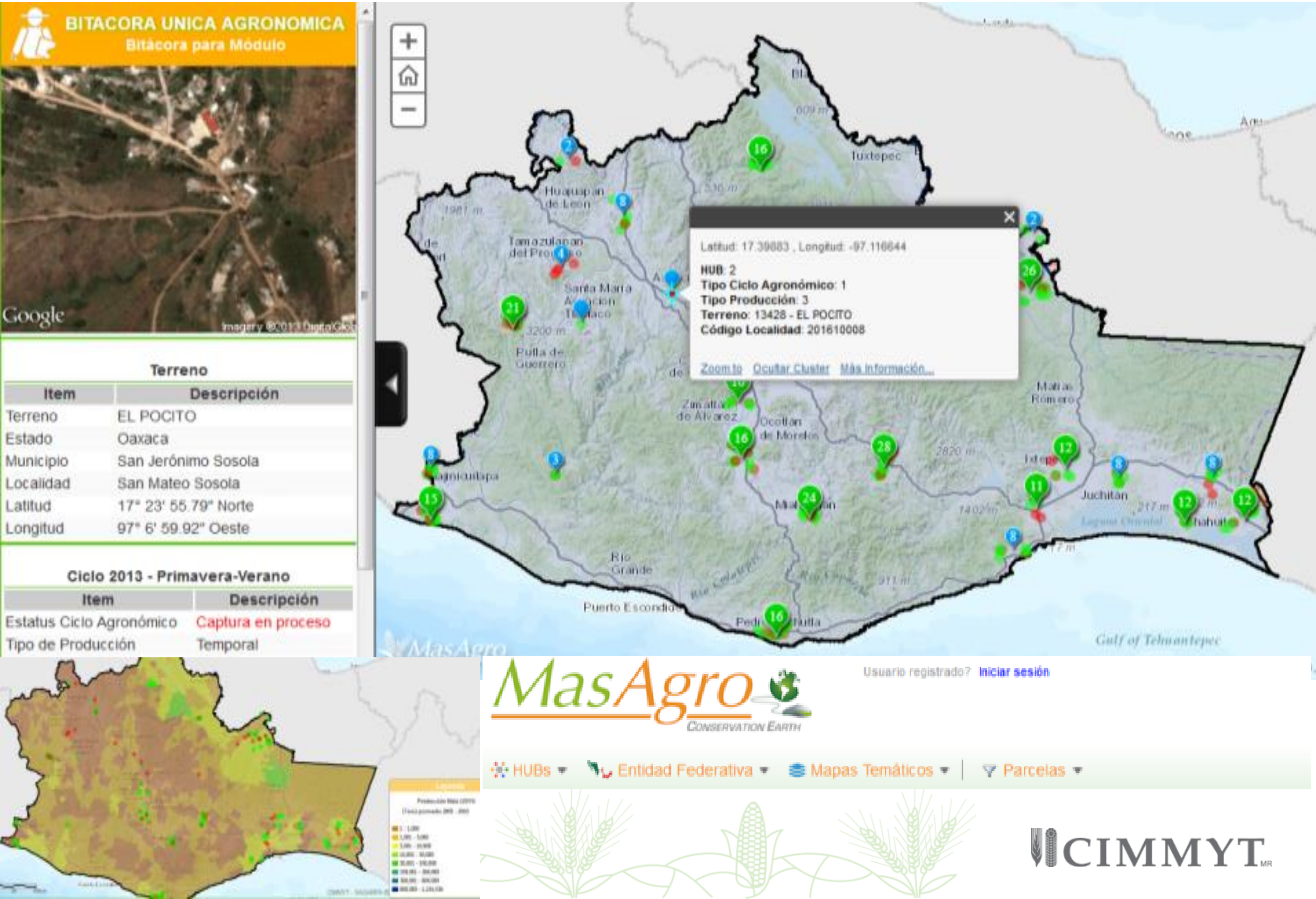
Agricultura de precisión */GreenSeeker, GreenSat, Mecanización Inteligente*

Comunicación 4D&I /Boletines, celulares, redes sociales, teatro, audiovisual, infografías, comics…



Investigador
Plataforma experimental
Técnico
Comité
Áreas de impacto
Áreas de impacto
Calibración de tecnologías
MasAgro
única
HUB
Técnico
Productor
Áreas de extensión
Módulo

Información geo-referenciada en tiempo real para el mapeo de parcelas y rendimientos



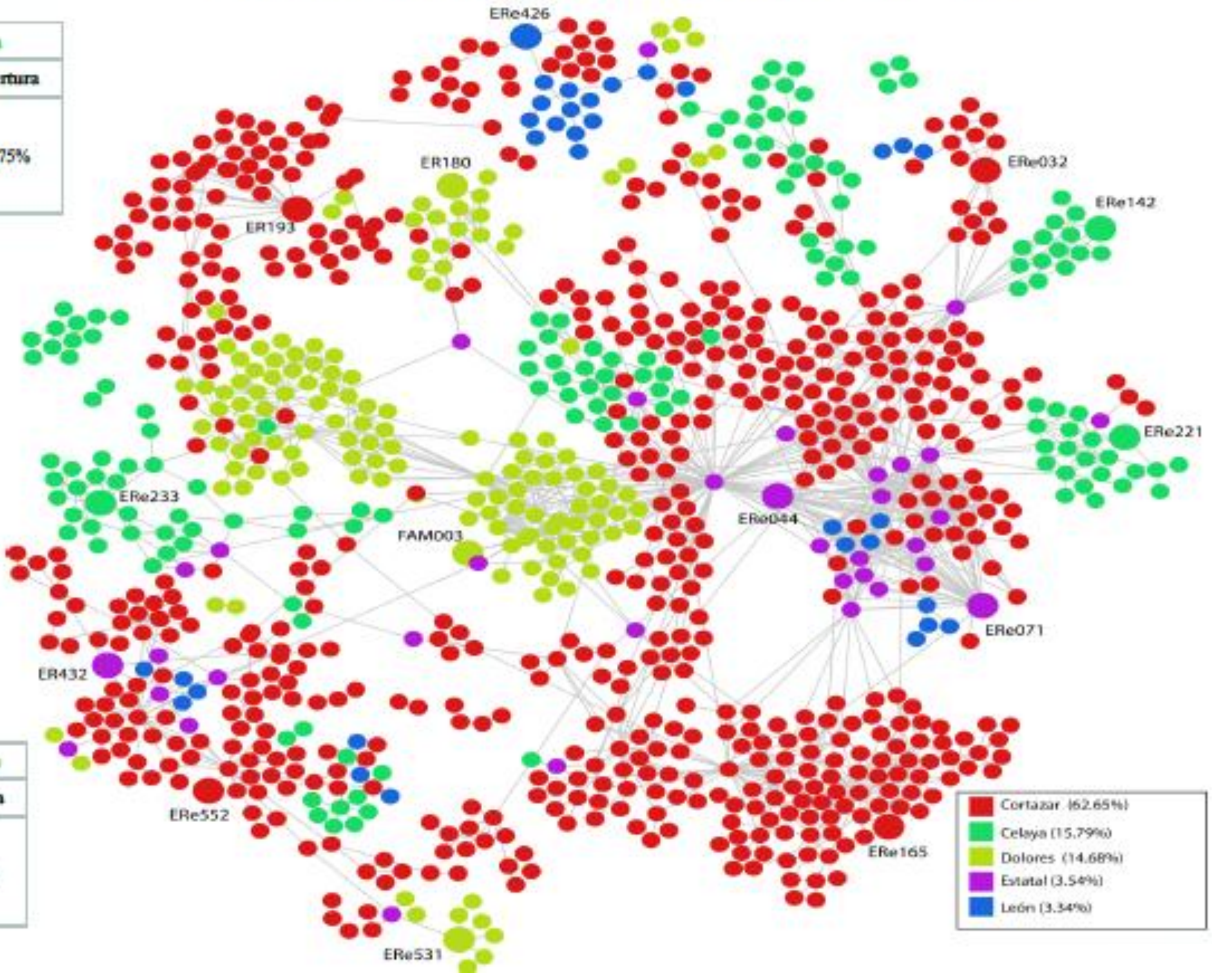
Mapeo de redes de innovación

La cobertura es el alcance que tienen los productores clave en la red

DDR Celaya	
ID	Cobertura
ERe142	9.75%
ERe221	
ERe233	

DDR León	
ID	Cobertura
ER071	11.53%
ER432	
ERe426	

DDR Dolores Hidalgo	
ID	Cobertura
ER180	5.96%
ER397	
FAM003	



DDR Cortázar	
ID	Cobertura
ER193	7.25%
ERe032	
ERe044	
ERe165	
ERe552	

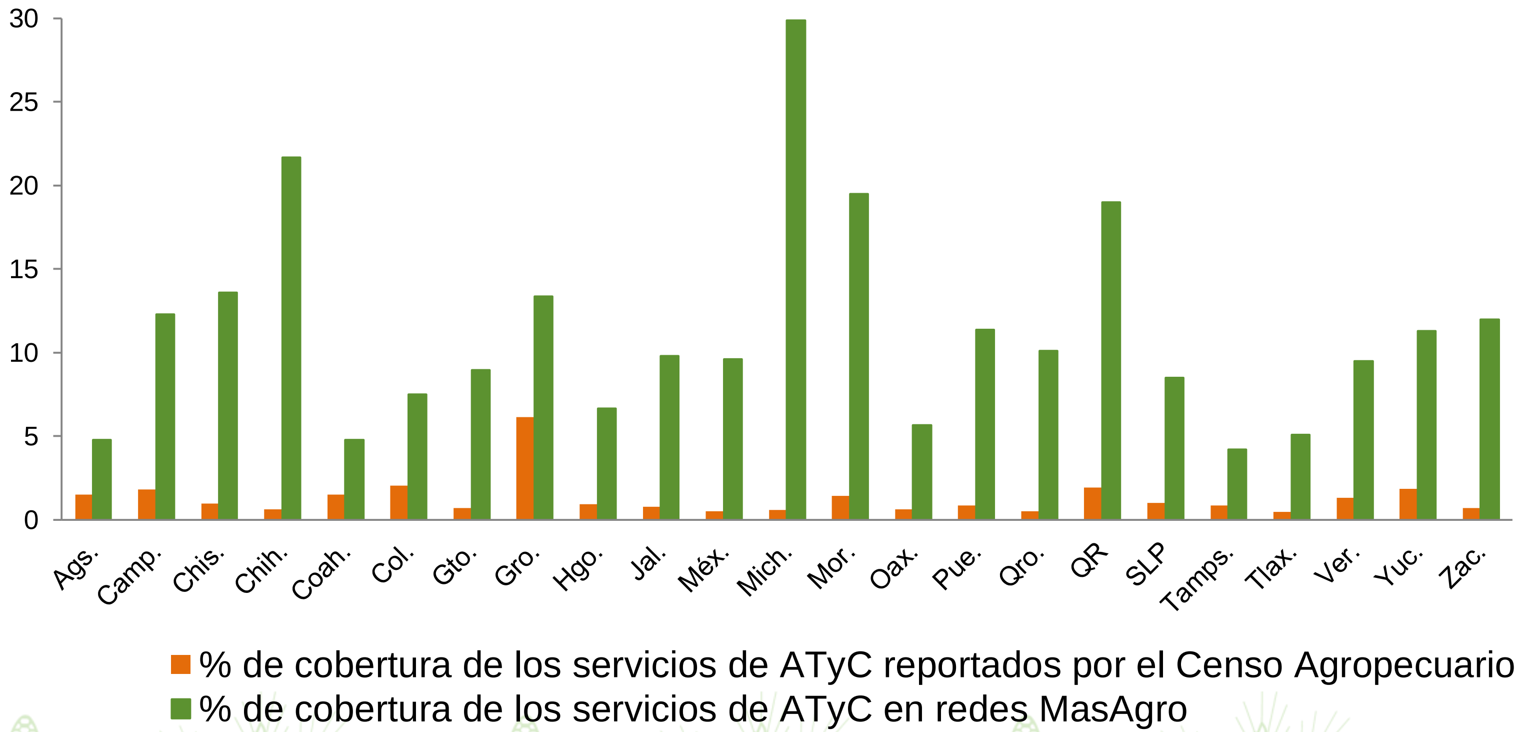
"Con los productores seleccionados en los DDR se alcanza una cobertura promedio del 8.6%"

Asistencia Técnica

La selección tradicional de productores logra coberturas promedio de Asistencia Técnica de 1.3% de las Unidades Productivas Rurales.

Los productores seleccionados en MasAgro logran coberturas promedio de Asistencia Técnica de 11.3% de las Unidades Productivas Rurales.

✓ Mayor eficiencia de los recursos públicos



CIMMYT

Rendon et al., CIESTAAM

Impacto en el campo de los productores mexicanos

Rendimiento promedio aumentó en **maíz 21%** y **trigo 3%**; **ingreso** promedio aumentó entre un **4%** y un **25%**

+400 entrenadores entrenados -> +310 técnicos certificados -> **+2,500 técnicos** (22% mujeres) con cobertura estimada de 17,000 productores

11.3% cobertura promedio de **asistencia técnica,**10 veces superior a la media nacional

+300 mil productores participan en MasAgro (21% mujeres)

+970 mil has de impacto

Solo en México, **100 millones USD** ingresos adicionales para el campo

Potencial → Real

CIMMYT[MR]

Más de 150 colaboradores


Yaqui Valley

LANDSAT
January, 11
2001


Yaqui Valley
230,000 has
160,000 wheat
Safflower, maize, garbanzo, alfalfa, vegetable crops
y citrus trees
Agro ecologically representative of environments where 40%
of the wheat is produced in the developing world

An example of adaptation to climate change in wheat in Mexico

CIMMYT

MEXICO

Published online February 6, 2007

Impacts of Day Versus Night Temperatures on Spring Wheat Yields: A Comparison of Empirical and CERES Model Predictions in Three Locations

David B. Lobell* and J. Ivan Ortiz-Monasterio

ABSTRACT

Trends in recent temperature observations and model projections of the future are characterized by greater warming of daily minimum (tmin) relative to maximum (tmax) temperatures. To aid understanding of how tmin and tmax differentially affect crop yields, we analyzed variations of regional spring wheat yields and temperatures for three irrigated sites in western North America that were characterized by low correlations between tmin and tmax. The crop model CERES-Wheat v3.5 was evaluated in each site and used to project future response to temperature changes. Tmin and tmax exhibited distinct historical correlations with yields, with CERES successfully capturing the observed relationships in each region. In the Yaqui Valley of Mexico, historical yields were strongly correlated with tmin but not tmax. However, CERES projections of response to increased tmin or tmax (holding other variables constant) were similar (~6% °C^{-1}), indicating that the apparent historical importance of tmin mainly results from covariation between temperatures and solar radiation and not greater direct effects of tmin on yields. In the San Luis-Mexicali Valley of Mexico and in the Imperial Valley of California, the opposite was observed: historical yield correlations with tmin and tmax were similar, but projected responses to tmax were roughly three times larger than tmin. The latter is explained by opposing effects of tmin and tmax on grain filling rates in CERES, with higher tmin increasing harvest indices. This model mechanism was not clearly supported by historical data and remains an area of uncertainty for projecting yield responses to climate change.

dition, impacts of extreme hot or cold temperatures, such as winterkill in wheat or spikelet sterility in rice, depend on changes in daily extremes (Ziska and Manalo, 1996; Porter and Gawith, 1999).

Models capable of simulating the crop yield response to temperature and other environmental factors are useful tools to anticipate the impacts of climate change and to develop appropriate responses. Commonly used models of the major cereal crops, such as the models included in the DSSAT software (Jones et al., 2003), consider the effect of temperature on rates of several processes affecting crop yields. These processes include vernalization, crop phasic development, leaf appearance and expansion rates, photosynthesis and respiration, evapotranspiration, and grain filling (Ritchie and NeSmith, 1991; Wilkens and Singh, 2001).

Several studies have used crop models to investigate the impacts of asymmetric warming on rainfed crops in the USA. Rosenzweig and Tubiello (1996) compared the effects of tmin and tmax on winter wheat in the central USA using CERES-Wheat and found that, for identical changes in average temperatures, increasing tmin more than tmax resulted in higher simulated yields than when increasing both by equal amounts. This disparity was attributed to reduced winterkill in experiments with

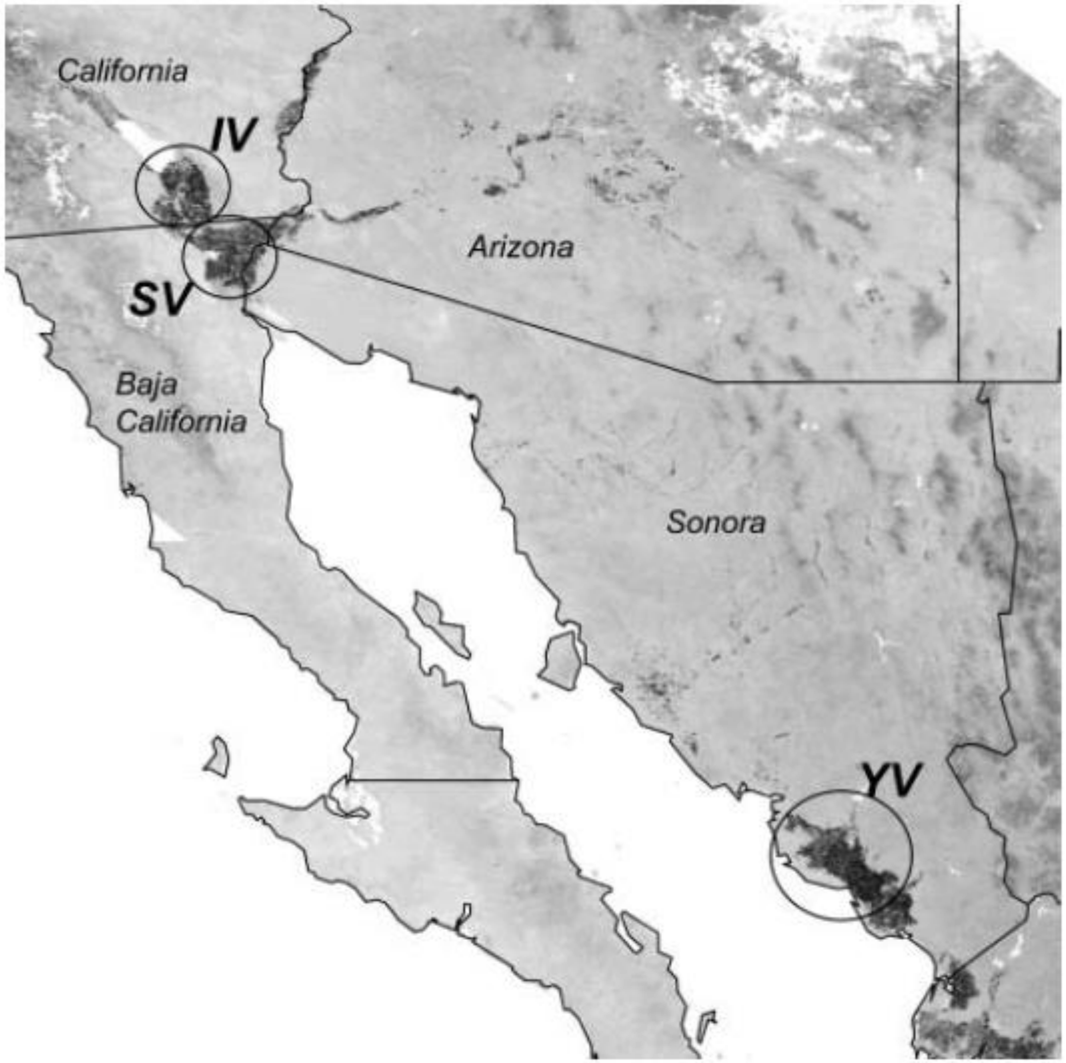


Fig. 2. Study site locations shown on an enhanced vegetation index from the Moderate Resolution Imaging Spectroradiometer image from March 2006. Dark pixels indicate higher values of enhanced vegetative index corresponding to dense vegetation, which are mostly wheat crops in this region at this time of year.

Predictions of the Empiric Model (Regression) vs CERES 1980 to 2004

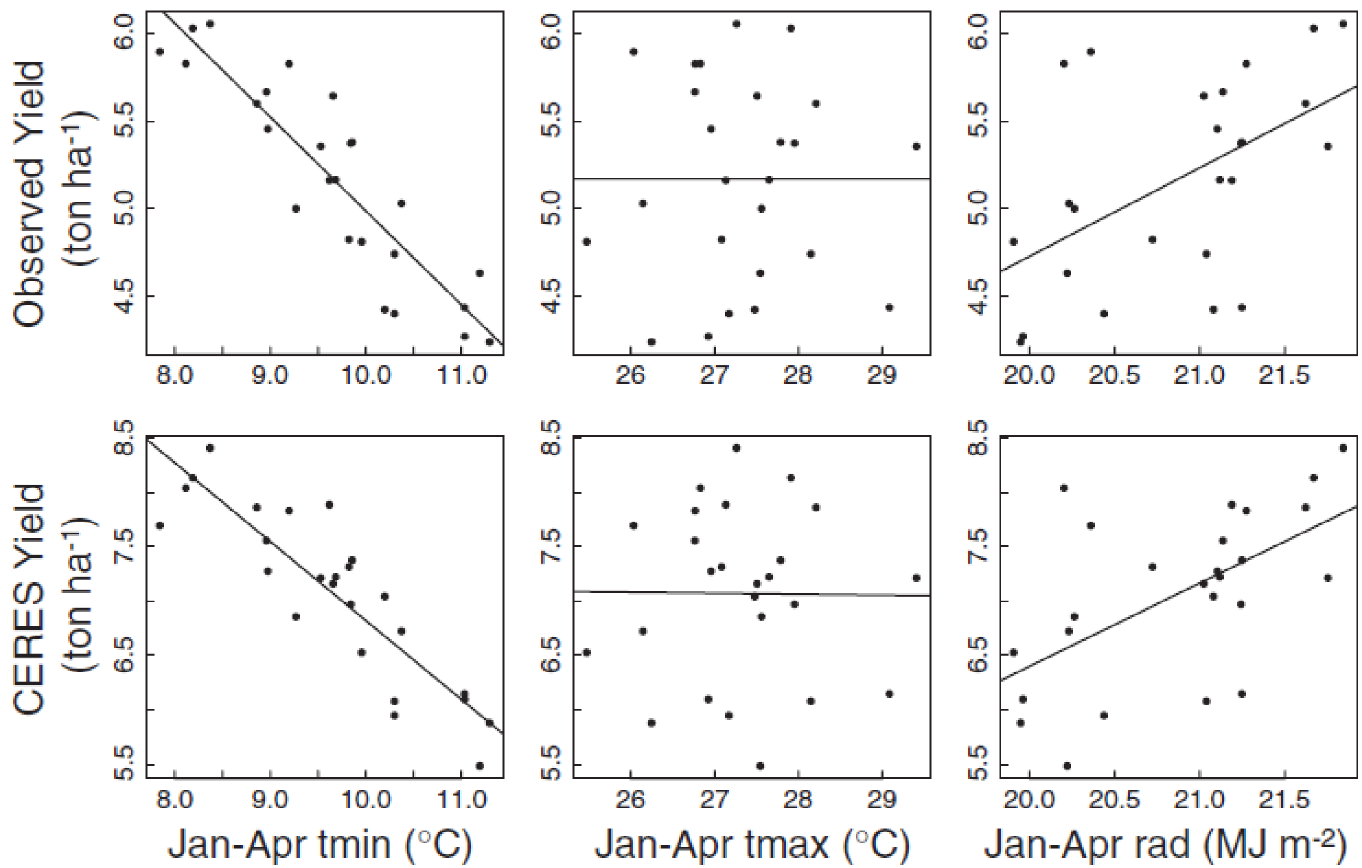
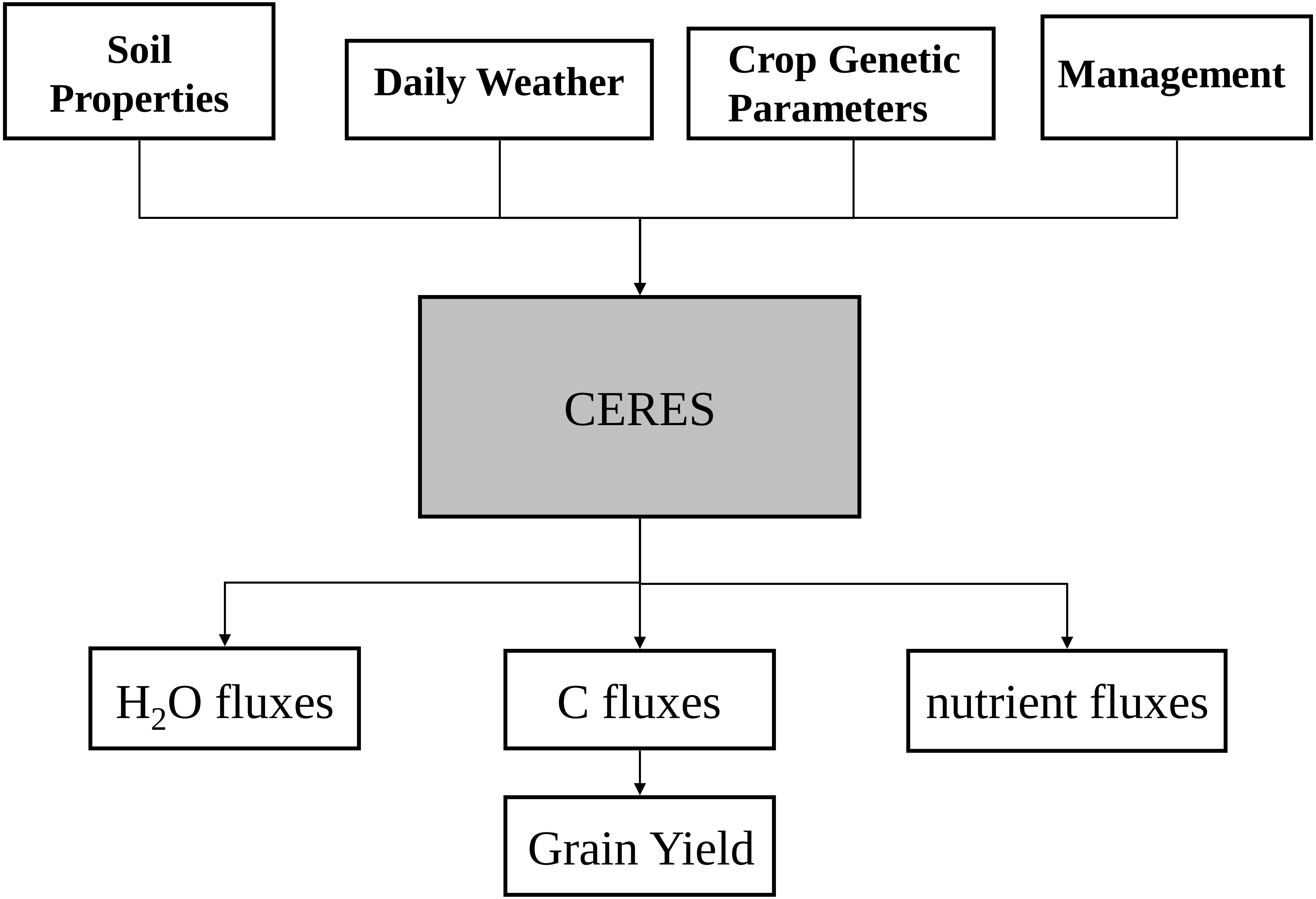


Fig. 4. January–April average daily minimum temperature (tmin), daily maximum temperature (tmax), and solar radiation (rad) vs. observed (top) and CERES-simulated (bottom) yields in YV.

Modeling Crop Production with CERES



Less than a 3% difference between the predictions of symmetric warming of 1 º C between the empiric models vs CERES

Table 8. Modeled impact of 1°C temperature increase using empirical and CERES models.

		Simulated avg. yield change (%)		
Site†	Temperature scenario	Empirical model‡	CERES	Difference
YV	Δtmin = 1, Δtmax = 1	−10.4 (−13.5, −7.0)	−12.0	1.6
	Δtmin = 2, Δtmax = 0	−17.0 (−23.2, −11.6)	−11.7	−5.3
	Δtmin = 0, Δtmax = 2	−4.0 (−9.4, 1.3)	−12.2	7.8
SV	Δtmin = 1, Δtmax = 1	−9.1 (−15.3, −0.6)	−6.9	−2.2
	Δtmin = 2, Δtmax = 0	−4.2 (−16.2, 7.7)	−3.6	−0.6
	Δtmin = 0, Δtmax = 2	−12.0 (−23.4, 1.0)	−10.3	−1.7
IV	Δtmin = 1, Δtmax = 1	−6.6 (−11.2, −3.2)	−7.0	0.4
	Δtmin = 2, Δtmax = 0	−2.9 (−6.5, 1.6)	−3.2	0.3
	Δtmin = 0, Δtmax = 2	−10.1 (−16.6, −4.0)	−10.8	0.7

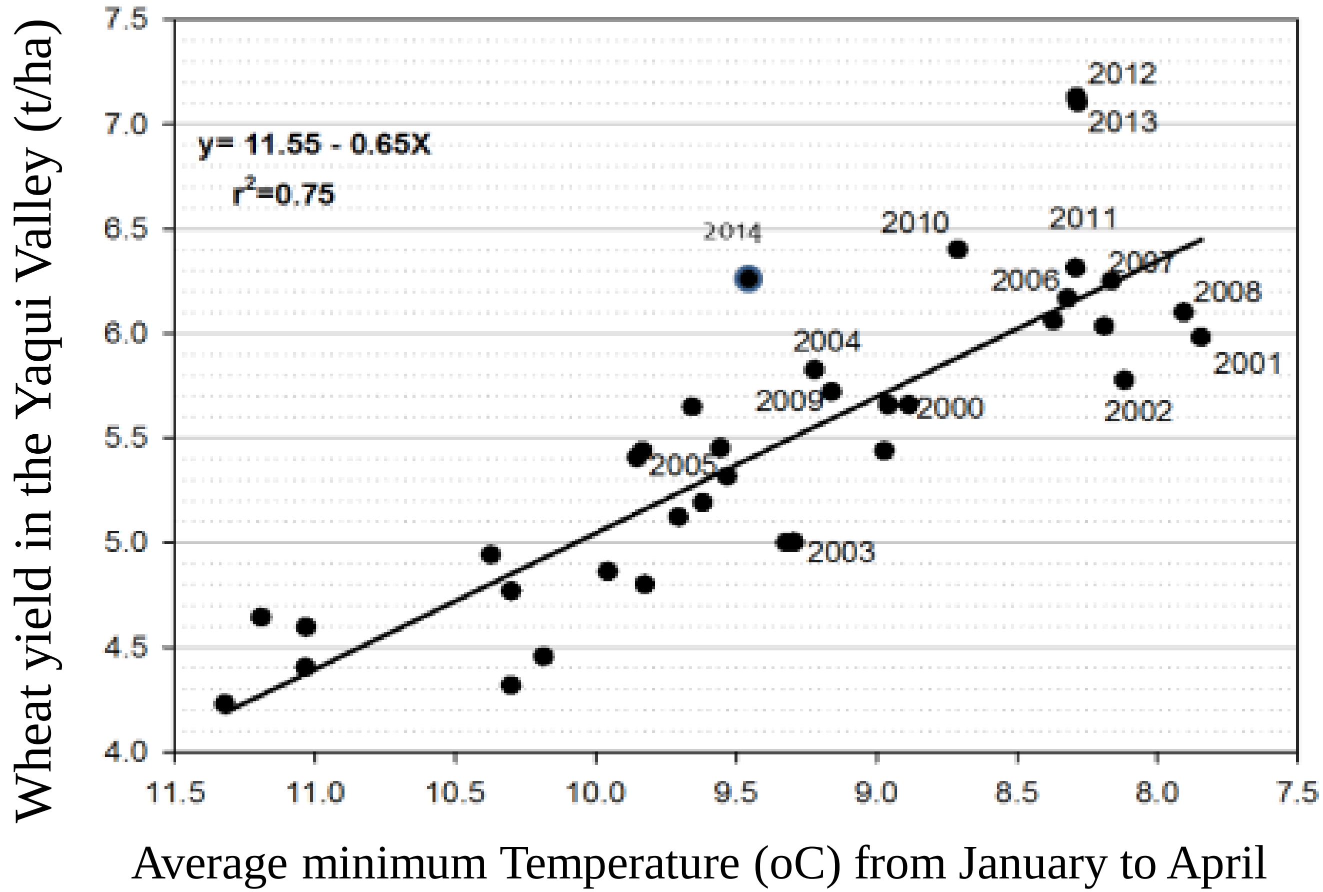
† IV, Imperial Valley, California; SV, San Luis and Mexicali Valleys, Mexico; YV, Yaqui Valley, Mexico.

‡ Empirical models are summarized in Table 6. Confidence intervals for empirical models (shown in parentheses) were estimated by repeating regression for 100 bootstrap samples of historical data.

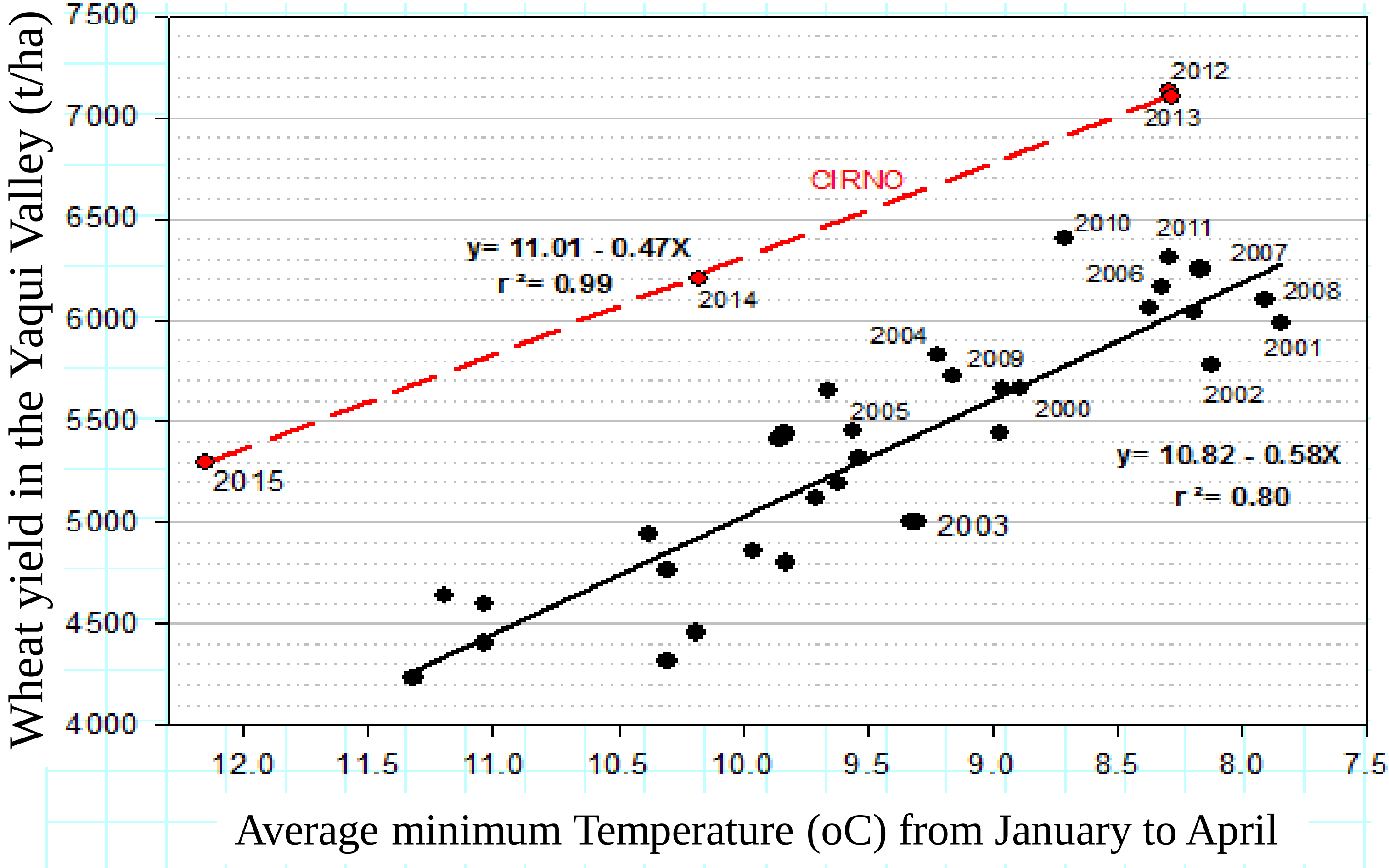
CONCLUSIONS

- Wheat production in this region is very vulnerable to increments in temperature.
- Each increment of 1 ^{o}C in minimum and maximum temperature will reduce wheat yields between 7 and 10%.
- To maintain the current wheat yields with a forecast of 1 to 4 ^{o}C during the next 50 years, represents a considerable challenge to the farmers of this region.
- Plant breeders will also have a great challenge to generate new varieties that can maintain the current yields with a warmer future climate.

Wheat yield in the Yaqui Valley vs Minimum Temperatures from 1980 to 2014



Wheat yields in the Yaqui Valley vs average mínimum temperaturas from 1980 -2015



Ortiz-Monasterio y Lobell, 2015

Soil quality and vulnerability to climate change in Mexico

CIMMYT

ELSEVIER

Agricultural and Forest Meteorology 114 (2002) 31–43

AGRICULTURAL AND FOREST METEOROLOGY

www.elsevier.com/locate/agrformet

Soil, climate, and management impacts on regional wheat productivity in Mexico from remote sensing

David B. Lobell [a,b,*], J. Ivan Ortiz-Monasterio [c], C. Lee Addams [b], Gregory P. Asner [a,b]

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[b] *Department of Geological and Environmental Science, Stanford University, Stanford, CA 94305, USA*

[c] *International Maize and Wheat Improvement Center (CIMMYT), Wheat Program, Apdo. Postal 6-641, 06600 Mexico D.F., Mexico*

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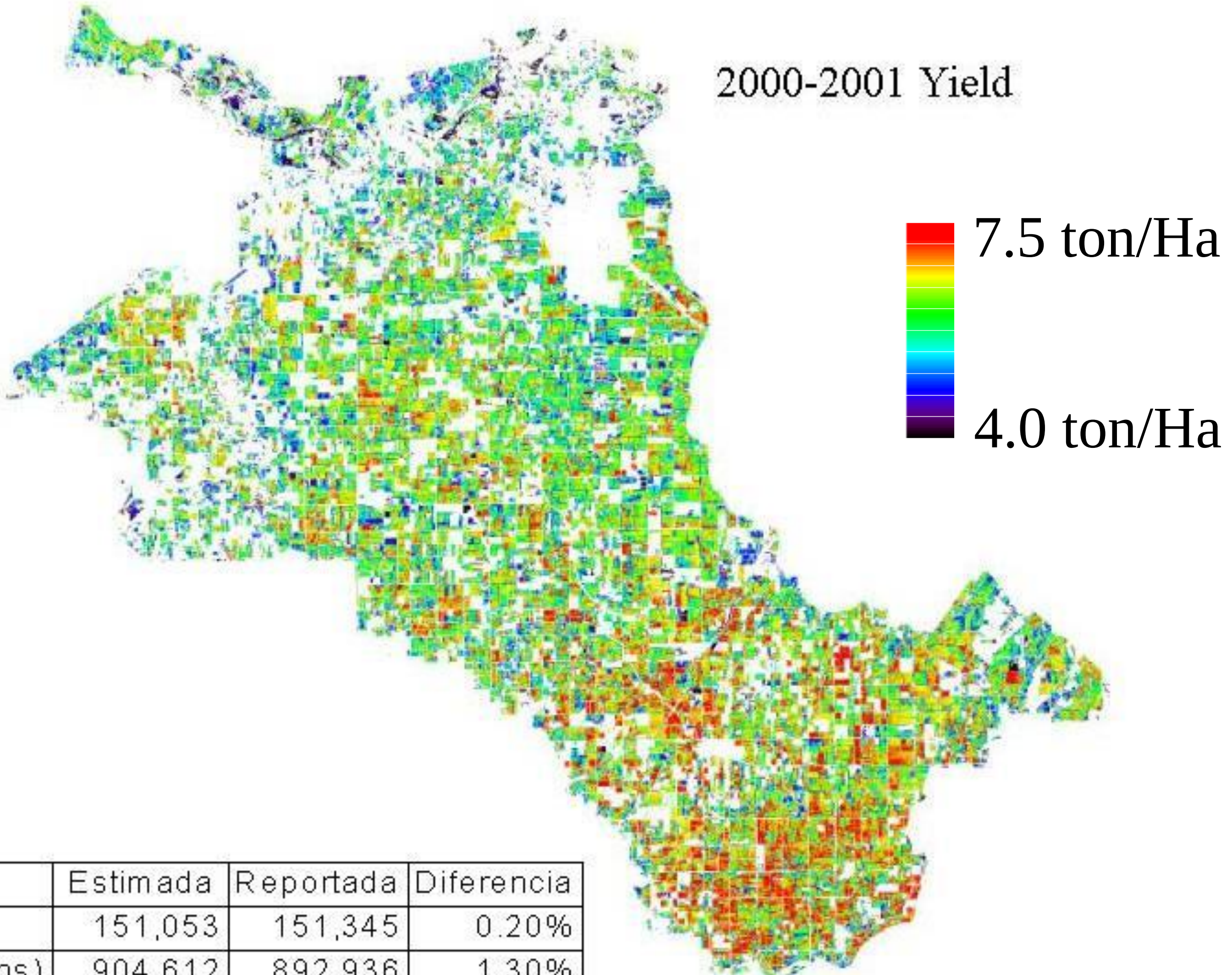
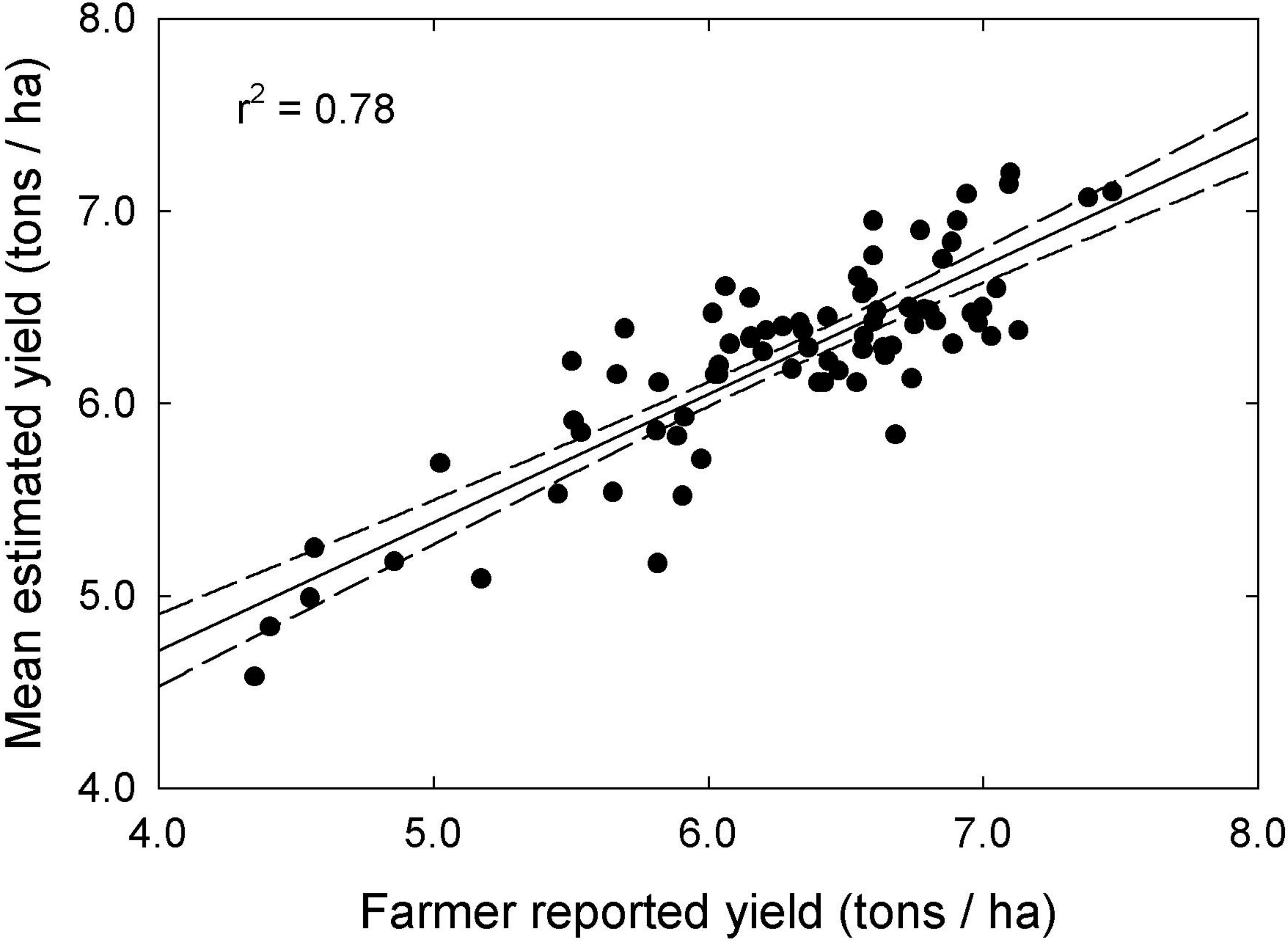
Abstract

Understanding sources of variability in net primary productivity is critical for projecting ecosystem responses to global change, as well as for improving management in agricultural systems. However, the processes controlling productivity cannot be fully addressed with field- or global-scale observations. In this study, we performed a regional observational experiment using remote sensing to analyze sources of yield variability in an irrigated wheat system in Northwest Mexico. Four different soil types and 3 years with contrasting weather served as the two main experimental factors, while remotely sensed yields provided thousands of observations within each treatment. Analysis of variance revealed that 6.6 and 4.6% of the variability in yields could be explained by soil type and climate, respectively, with a negligible fraction explained by soil-type–climate

Wheat Yields

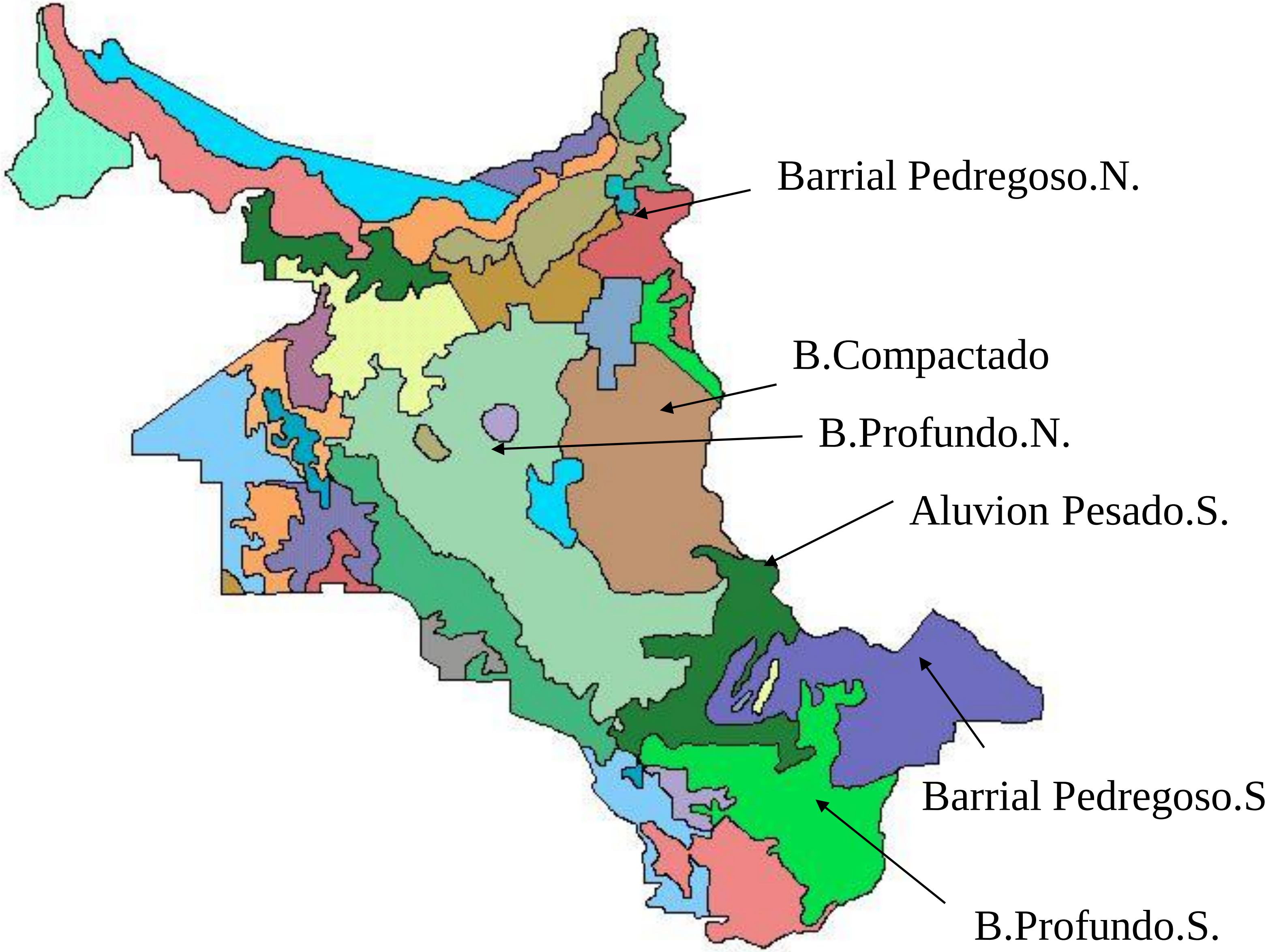


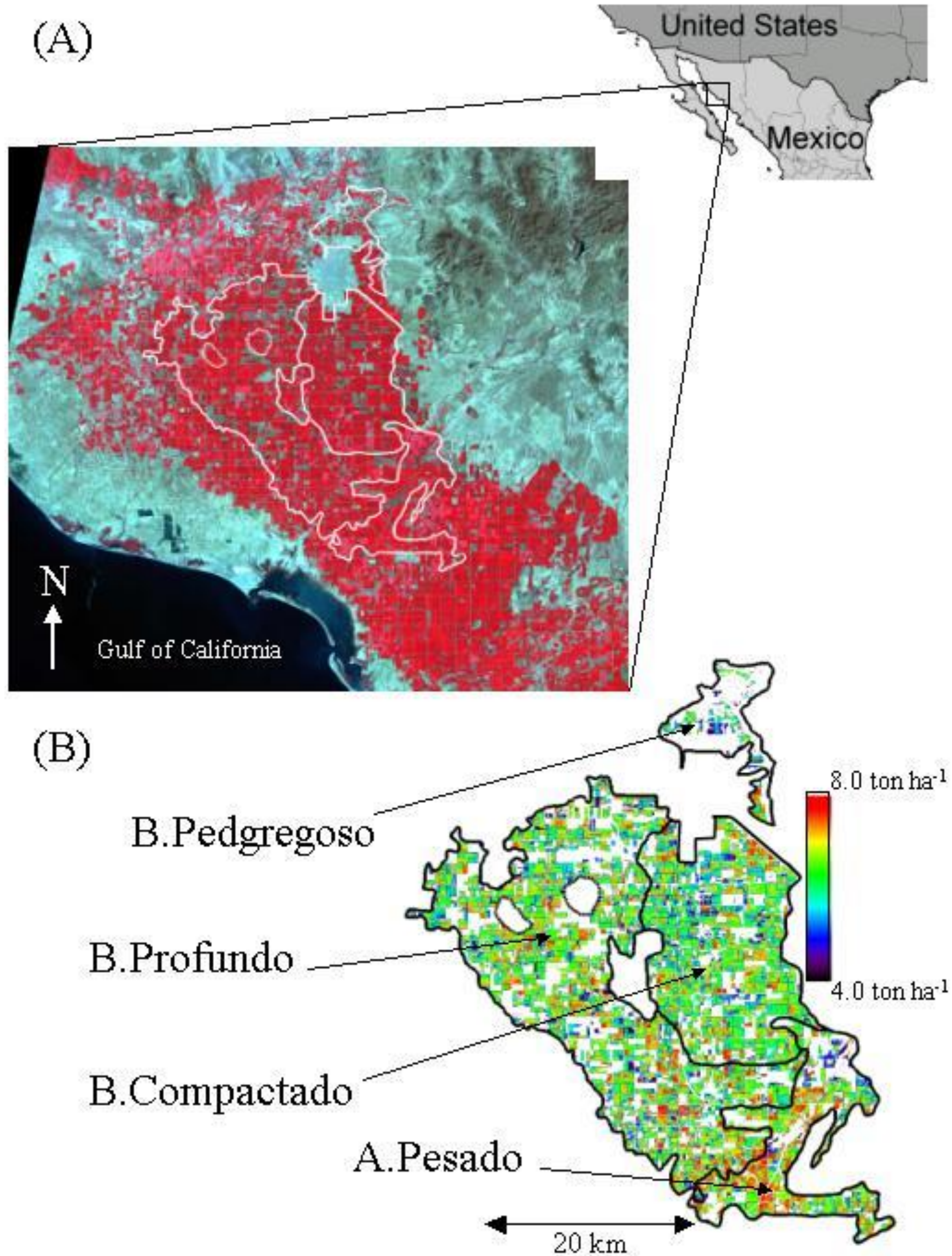
	Estimada	Reportada	Diferencia
Area (has)	151,053	151,345	0.20%
Producion (tons)	904,612	892,936	1.30%



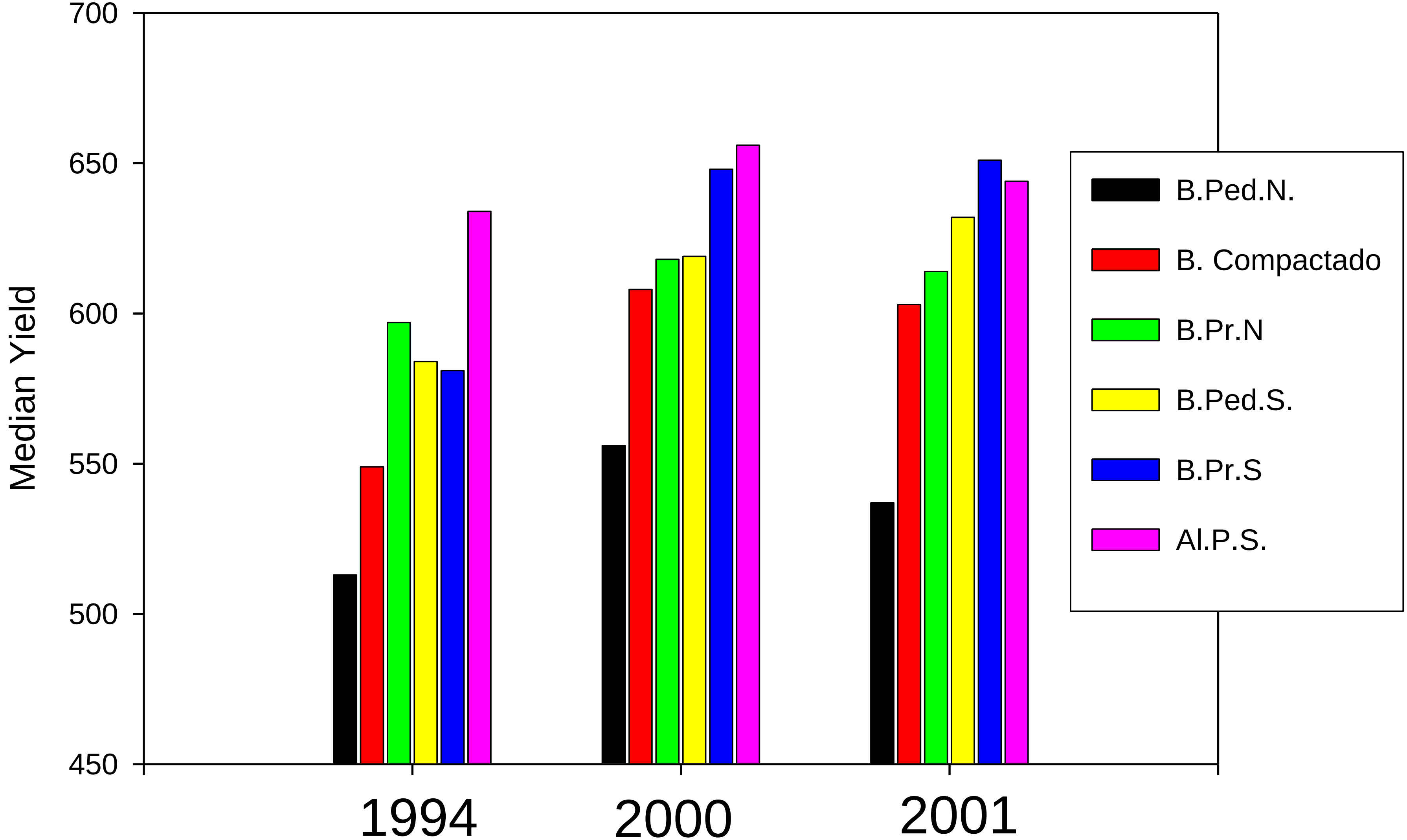
$r^2 = 0.78$
Mean estimated yield (tons / ha)
Farmer reported yield (tons / ha)
4.0
5.0
6.0
7.0
8.0

Soil Types in the Yaqui Valley





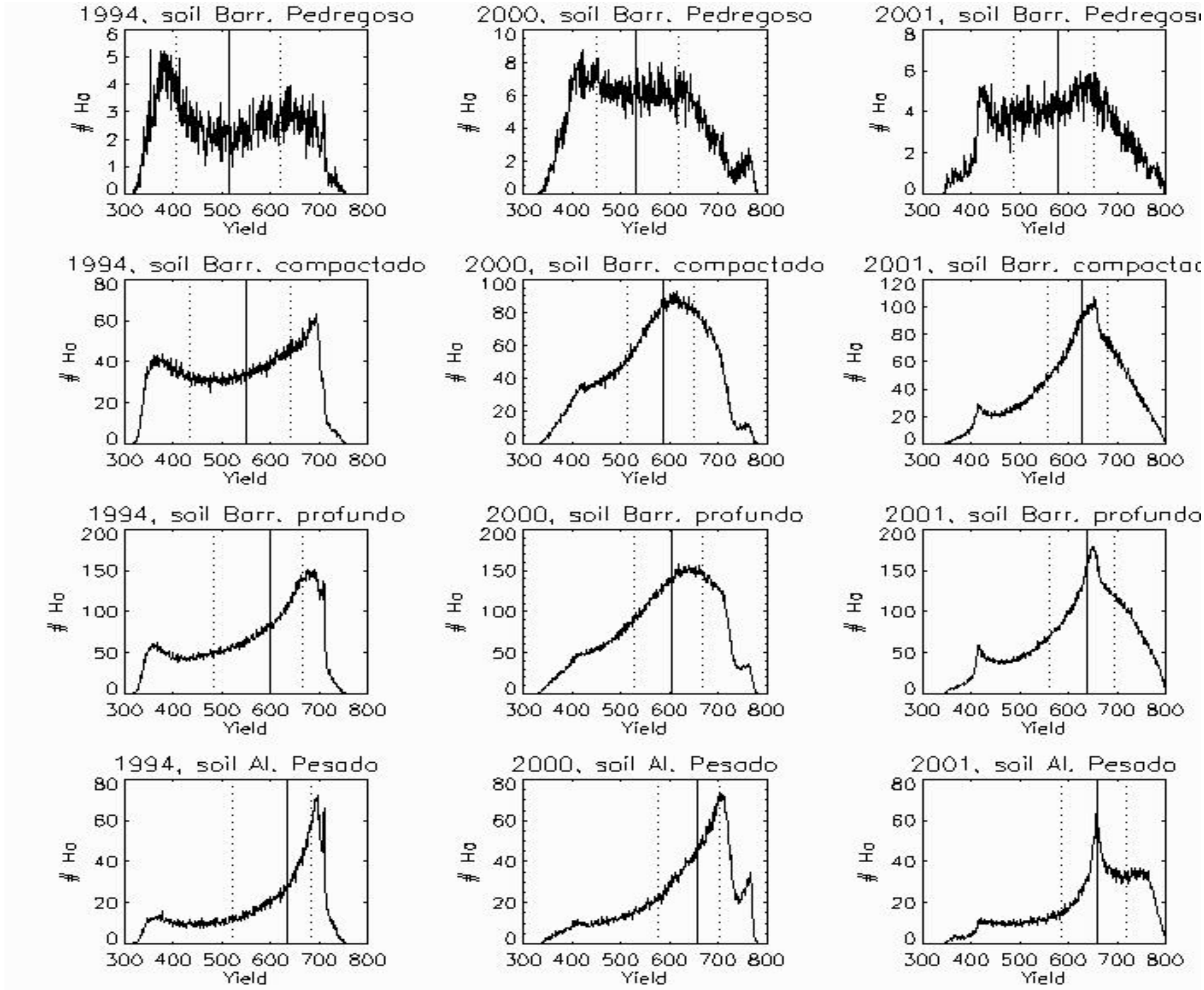
(A)
United States
Mexico
N
Gulf of California
(B)
B.Pedgregoso
B.Profundo
B.Compactado
A.Pesado
8.0 ton ha-1
4.0 ton ha-1
20 km



Median Yield
700
650
600
550
500
450
1994
2000
2001
B.Ped.N.
B. Compactado
B.Pr.N
B.Ped.S.
B.Pr.S
Al.P.S.

Better Climate

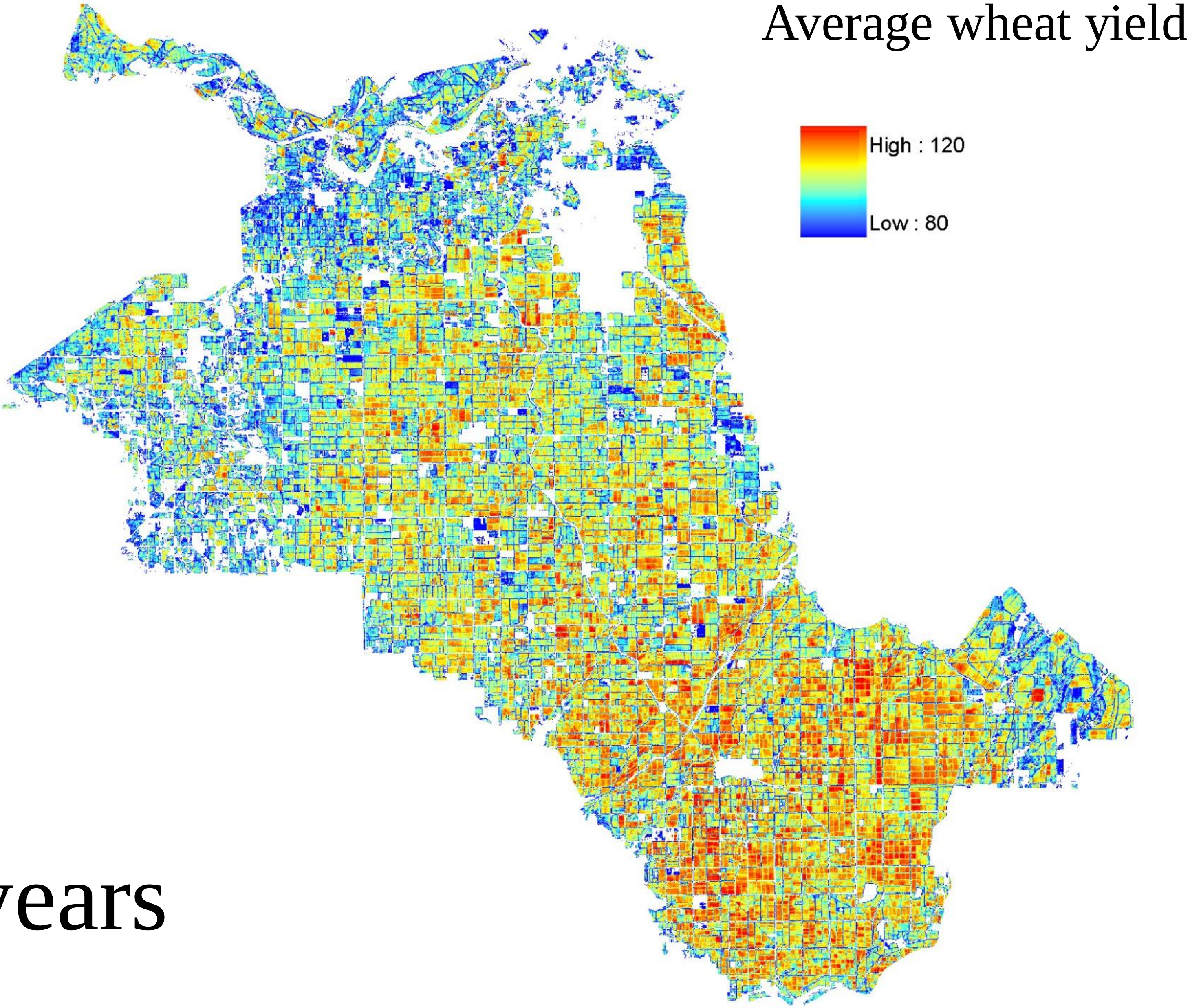
Better Soil



Solid line = median yield; dotted lines = 25th and 75th percentiles

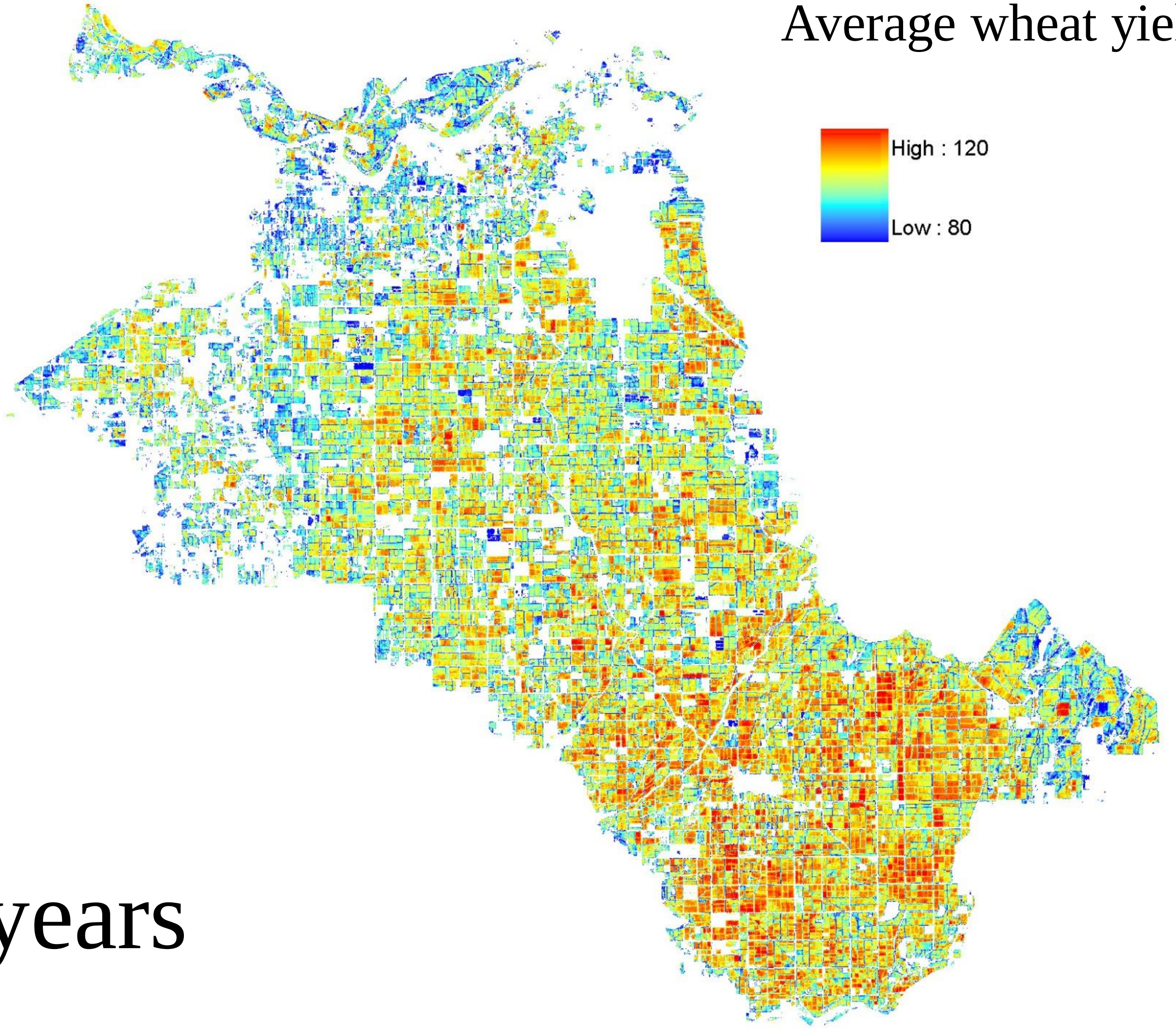
Wheat yield maps in the Yaqui Valley for the identification of low and high yielding areas for yield gap studies

CIMMYT



3 years

Average wheat yield



5 years

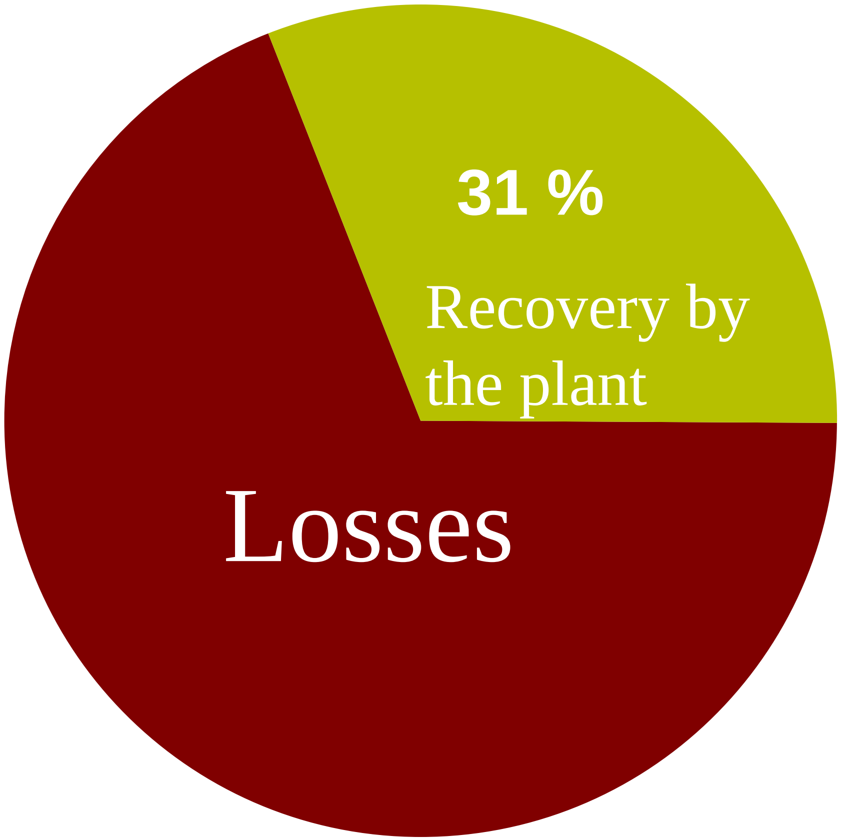
Yaqui Valley

Average Wheat Yield 2015-2016
6.6 t/ha

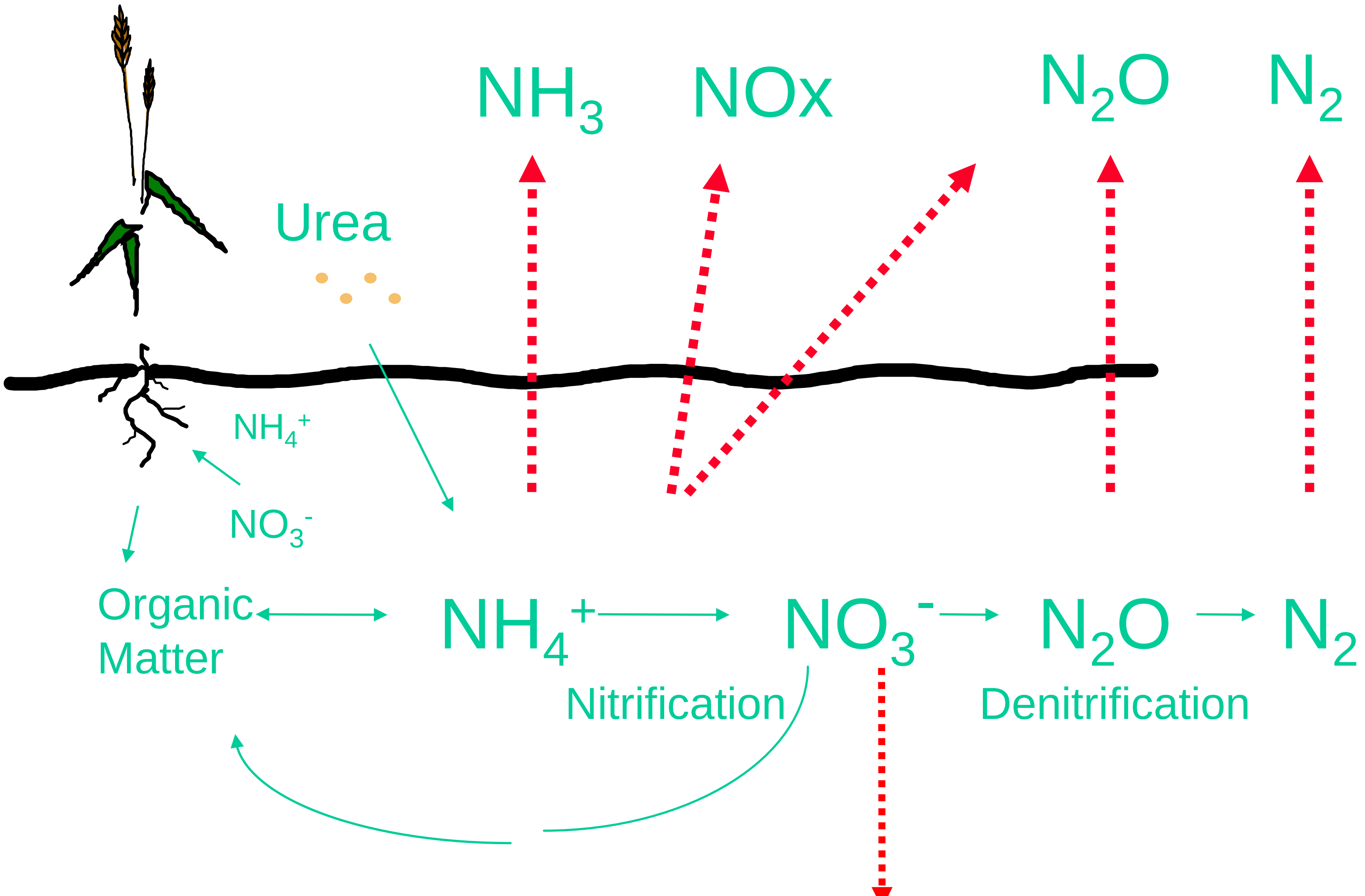
Average N rate
300 kgN/ha

Percentage Nitrogen Recovery in Wheat in the Yaqui Valley

(average of 30 fields)



Losses to the environment



Science AAAS

REPORT

Integration of Environmental, Agronomic, and Economic Aspects of Fertilizer Management

Pamela A. Matson*, **Rosamond Naylor**, **Ivan Ortiz-Monasterio**

- Author Affiliations

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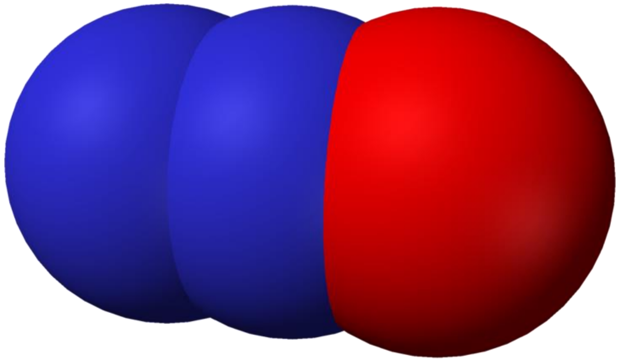
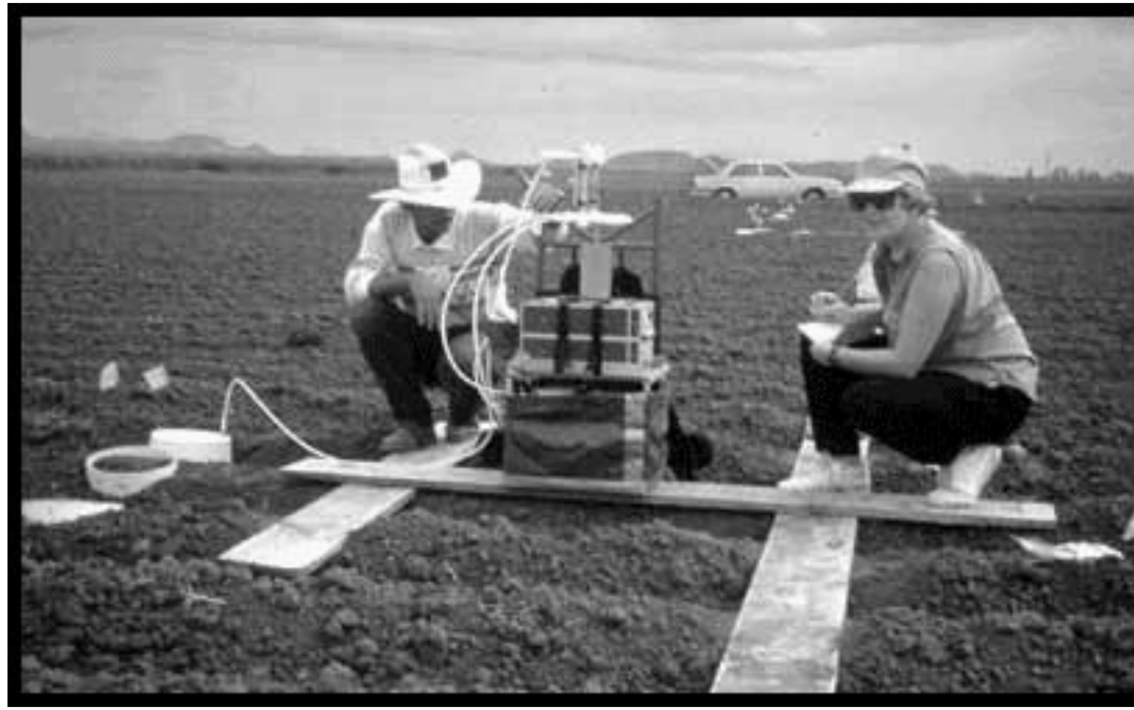
Science 03 Apr 1998:
Vol. 280, Issue 5360, pp. 112-115
DOI: 10.1126/science.280.5360.112



Nitrous oxide

N_2O



In the Yaqui Valley it is possible to reduce emissions by 50% without reducing wheat yields by improving nitrogen management (timing and rate).

Matson, Naylor and Ortiz-Monasterio., 1998 *Science*

Sensor Technology

Diagnostic tool that allows us to establish N fertilization needs for each individual field

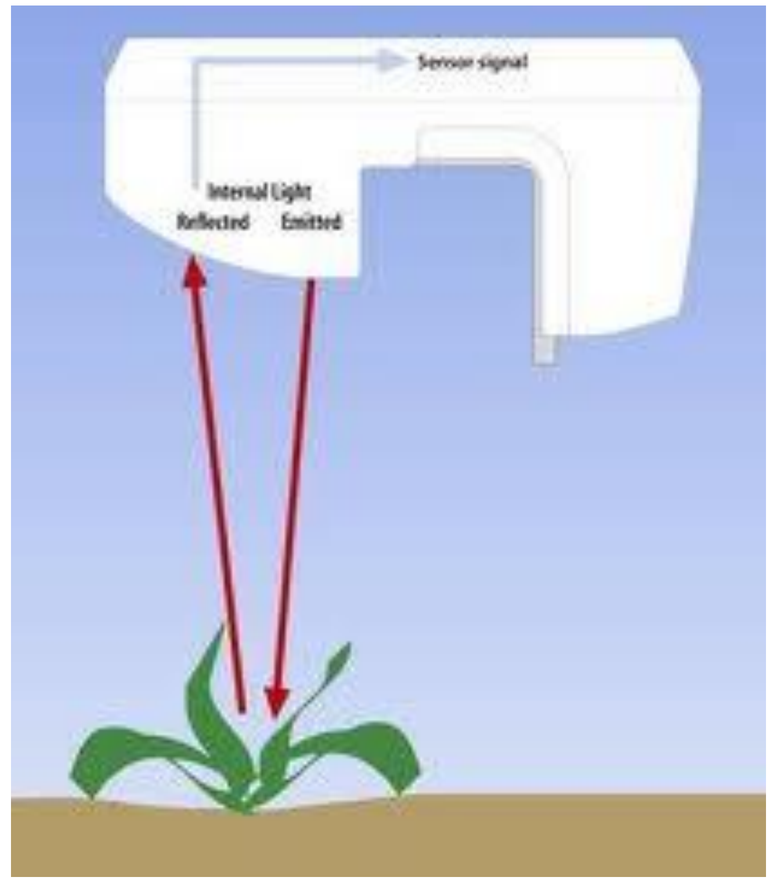
SITE SPECIFIC

Colaboration with Oklahoma State University Bill Raun

What does de sensor measure?

- Near infrared (NIR) 774 nm (biomass)
- Red 656 nm (Greenness)
- NDVI Range: 0.00 -0.99
- Vegetative Index

$$NDVI = \frac{R_{NIR} - R_{Red}}{R_{NIR} + R_{Red}}$$

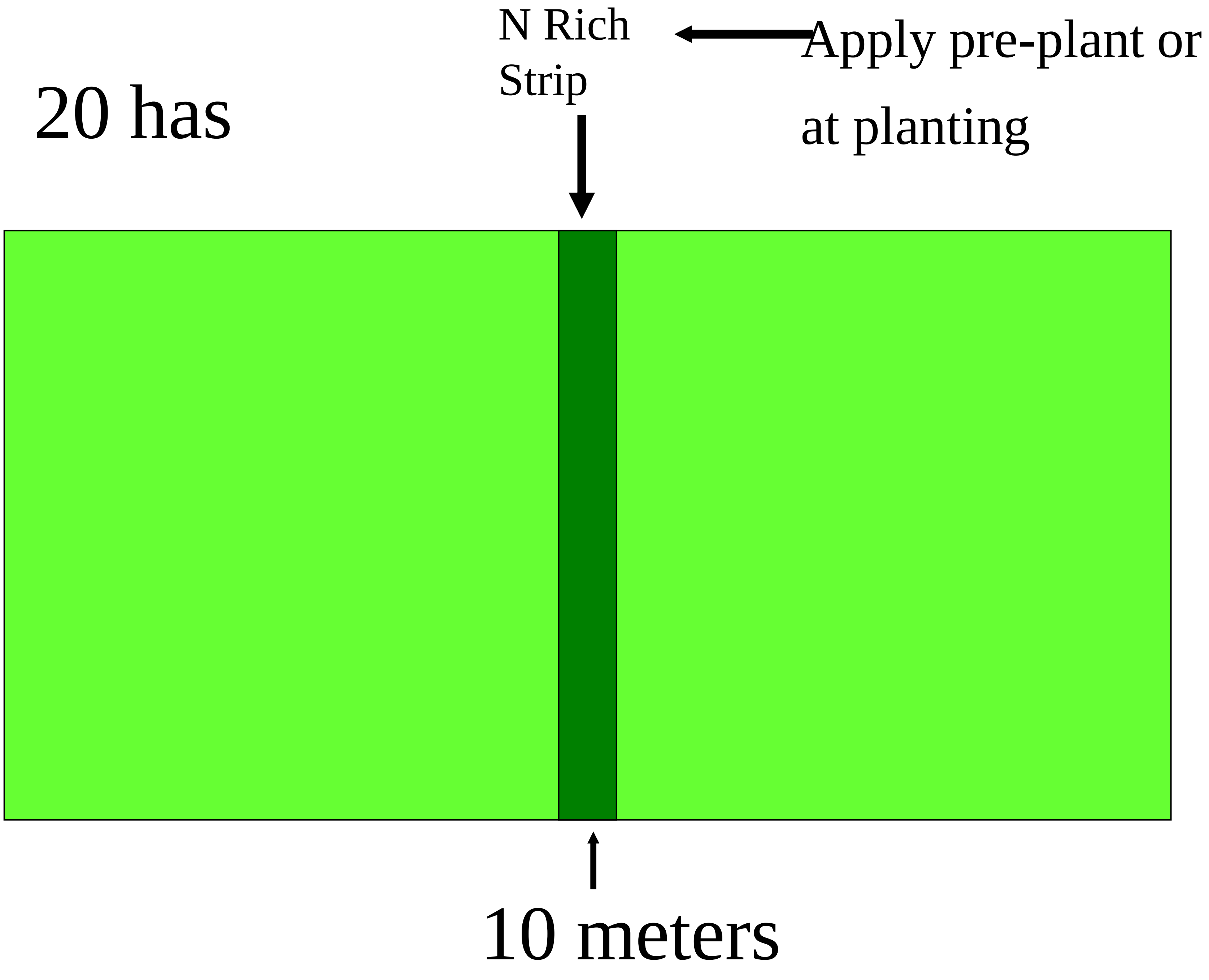


Technology Components

1. N Rich Strip

2. NDVI reading in the N rich strip and the field that will be diagnosed.

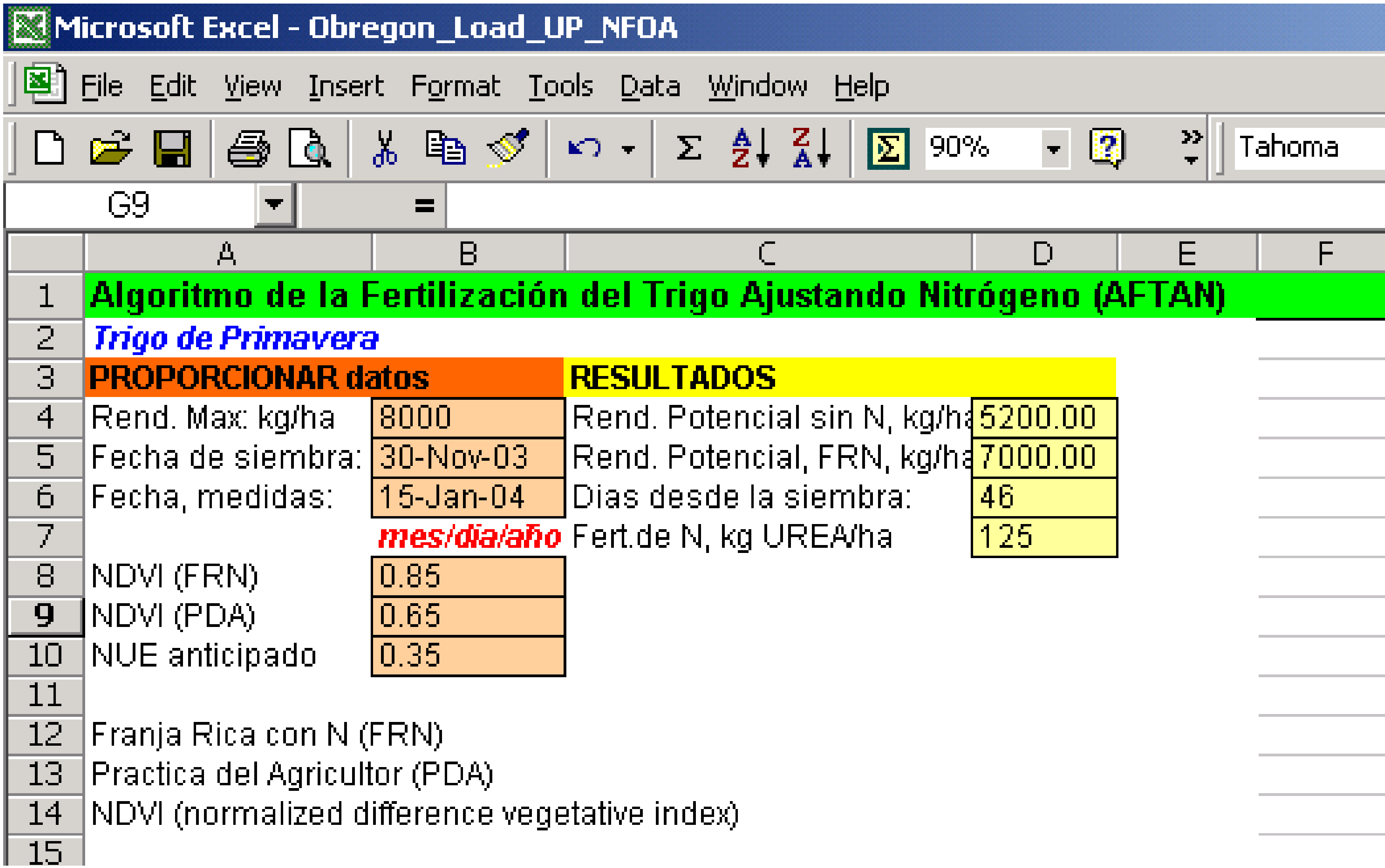
3. Use of an algorithm to calculate the optimum N rate.


N Rich
Strip
Apply pre-plant or
at planting
20 has
10 meters

2. NDVI reading in the N rich strip and the farmer's field that will be diagnosed

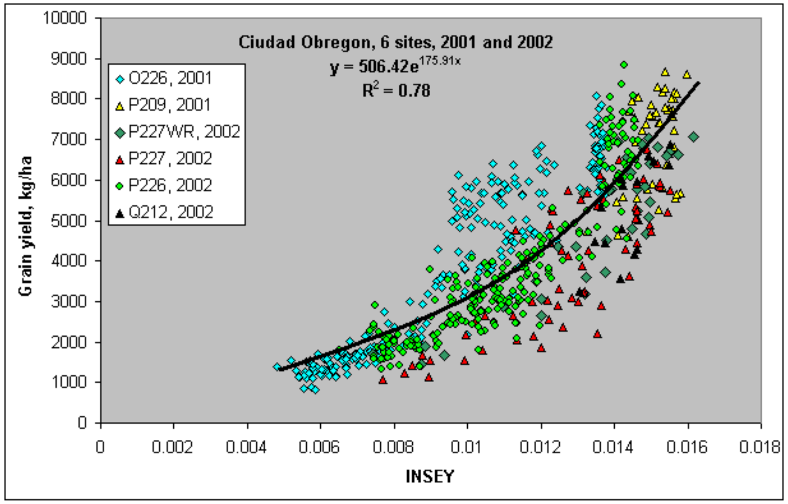
Measurement: As close as possible to the first post plant irrigation but 40 days after planting.

3. Use of the Crop Algorithm to derive a N recommendation



	A	B	C	D	E	F
1	**Algoritmo de la Fertilización del Trigo Ajustando Nitrógeno (AFTAN)**					
2	***Trigo de Primavera***					
3	**PROPORCIONAR datos**		**RESULTADOS**			
4	Rend. Max: kg/ha	8000	Rend. Potencial sin N, kg/ha	5200.00		
5	Fecha de siembra:	30-Nov-03	Rend. Potencial, FRN, kg/ha	7000.00		
6	Fecha, medidas:	15-Jan-04	Dias desde la siembra:	46		
7		***mes/dia/año***	Fert.de N, kg UREA/ha	125		
8	NDVI (FRN)	0.85				
9	NDVI (PDA)	0.65				
10	NUE anticipado	0.35				
11						
12	Franja Rica con N (FRN)					
13	Practica del Agricultor (PDA)					
14	NDVI (normalized difference vegetative index)					
15						

To be able to apply the technology of optical sensors it is necessary to calibrate it per crop and region where it will be used.




CIMMYT
30,000 USD


5,000 USD


precision SENSING
Oklahoma State University
120,000 USD


500 USD

Technology Transfer

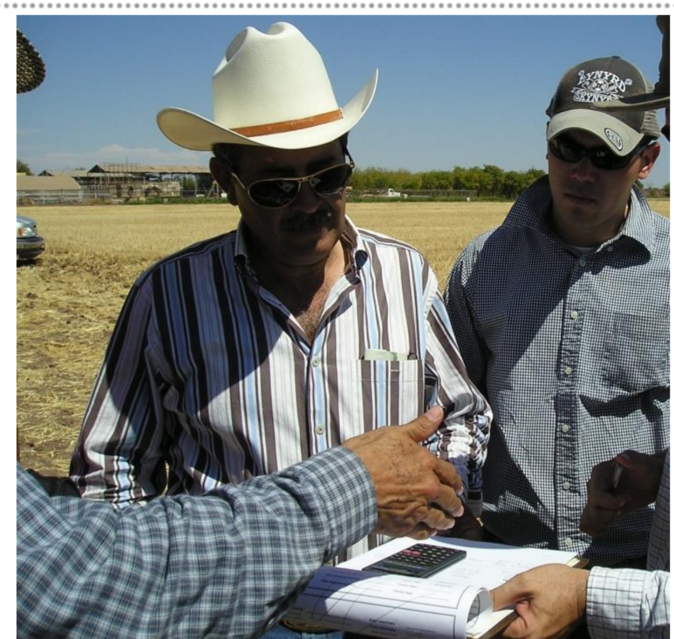
COLABORATORS

- Stanford University
- Oklahoma State University
- Fundacion Produce Sonora
- AOASS - USPRUSS
- Sistema Producto Trigo – Sonora
- MasAgro
- FIRA
- SAGARPA
- CONACYT
- Financiera Rural
- PIEAES, INIFAP

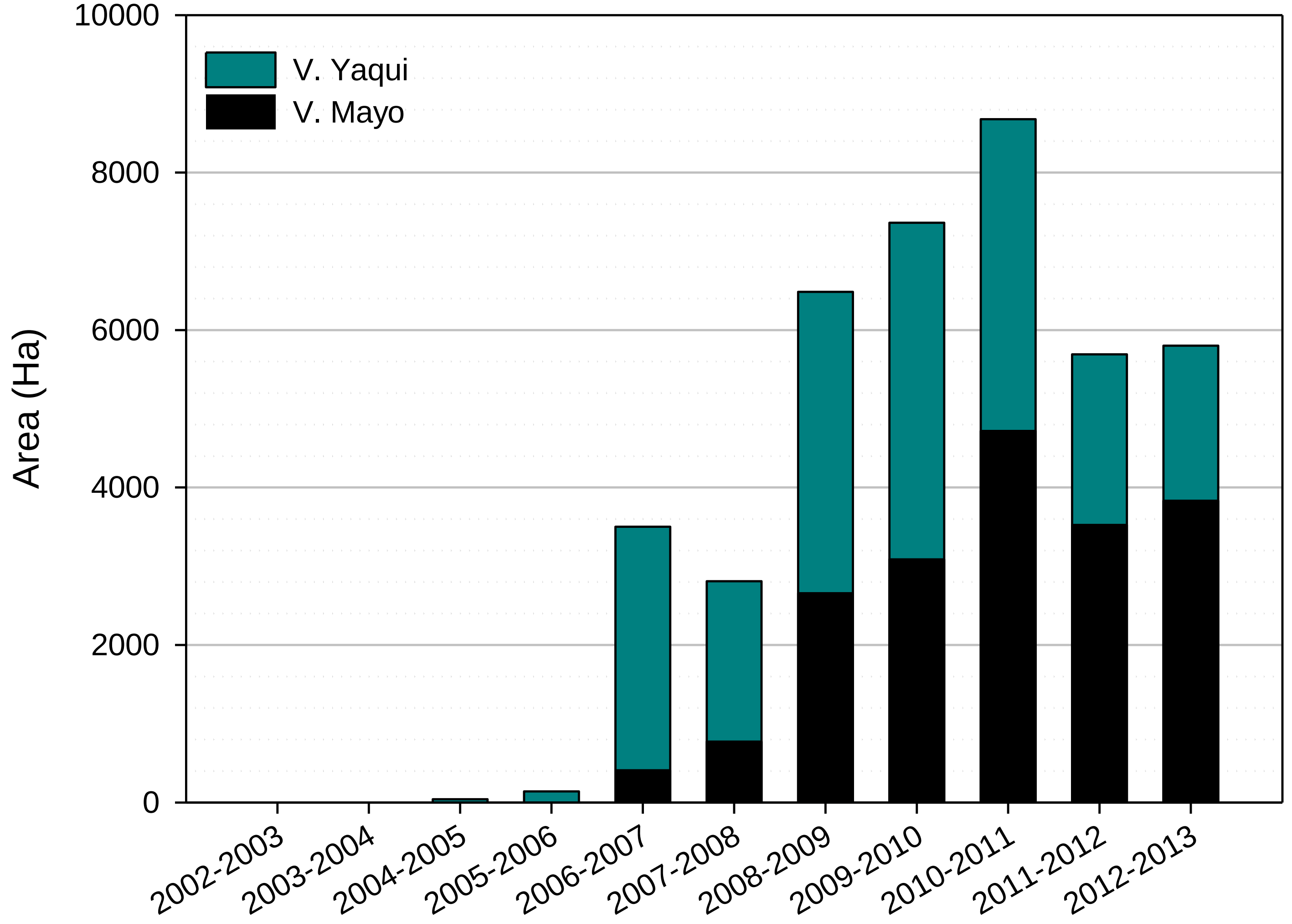
SONORA

Wheat

AOASS



Area Under GreenSeeker Management in Southern Sonora



TECHNICAL TEAM

COOPERATIVE	FARM ADVISERS
AOASS	Ing. Arturo Muñoz Cañez (coordinador)
UCAC	Ing. Emilio Acosta M. Ing. Julio Galaz Gil
UCAY	Ing. Ramón Gil Cota.
UCAH	Ing. Julio C. Espinoza.
AAVYAC	Ing. Carlos Remy M.
UCAYVISA	Ing. Raúl Salinas G.
USPRUSS	Ing. Carlos Rodríguez P Ing. Manuel Ferra M. Ing. Carlos Quiñones.
UCAMAYO	Ing. Manuel H. Alcántar
APRONSA	Ing. Ignacio Miranda I.

CIMMYT

Dr. Ivan Ortiz-Monasterio

Ing. Maria Elena Cardenas

Cost Reduction With the Use of the GreenSeeker in Sonora

50 kgN/ha

13.5 pesos/kgN = 675 pesos/ha

Maintaining the same yield

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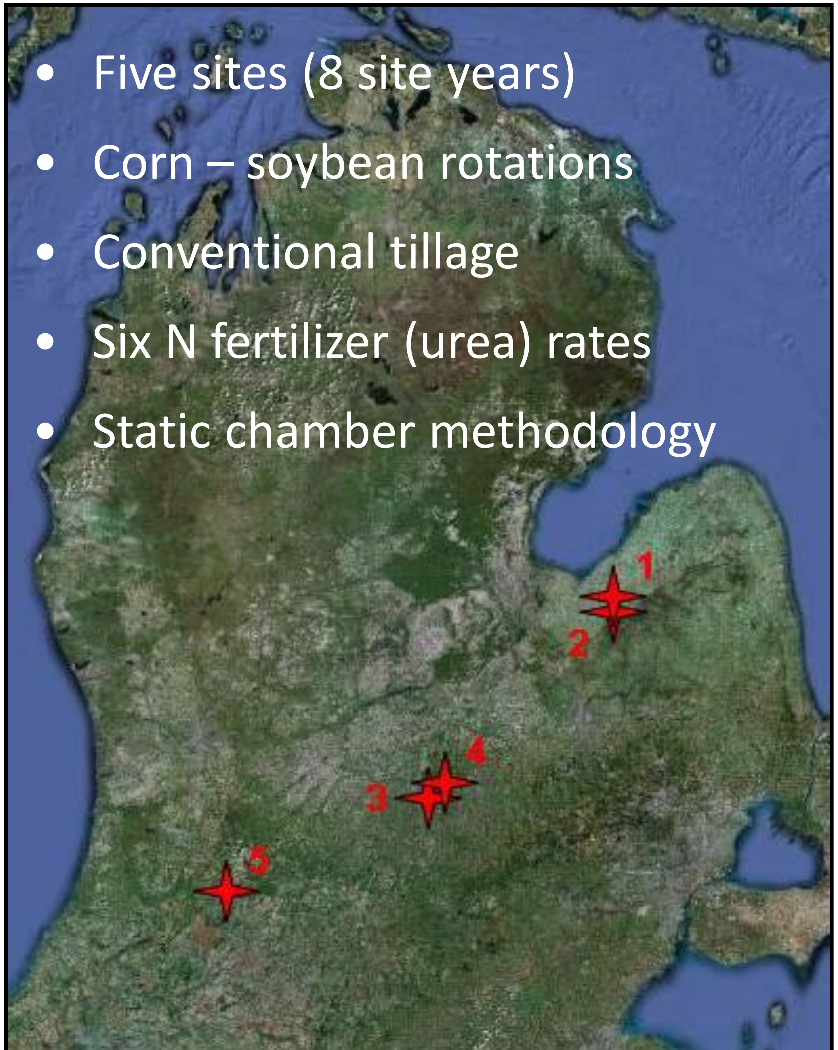
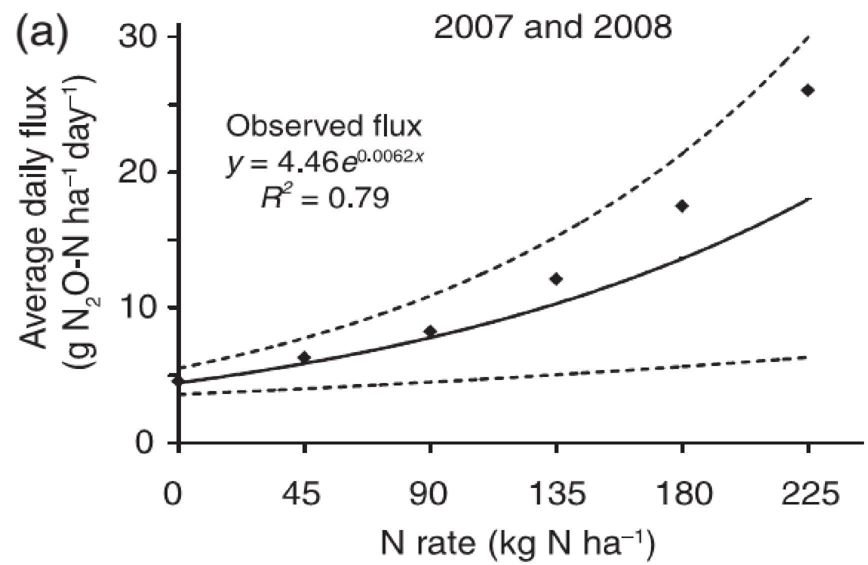
Emission factors for wheat in México

Michigan commercial farm fields

- Five sites (8 site years)
- Corn – soybean rotations
- Conventional tillage
- Six N fertilizer (urea) rates
- Static chamber methodology

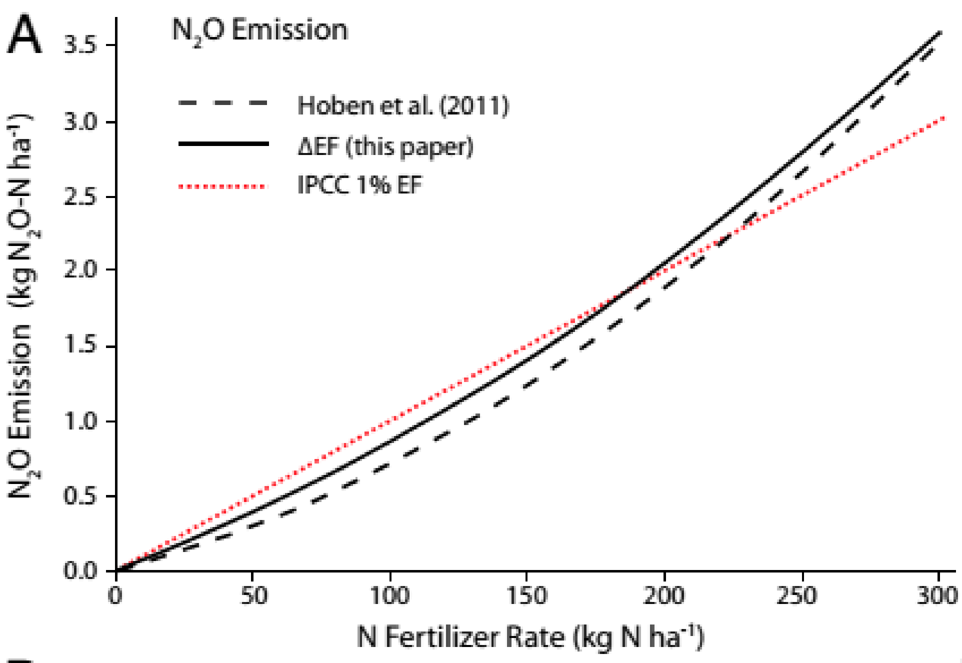


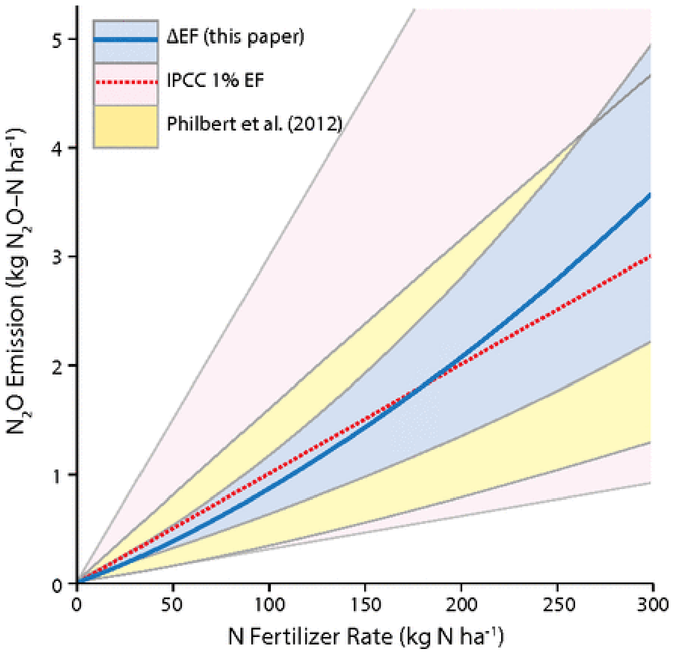


Global Meta-analysis

Shcherbak et al. 2015. PNAS

84 sites, ~230 site years





Provides Flexibility for Farmers

Farmers have multiple routes to reduce N rate

- More accurate estimates of N need (e.g. MRTN)
- Timing of N application (e.g. spring vs. fall)
- Source of fertilizer (e.g. formulation)
- Placement of fertilizer (e.g. precision agriculture)
- Cover crops use

N rate reduction is the integrated result

CCAFS Wheat: N rate experiment

Top view

2 x chamber per 'micro-site'
(in row [over plant], in furrow)

5 x treatments (N-Gradient)

4 x replicates (Blocks)

40 (2 x 5 x 4) chambers

AB-200 **parcelas de 4 camas y 5 metros de largo** **VARIEDAD: CIRNO C2008**
DENSIDAD: 120 KG/HA

AB-200 (2013-2014)

	2 camas	4 camas	4 camas	4 camas	4 camas	4 camas	4 camas	3 camas
	r	R	R	R	R	R	R	r
	r	502	503	402	403	108	101	r
	r	507	506	407	406	107	102	r
	r	504	508	405	401	106	103	r
	r	505	501	408	404	105	104	r
	r	607	608	302	303	202	205	r
	r	603	606	305	301	206	208	r
	r	605	601	304	307	207	201	r
	r	602	604	308	306	203	204	r
	r	FRANJA RICA						r
Con N	r	150 kgN/ha						r
	r							r
Sin N	r	0 N						r
	r							r
Con N	r	150kgN/ha						r
	r							r
	r							r
	r							r
Sin N	r	0 N						r
	r							r
Con N	r							r
	r							r
Con N	r	150 kgN/ha						r
	r							r
Sin N	r							r
	r							r
Sin N	r	0 N						r
	r							r
	r	150kgN/ha						r
con N	r							r

AB-MULTIPLICACION

BORDO DE CONTENCIÓN

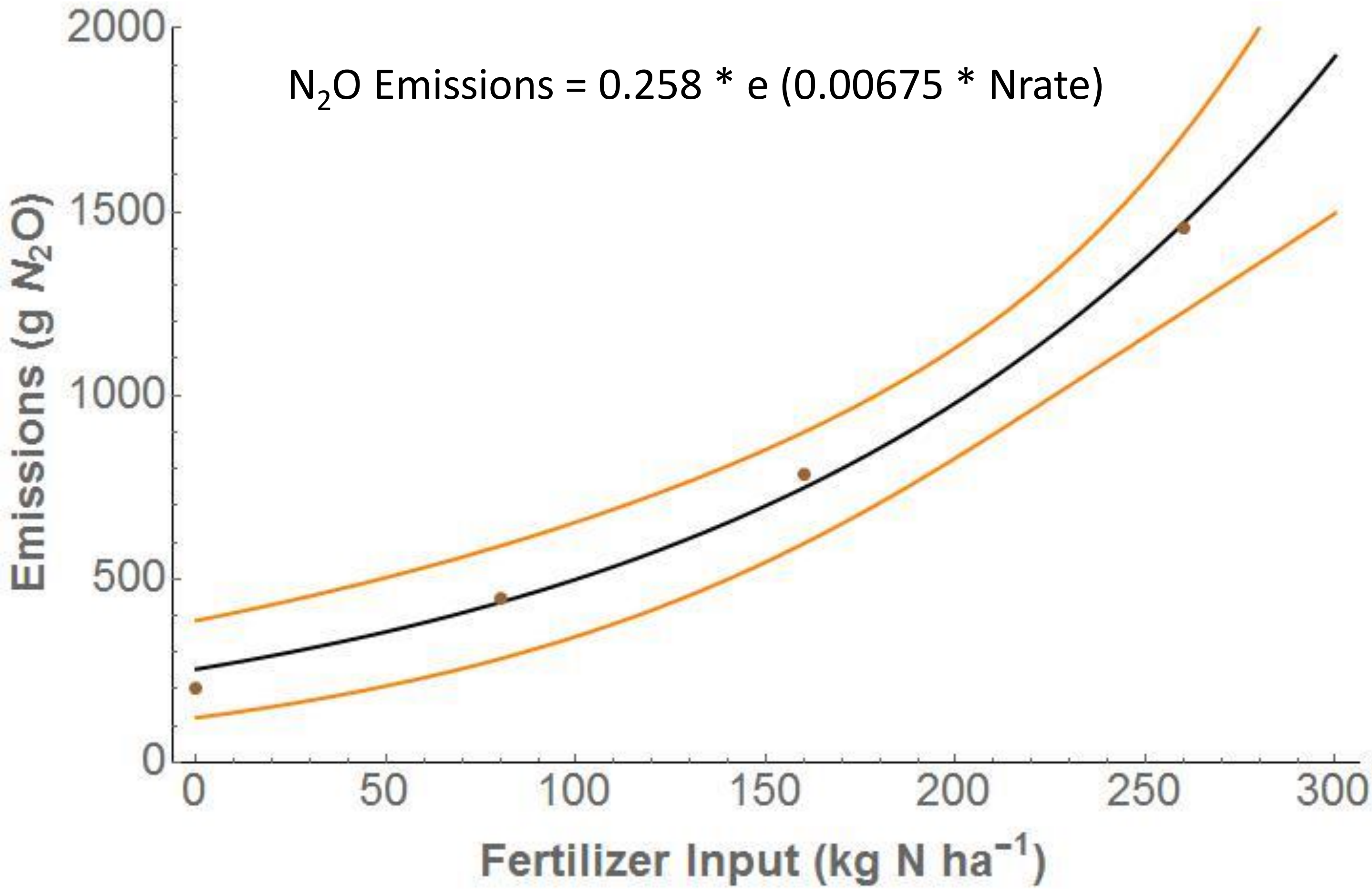
AB-250 C1

R = 4 camas de relleno cirno
r = 2 camas de relleno cirno

Repetición	Tratamientos	kg N/ha	Muestreo gases
10	1	0	
20	2	40	
30	3	80	
40	4	120	
50	5	160	
60	6	200	
	7	240	
	8	280	

N

N_2O Emission Factor for Wheat in México



N_2O Emission Factors of Different N Sources in Wheat in México

DESIGN: RCBD with 4 replications

1. 0 Kg/ha
2. 300 KgN/ha urea pre-plant
3. 180 KgN/ha as ENTEC-26 (26-0-0)
4. 180 KgN/ha as Urea ESN (44-0-0)
5. 180 KgN/ha as UREA FORTE (46-0-0)
6. 90 UN/ha pre-plant as UREA + 90 UN/ha as Urea ESN pre-plant
7. 180 KgN/ha Pre-plant as urea (46-0-0)
8. 0 kg N pre.plant + 100 N planting + greenseeker 1st irrigation

GreenSeeker handheld initial results: additional profits and avoided greenhouse gas emissions, by year

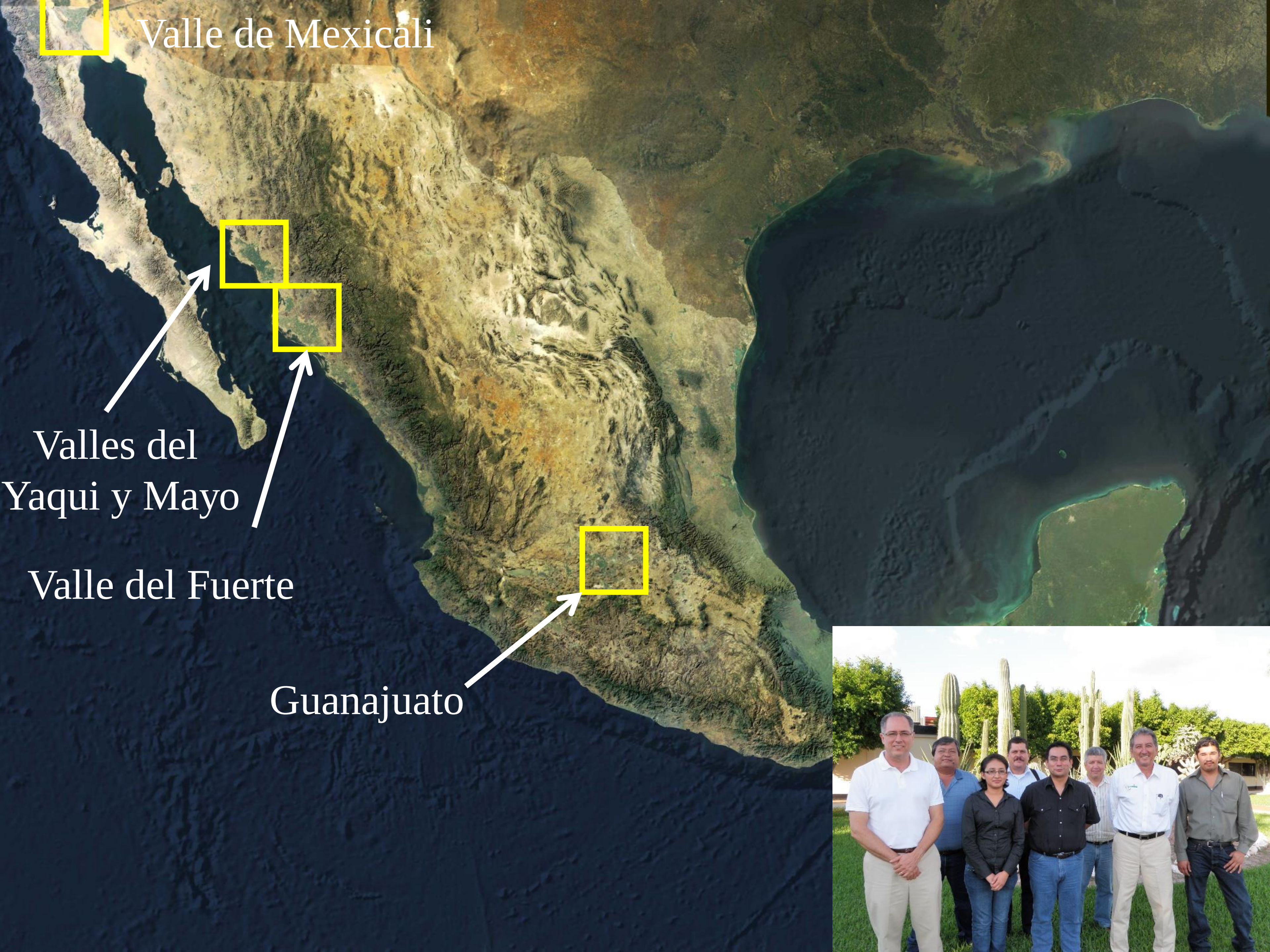
Year	Additional Profits (USD/ha)	Avoided Emissions ($tC0_2e/ha$)	Total Area (ha)	Total Profits (USD)	Total Avoided Emissions ($tC0_2e$)
2006-2007	$6.69	0.19	2,445	$16,352	464
2007-2008	$(5.66)	0.20	4,232	$(23,952)	861
2008-2009	$99.39	0.23	6,662	$662,182	1,557
2009-2010	$60.42	0.23	7,724	$466,669	1,752
2010-2011	$37.85	0.14	8,877	$336,010	1,211
2011-2012	$9.30	0.24	5,671	$52,754	1,373
2012-2013	$18.66	0.22	5,665	$105,713	1,264
2013-2014	$10.56	0.16	7,149	$75,476	1,163
Total	$34.92	0.20	48,425	$1,691,203	9,646

Lapidus et al., 2016

How to address disadoption

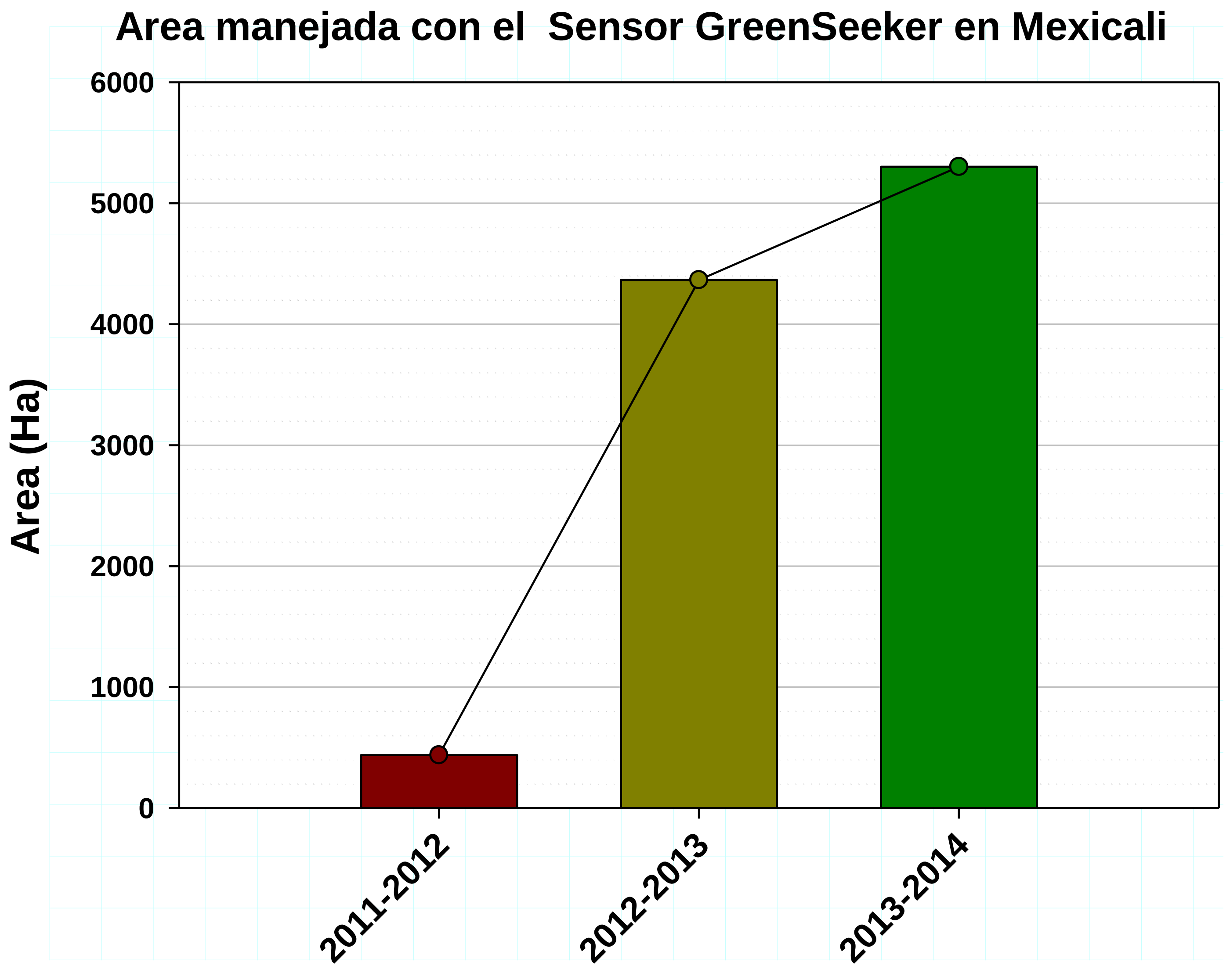
- Government Policy
- Business models

Modernización Sustentable de la Agricultura Tradicional


Valle de Mexicali
Valles del
Yaqui y Mayo
Valle del Fuerte
Guanajuato

BAJA CALIFORNIA
Wheat

Private Farm Advisors


Area manejada con el Sensor GreenSeeker en Mexicali
Area (Ha)
6000
5000
4000
3000
2000
1000
0
2011-2012
2012-2013
2013-2014

Cost reduction with the use of the GreenSeeker in Mexicali

70 kgN/ha

13.5 pesos/kgN = 945 pesos/ha

Maintainig the same Yield

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GUANAJUATO

Maize

SDAyR

Validation in Guanajuato

No.	Municipio	Parcelas
1	Acambaro	5
2	Apaseo el Grande	1
3	Celaya	2
4	Comonfort	3
5	Cortázar	1
6	Dolores Hidalgo	2
7	Irapuato	2
8	Manuel Doblado	2
9	Pénjamo	6
10	Purísima del Rincón	2
11	San Miguel Allende	1
12	Valle de Santiago	4
13	Yuriria	1
Total		**32**

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Modernización de la Agricultura Tradicional

MasAgro Guanajuato

Results in Irrigated Maize

Manejo fertilización	siembra	1ra aplicación	2da aplicación	Total
Manejo sensor	95	111	67	**273**
Manejo convecional	99	124	105	**328**

Se observo una diferencia **de 55 UN** menos con el manejo del sensor vs el manejo del agricultor que equivalente a:

Fuente	valor $/UN
Urea	718.3
Sulfato de amonio	938.9
Fosfonitrato	1067.0

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Modernización de la Agricultura Tradicional

MasAgro Guanajuato

GUANAJUATO

Wheat

SDAyR

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Cost Reduction with the use of the GreenSeeker in Guanajuato

32 kgN/ha

13.5 pesos/kgN = 432 pesos/ha

Maintainig the Same Yield

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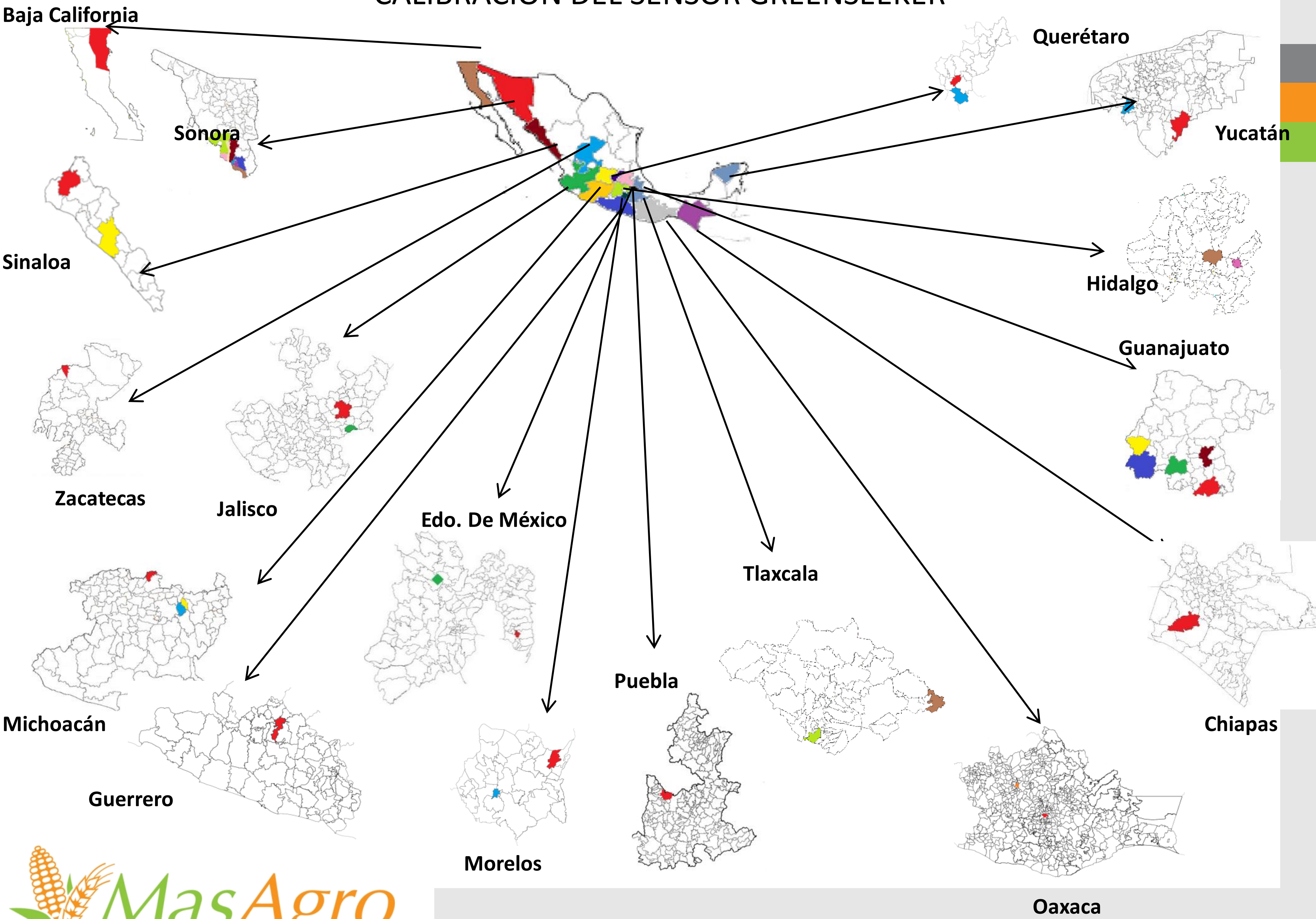
CALIBRACION DEL SENSOR GREENSEEKER



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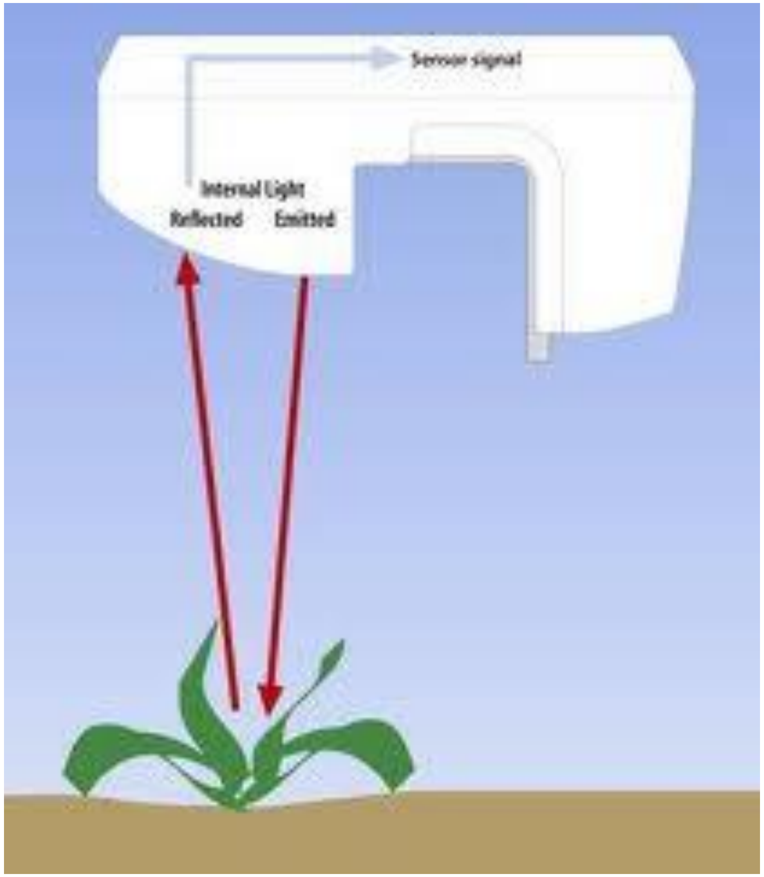
What does de sensor measure?

- Near infrared (NIR) 774 nm (biomass)
- Red 656 nm (Greenness)
- NDVI Range: 0.00 -0.99
- Vegetative Index

$$NDVI = \frac{R_{NIR} - R_{Red}}{R_{NIR} + R_{Red}}$$



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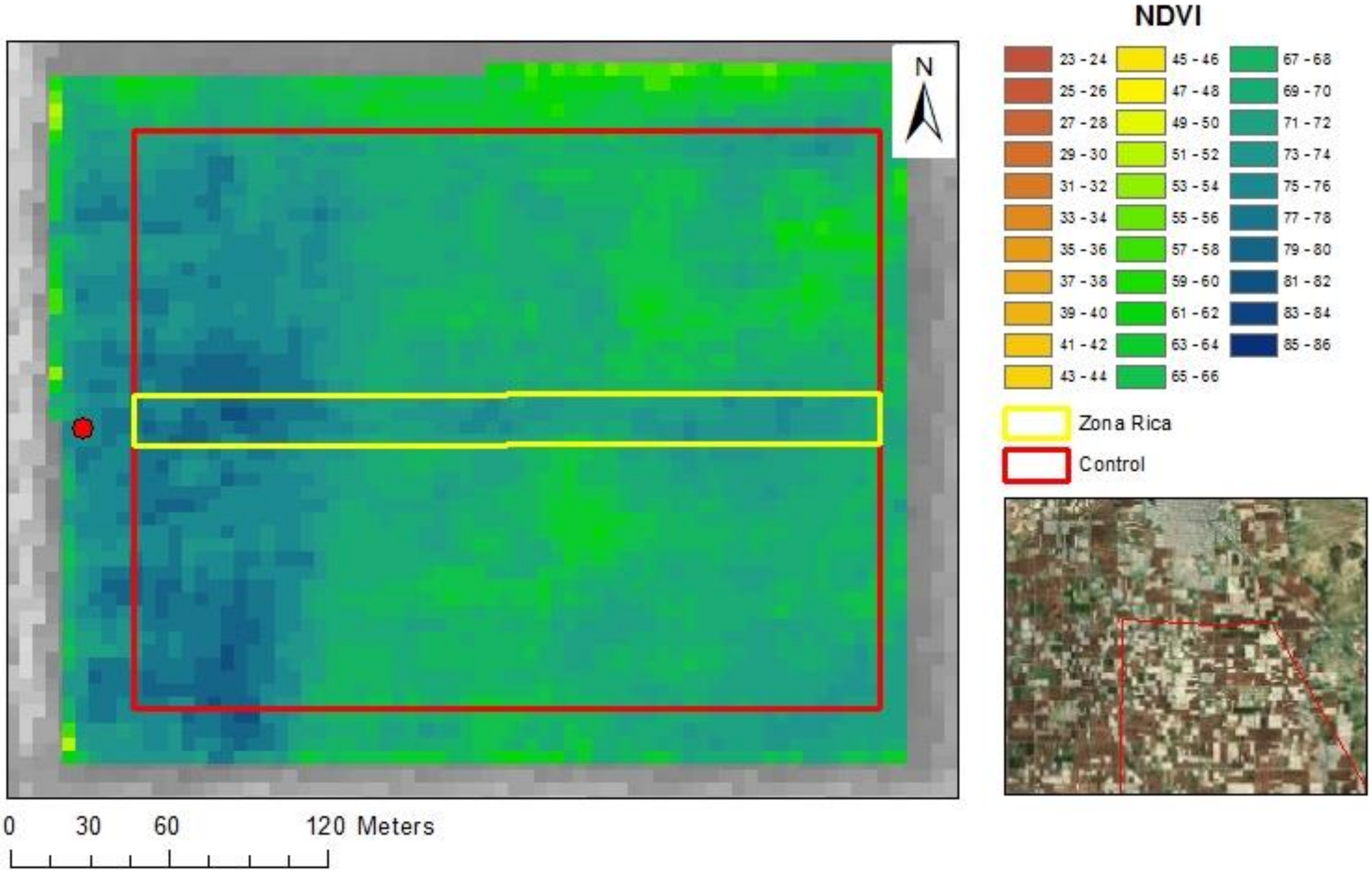
GreenSat

N Diagnostics with the Satellite Rapid Eye

Example of a wheat field in the Yaqui Valley with a N rich strip



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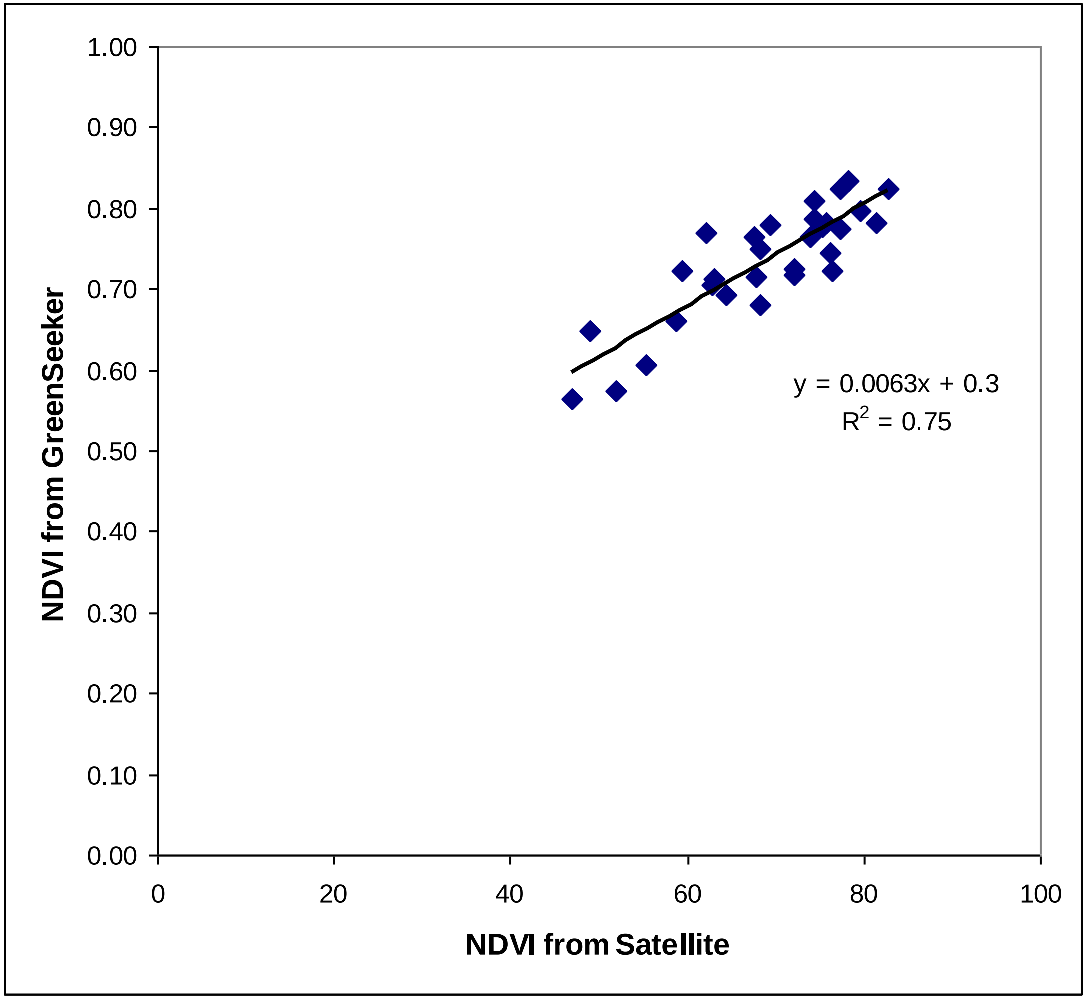
Comparison of NDVI from GreenSeeker y vs a Rapid Eye Satellite image of 23 de January, 2012



Information from:

- 15 farmers fields
  - N Rich Strips
  - Control

Total of 30 points

GreenSeeker reading were collected with +/- 7 days from when the satellite image was collected,

The satellite seems to measure larger differences in NDVI than the GreenSeeker (Slope = 0.63). This will have implications for N recommendations

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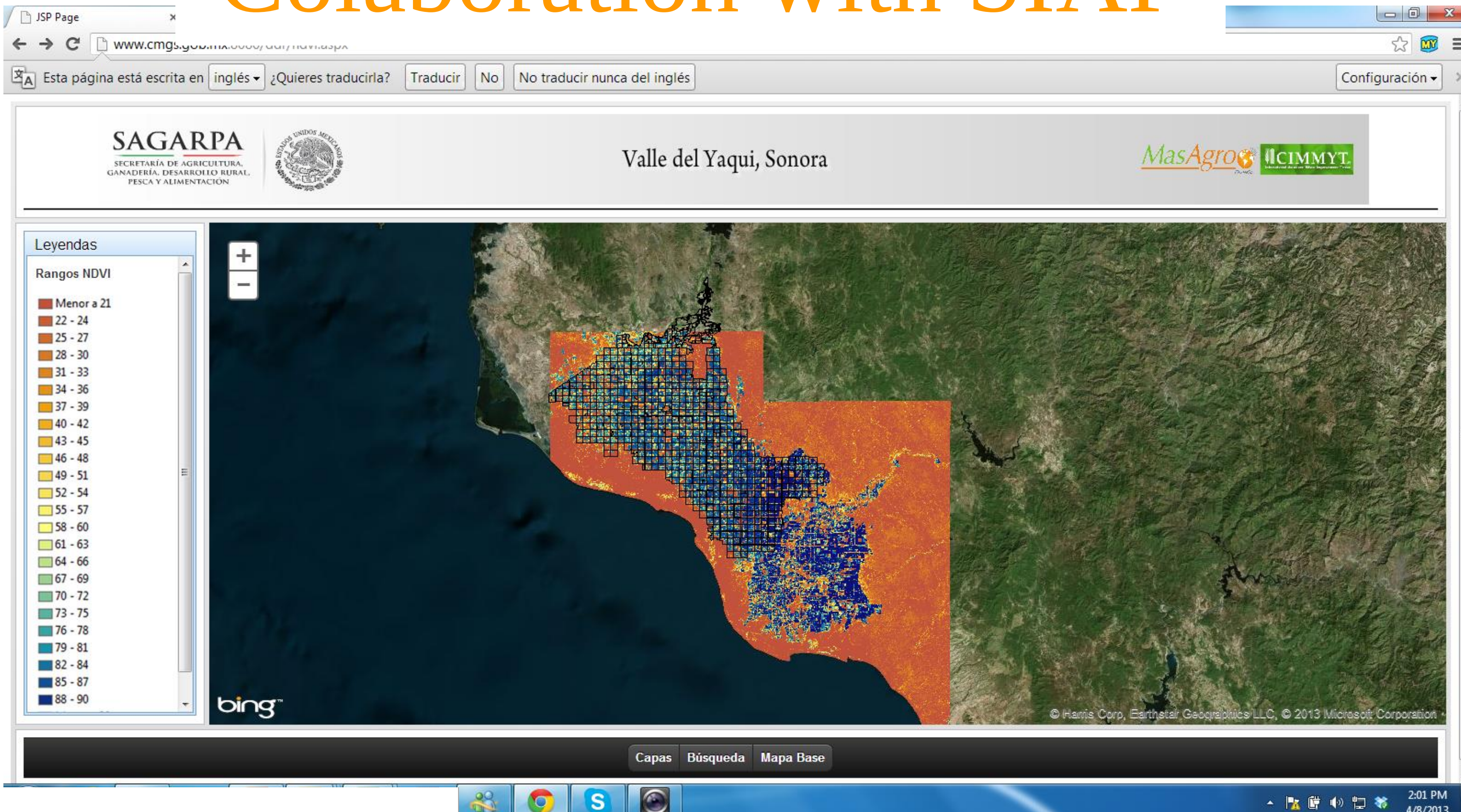
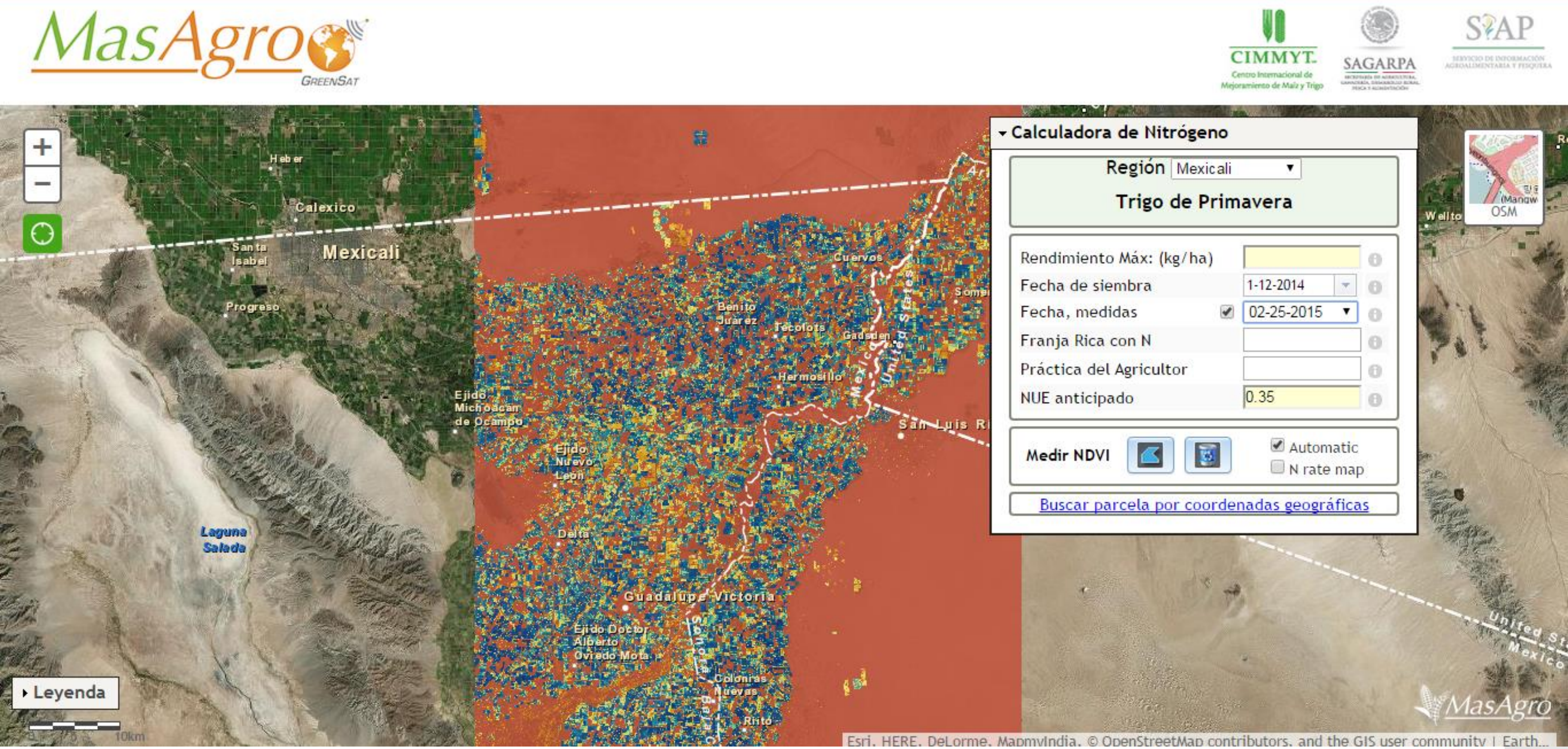
Modernización Sustentable de la Agricultura Tradicional

GreenSat with Spot 6 y 7 Colaboration with SIAP



http://www.cmgs.gob.mx:89/GreenSat/

GreenSat with SPOT 6 & 7



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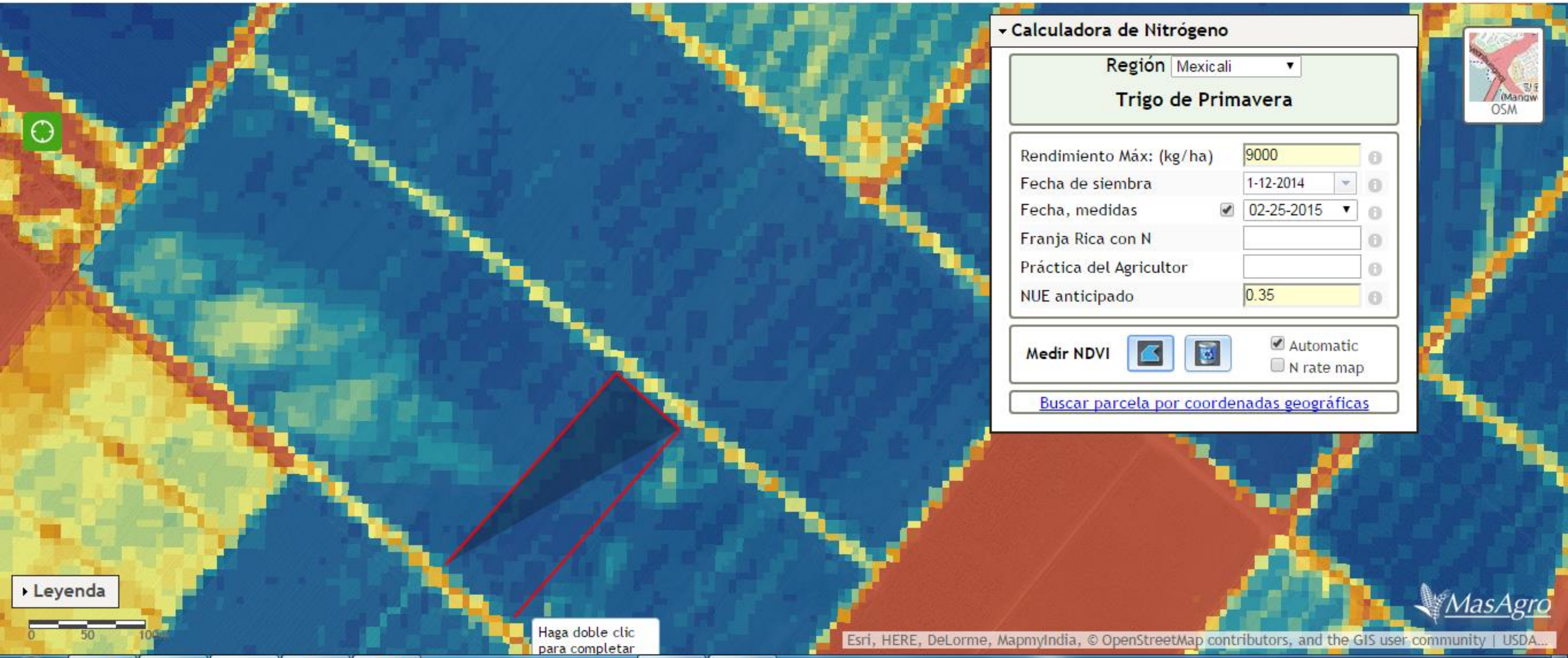
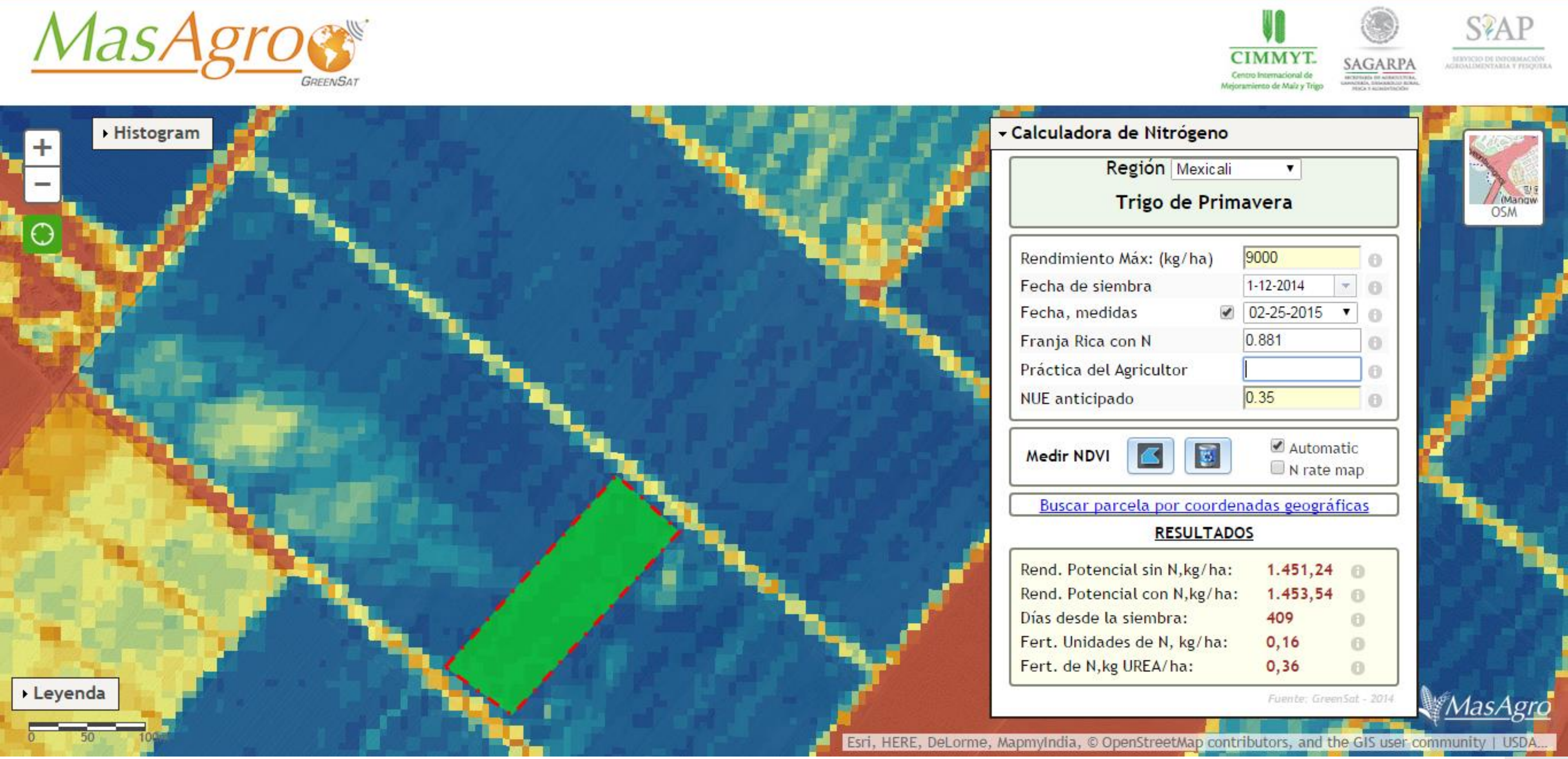
Modernización Sustentable de la Agricultura Tradicional

Calculation of NDVI using the internal tool



http://www.cmgs.gob.mx:89/GreenSat/

Calculation of NDVI using the internal tool



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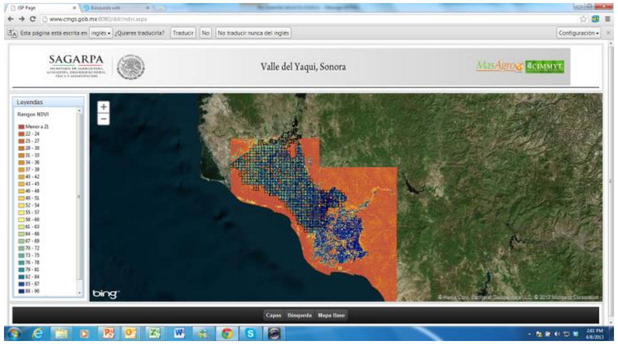
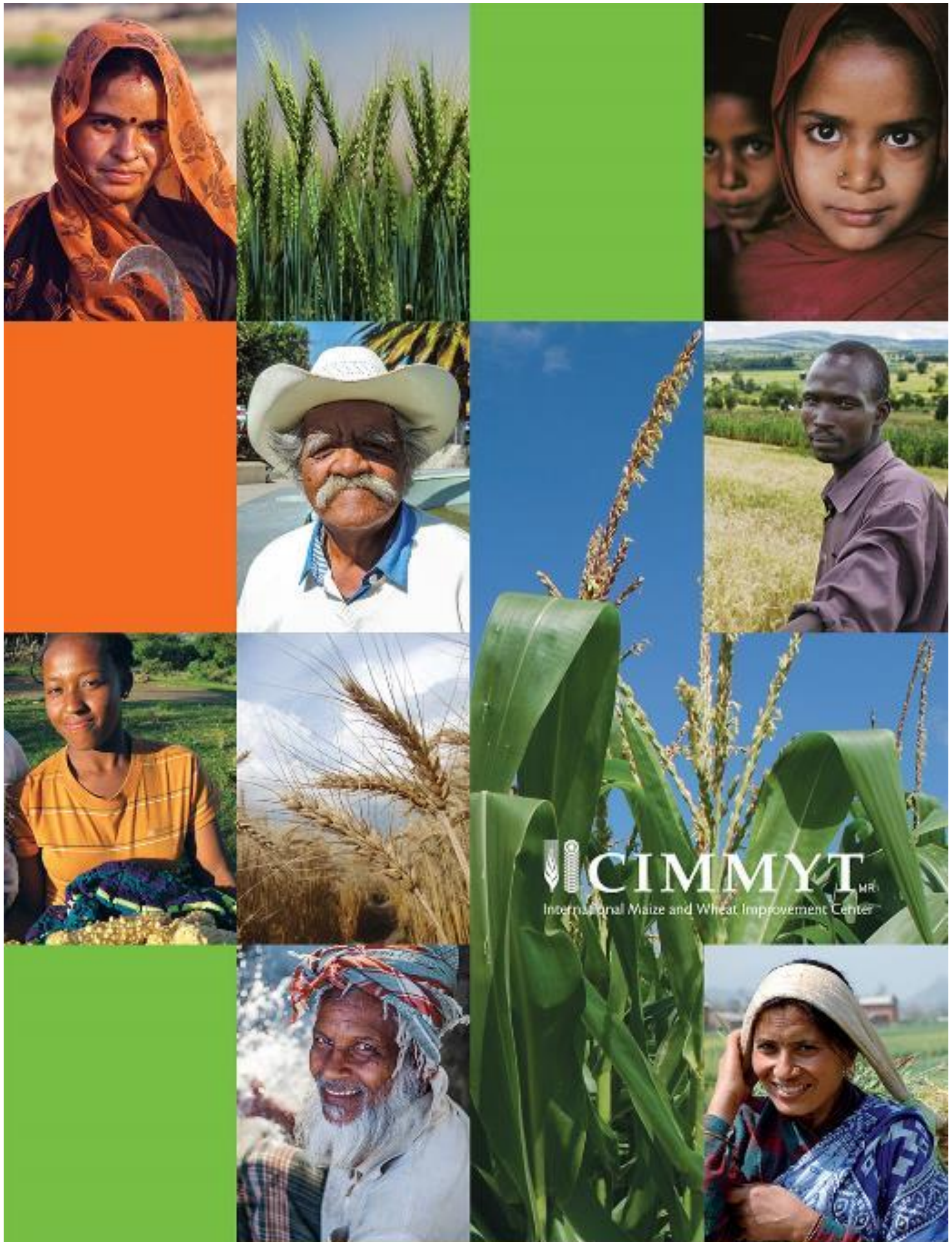
Sensor technology for nutrient management different costs and scales

Satellite



Maned airplane

Drone



Thank you for your interest!

1966-2016
CIMMYT