ICARDA in Central Asia and the Caucasus
Recent research highlights

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Tashkent

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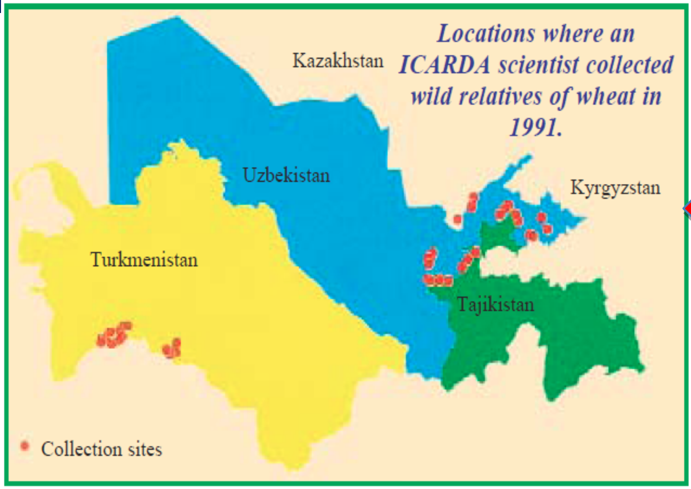
ICARDA - History of partnership in the CAC region

1980's

- ICARDA collaborated with VASKHNIL (The Soviet Union Academy of Agricultural Sciences)
- In 1987 the first scientific visit from ICARDA in Kazakhstan
- During 1989-1990 a visiting scientist from Uzbekistan spent one year at ICARDA's Genetic Resources Unit

1991

ICARDA scientist made germplasm collections of wild relatives of wheat in Turkmenistan and Uzbekistan



Locations where an ICARDA scientist collected wild relatives of wheat in 1991

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ICARDA - History of partnership in the CAC region

1995

The first workshop held in Tashkent in December 1995 brought together participants from ICARDA and other CG Centers, from donor organizations and NARS of CAC to identify areas of collaboration

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Research Centers of the CGIAR Consortium

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ICARDA - History of partnership in the CAC region

1998

- Nine CGIAR Centers agreed to form a Consortium to assist the eight CAC countries in agricultural research with ICARDA as the lead Center
- ICARDA's CAC Regional Program Office was established on 1 August 1998 in Tashkent, Uzbekistan
- ICARDA facilitated the establishment of the CGIAR Regional Program for Sustainable Agriculture in CAC (www.cac-program.org). ICARDA serves as the Convening Center for the CAC Regional Program.

Kazakhstan
Kyrgyzstan
Tajikistan
Turkmenistan
Uzbekistan
Armenia
Azerbaijan
Georgia

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Program Elements

CAC
ЦАЗ

Productivity of Agricultural Systems

Germplasm Enhancement

Strengthening National Seed Supply Systems

Cropping Systems Management and Agricultural Diversification

Livestock Production Systems and Integrated Feed/ Livestock Management

Natural Resource Conservation and Management

Irrigation, Drainage, and Water Basin Analysis

On-Farm Soil and Water Management

Rangeland Rehabilitation and Management

Conservation and Evaluation of Genetic Resources

Plant Genetic Resources

Animal Genetic Resources

Socioeconomic and Public Policy Research

Strengthening national programs

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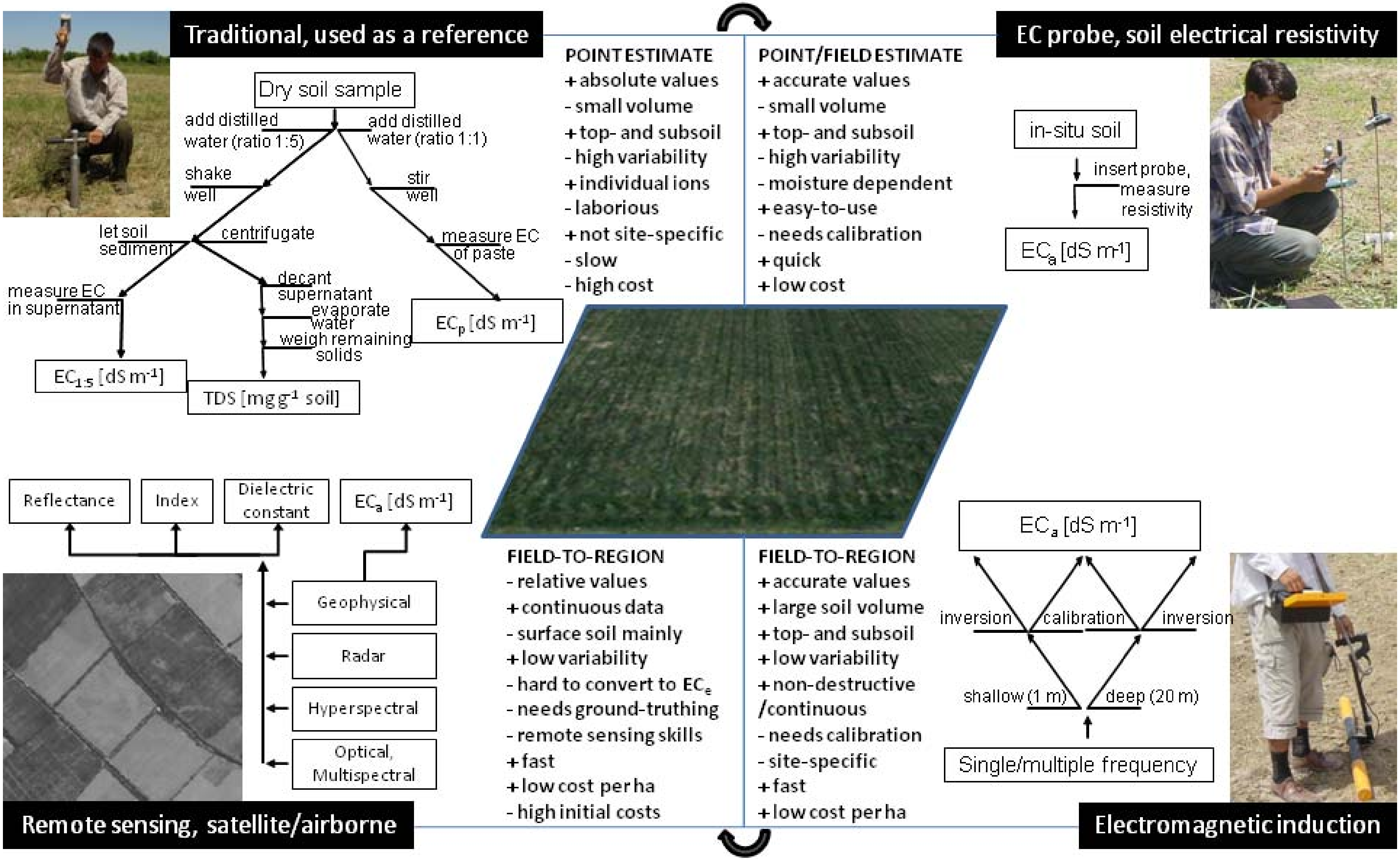
Context

- Low irrigation and water use efficiency
- Shallow groundwater table
- Deteriorating drainage network
- Secondary soil salinity requiring leaching
- Inadequate soil salinity monitoring

Select innovations to tackle challenges

- **Monitoring** – The use electromagnetic and remote sensing tools for soil salinity mapping
- **Irrigation** – Delineating irrigation response units for management of surface and groundwater resources
- **Irrigation** – ET-based irrigation scheduling to improve WUE
- **Water** – Conjunctive water management using canal and drainage water
- **Crop** – Synthetic wheat to tackle soil salinity and boost yields

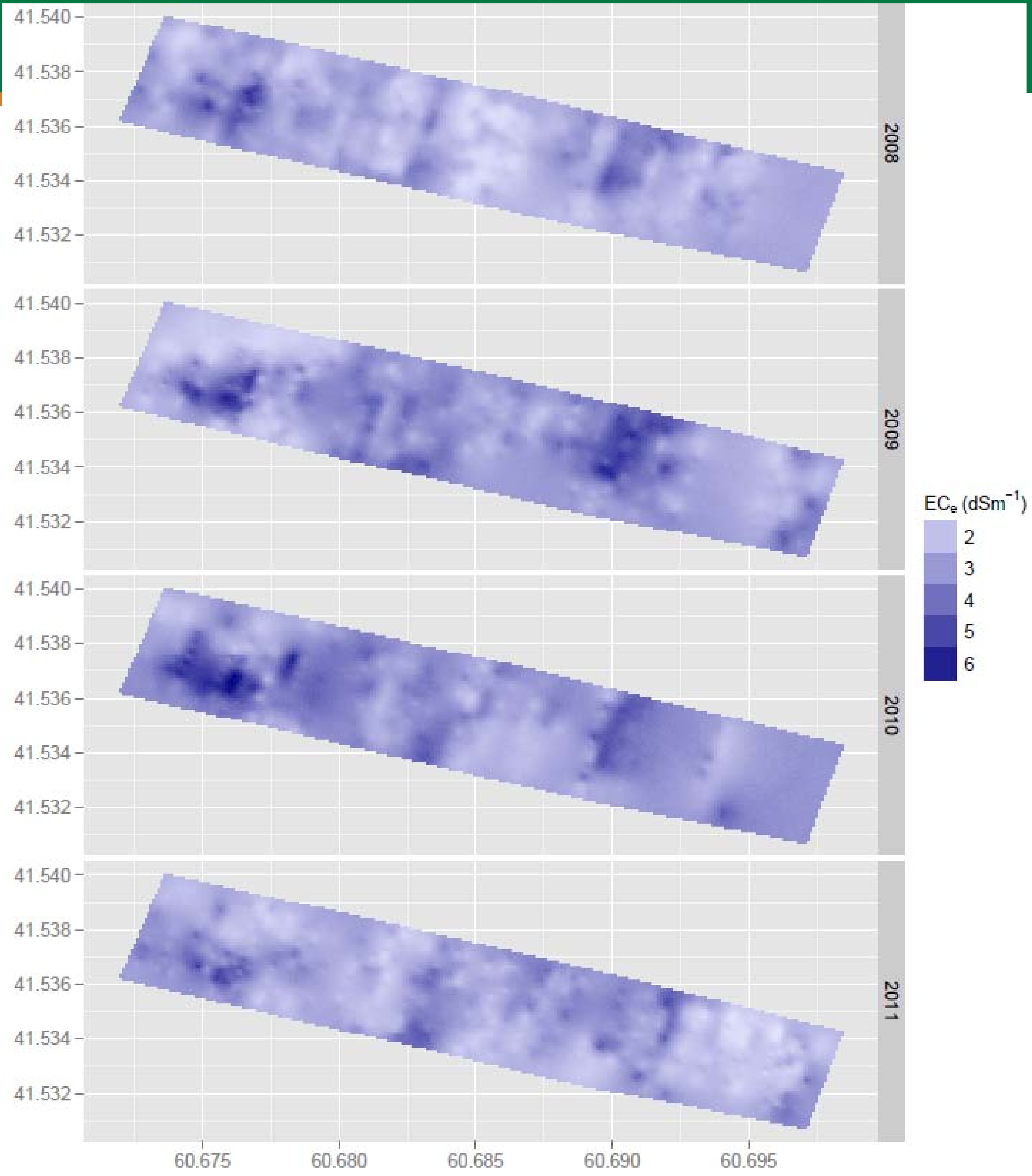
SOIL SALINITY ASSESSMENT FROM POINT-TO-FIELD, FIELD-TO-REGION SCALES



Predicted EC_e

- Only few areas with predicted EC_e above 6 dSm^{-1}

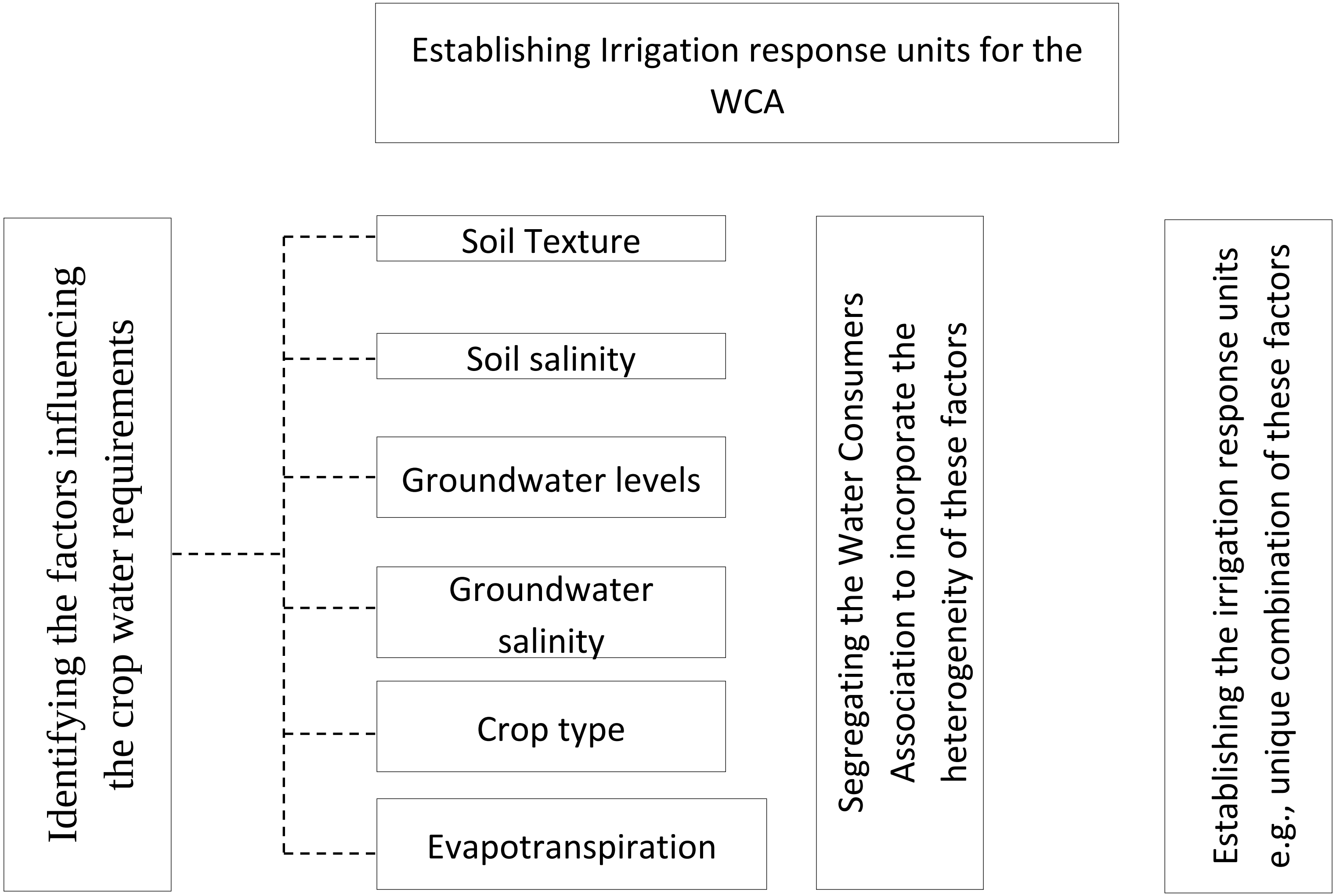
- The areas with high salinity were more pronounced in 2009-2010 and less so in 2008 and 2011



Akramkhanov et al. 2014

Irrigation – Delineating irrigation response units for management of surface and groundwater resources

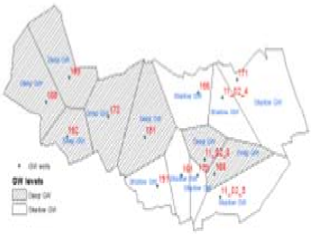
Delineating irrigation response units (IRU)



Concept of irrigation response units for effective management of surface and groundwater resources - A case study from the multi-country Fergana valley, Central Asia (Awan et al. 2016)

Delineating irrigation response units (IRU)

Groundwater levels



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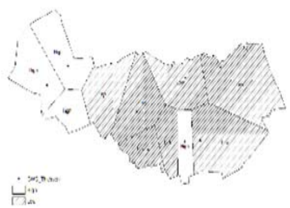
Groundwater salinity



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Soil texture

+

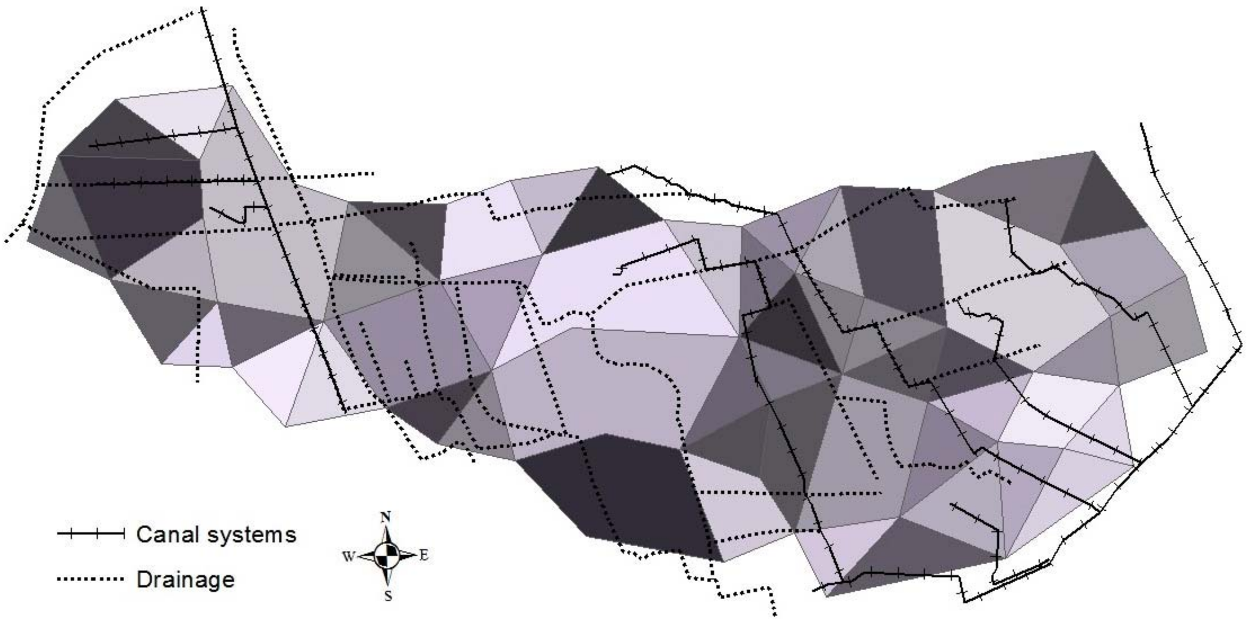
Soil salinity

+

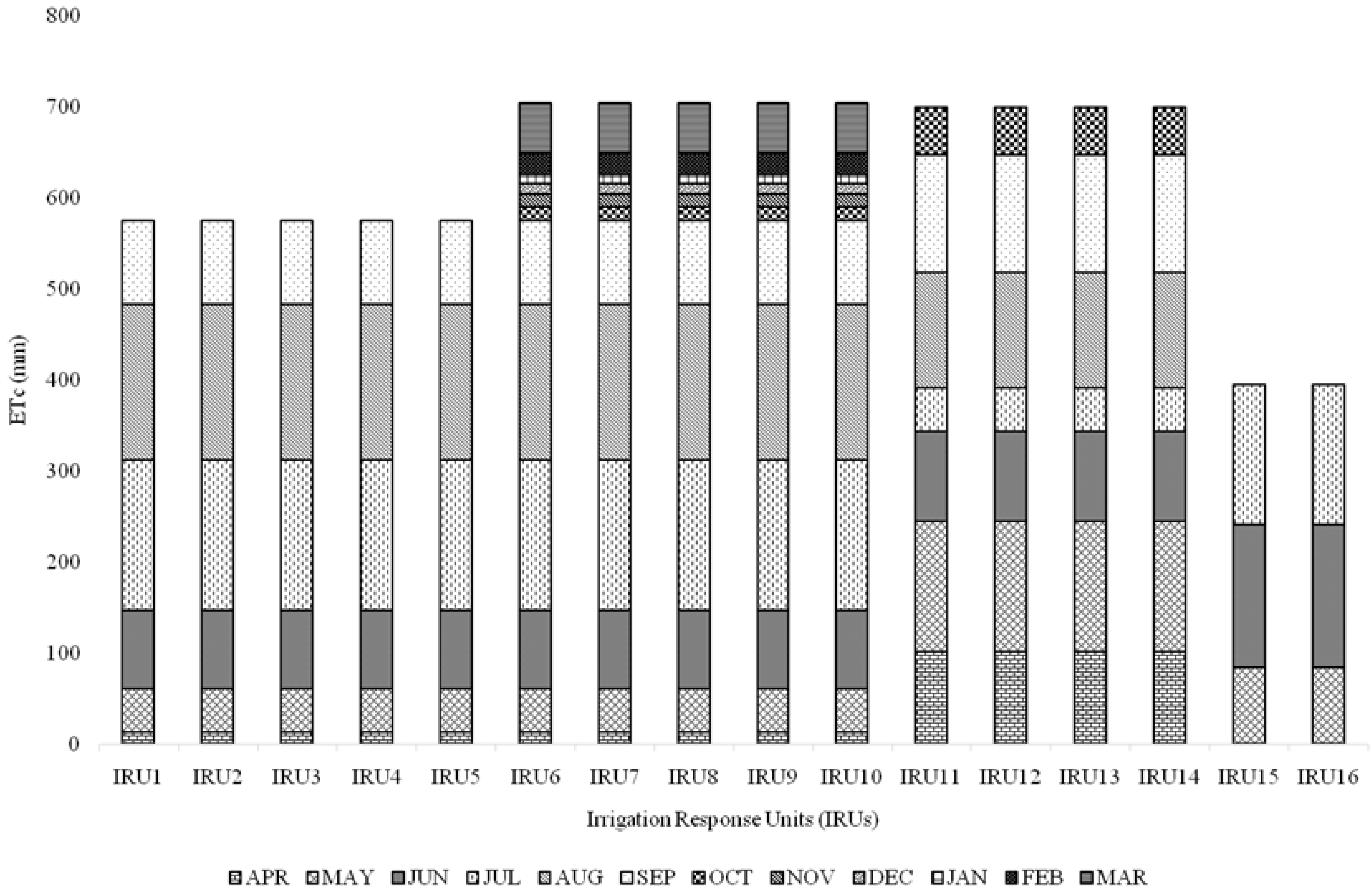
Land use

=

Irrigation response units



Annual crop ET for different IRUs



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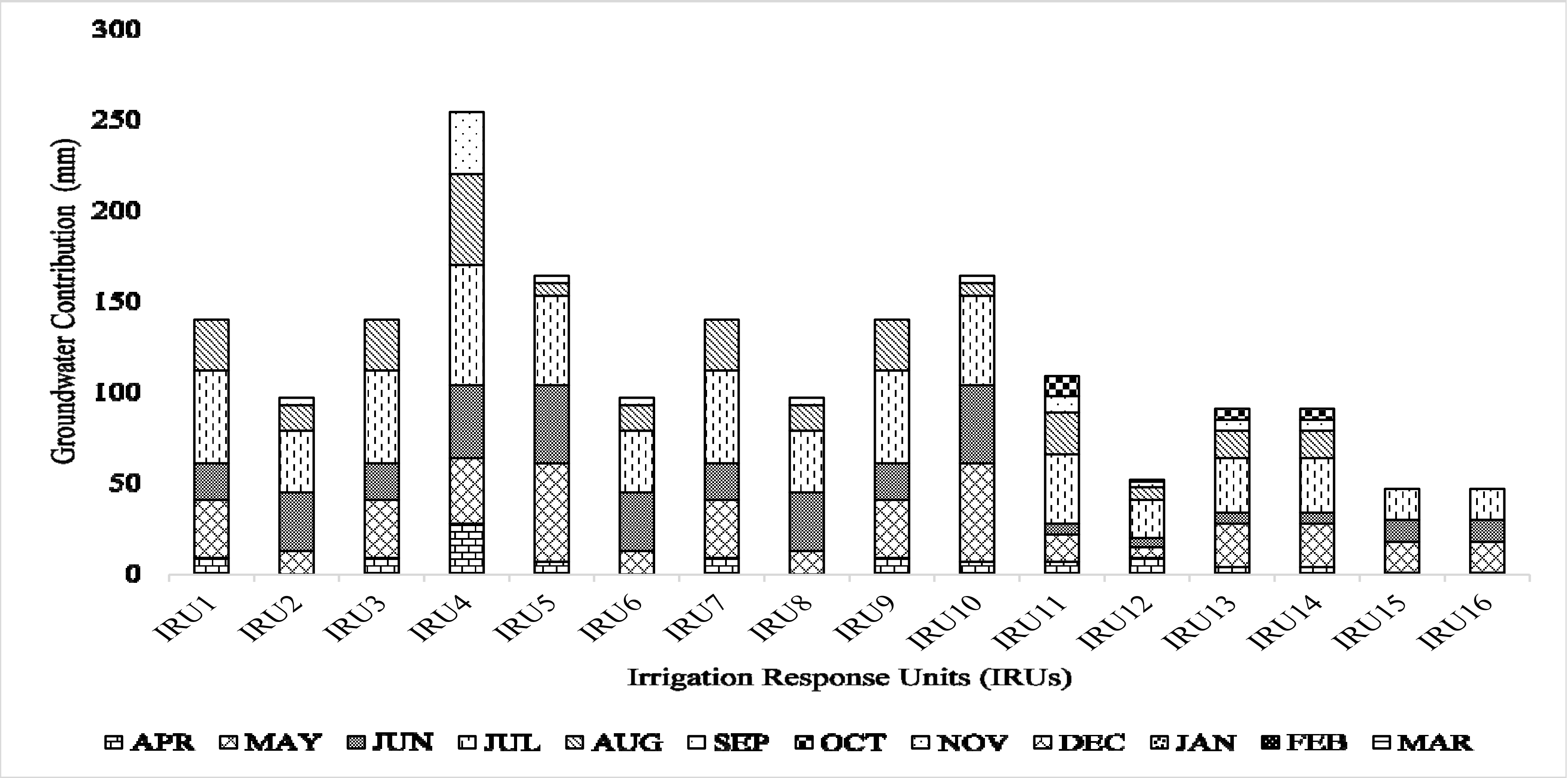
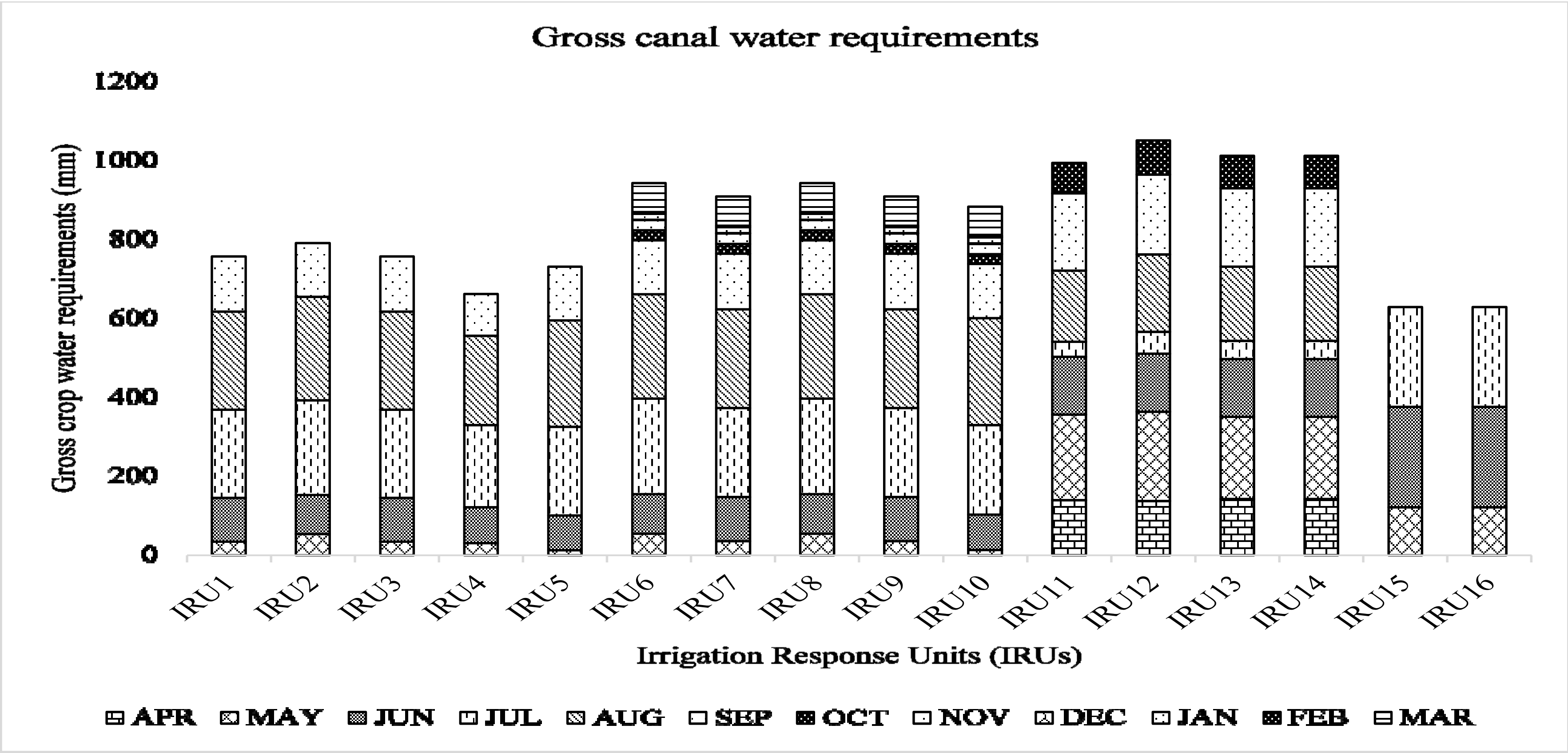
Annual groundwater contribution for different IRUs



Annual canal water requirements for different IRUs



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Delineating irrigation response units (IRU)

- The Gross Irrigation Requirement varied significantly among IRUs (average 851 mm) with a maximum (1051 mm) in IRU-12 and a minimum (629 mm) in IRUs-15, 16

- The maximum groundwater contribution occurred in IRUs dominated by cotton-fallow rotations

- Crop water requirements are about 32% lower than the actual water supplied into the irrigation network

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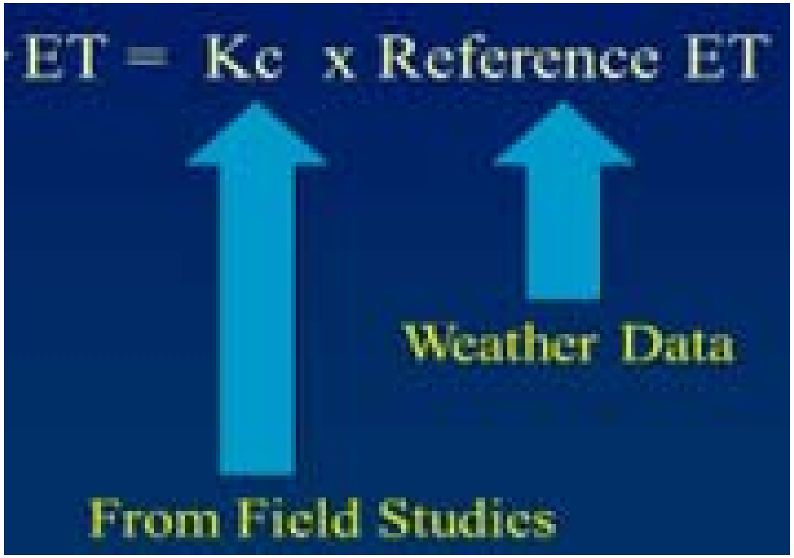
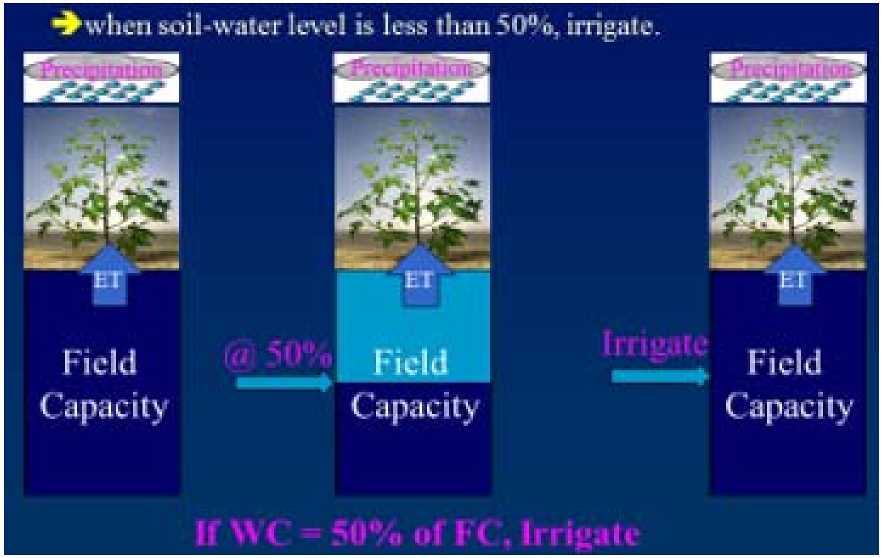
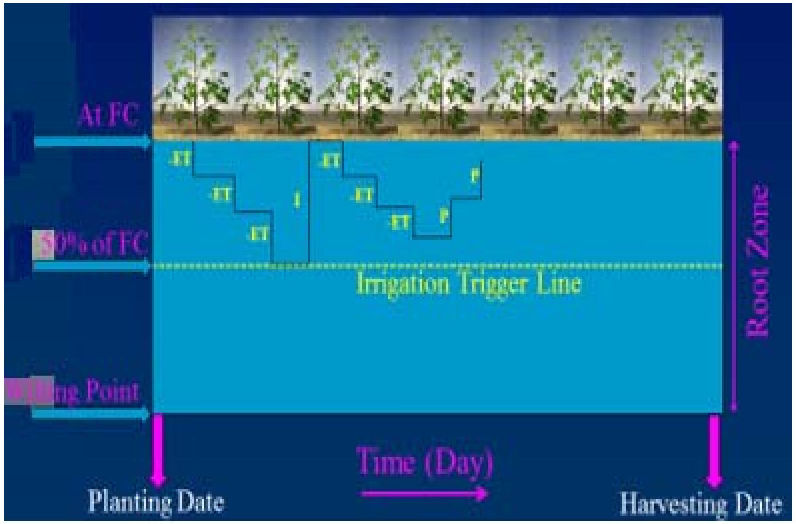
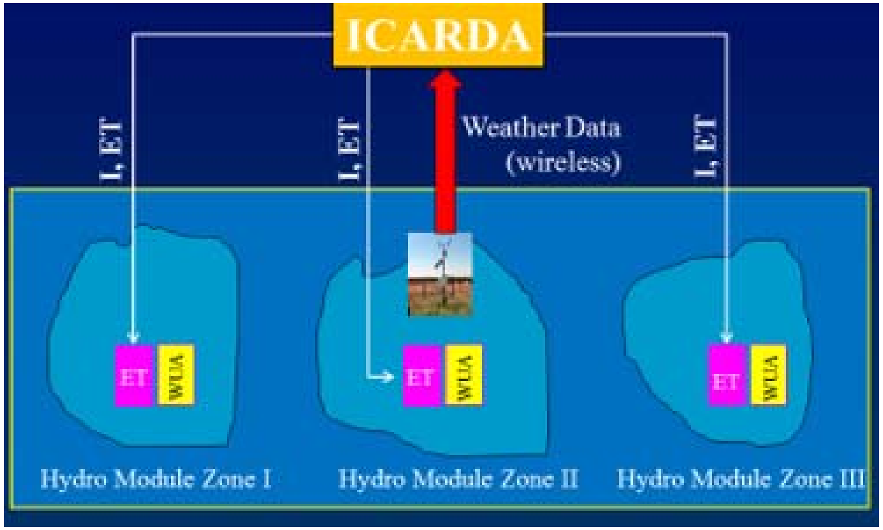
Irrigation – ET-based irrigation scheduling to improve WUE

ET-based irrigation scheduling – concept

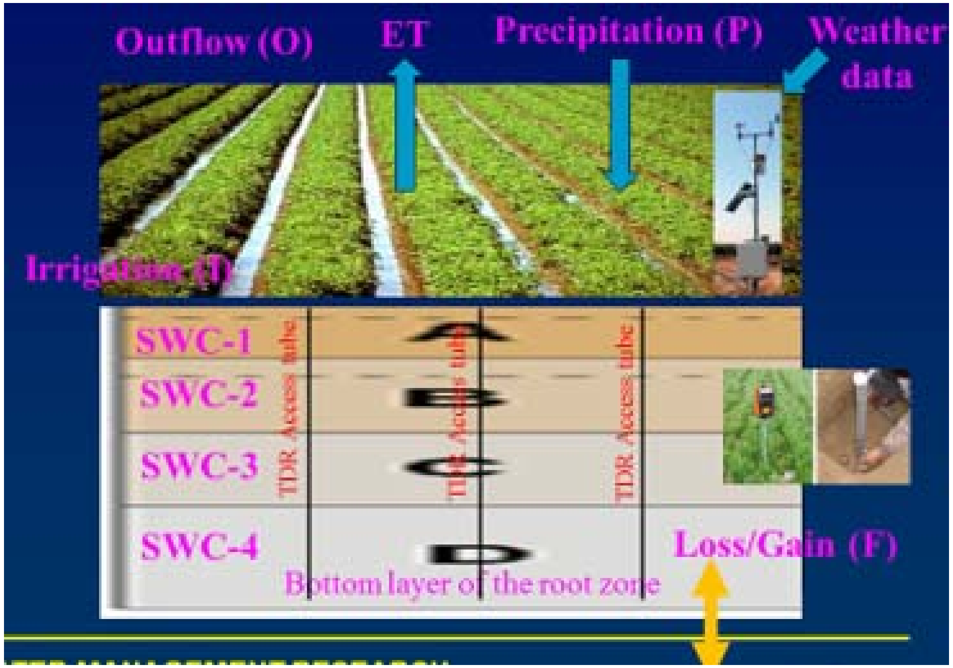






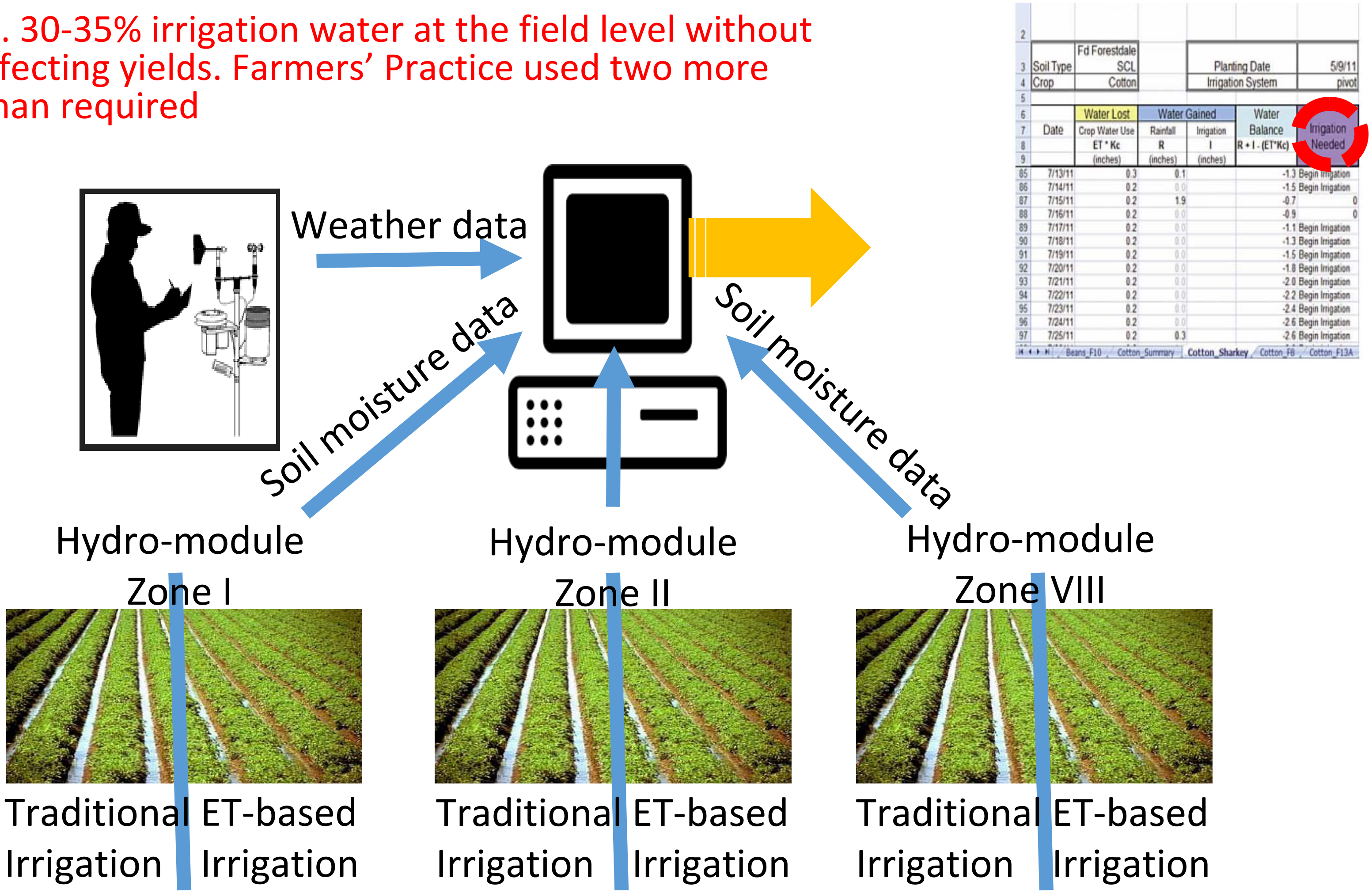


ET-based irrigation scheduling – calculator



ET-based irrigation scheduling – data flow

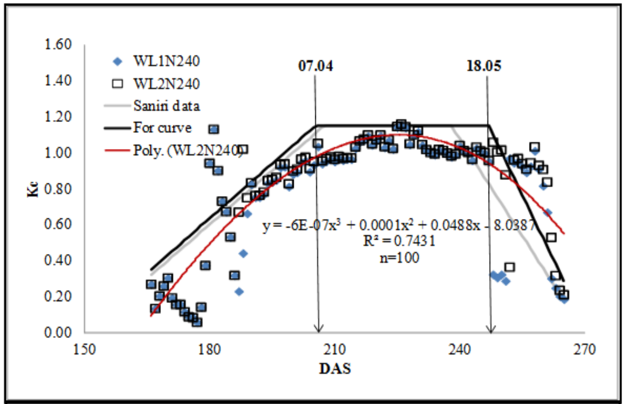
Save approx. 30-35% irrigation water at the field level without adversely affecting yields. Farmers' Practice used two more irrigations than required

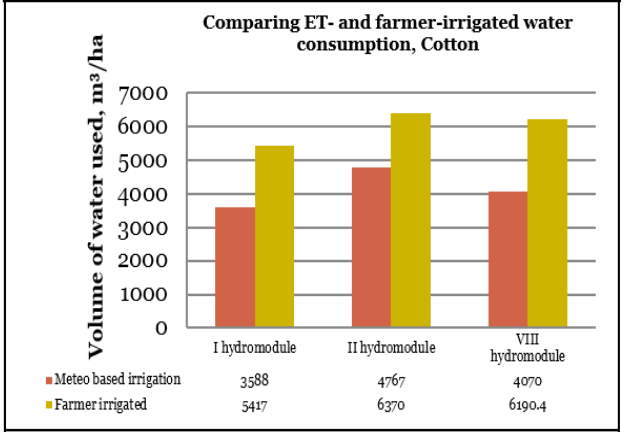


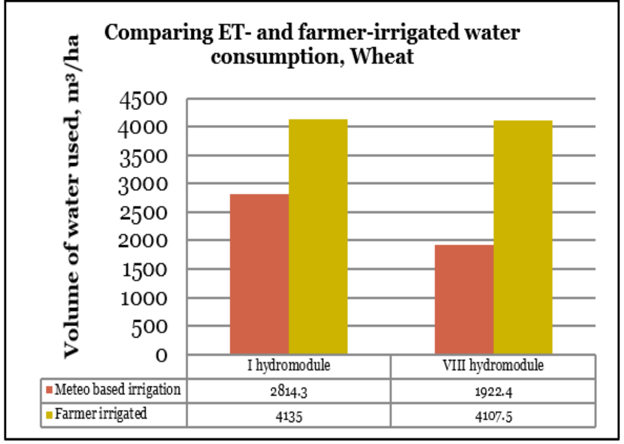
ET-based irrigation scheduling

Results

- There was on average **32% saving of irrigation** water and **50% increase in water productivity**
- There was **excellent match** between model-predicted and literature-reported values of **Kc**
- The pilot area selected for research is representative of **35%** of irrigated areas in Fergana Valley and **50%** in Aral Sea Basin
- Saved water can be used for supporting ecosystem services, expanding agriculture or for industrial and municipal purposes







Water – Conjunctive water management using canal and drainage water

ICARDA – Outcomes of partnership in the CAC region

Laser-guided land leveling

- saves 15% or more irrigation water

Conjunctive use of canal and drainage water

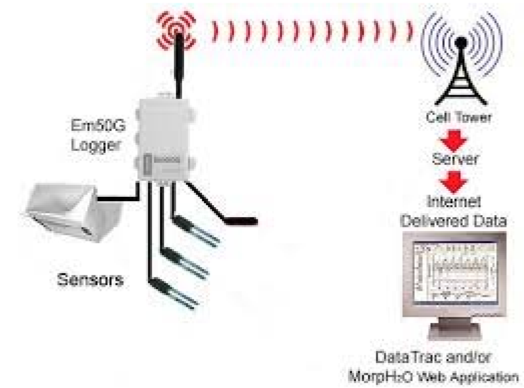
Impact of controlled drainage on crop yield and soil salinity






Conjunctive use of canal and drainage water

EM50G Monitoring Soil Salinity, Moisture and Temperature with Telemetry (GSM Module)



5TE Soil Salinity, Moisture and Temperature Sensors

CTD-10Groundwater salinity and depth sensors

PROCHECK Irrigation water salinity

Conjunctive use of canal and drainage water – data

#	Parameters	Time/Period
1	Soil moisture contents at 30, 60 and 120 cm depths	5-days basis
2	Soil salinty at 30, 60, 90 and 120 cm depths	5-days basis
3	Soil texture (sand, silt and clay content) at 30, 60, 90 and 120 cm using pipette method	Only once
4	Soil organic matter at 30, 60, 90 and 120 cm using titration method	Only once
5	Hydraulic conductivity at 30, 60, 90 and 120 cm by field experiments	Only once
6	pF Curves	Only once
7	Rainfall and other metrological measurements	Daily basis
8	Irrigation depths	Same day
9	Irrigation water salinity	Same day
10	Drainage outflows with salinty and nutrients	During draiange
11	Groundwater depth and groundwater salinity	daily basis
12	Drainage system charachteristics	Only once
13	Crop height and rooting depth	15-days basis
14	Yield	Only once
15	Fertilzer, pesticides and other inputs	When applied

Conjunctive use of canal/drainage water

- Introduction of the concept of controlled drainage first time in Central Asia
- Saving of surface water 45 – 50%
- Reduction of the drainage outflows to 10 – 15%
- Additional seasons needed to compile required data for fine-tuning and validating DRAINMOD
- Strengthening partnership with national institutions
- Maintenance of instrumentation for data collection

Crop – Synthetic wheat to tackle soil salinity and boost yields

Genetic Variation of Traits Related to Salt Stress Response in Wheat (*Triticum aestivum* L.)

Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung

Center for Development Research
Zentrum für Entwicklungsforschung
University of Bonn

universitätbonn

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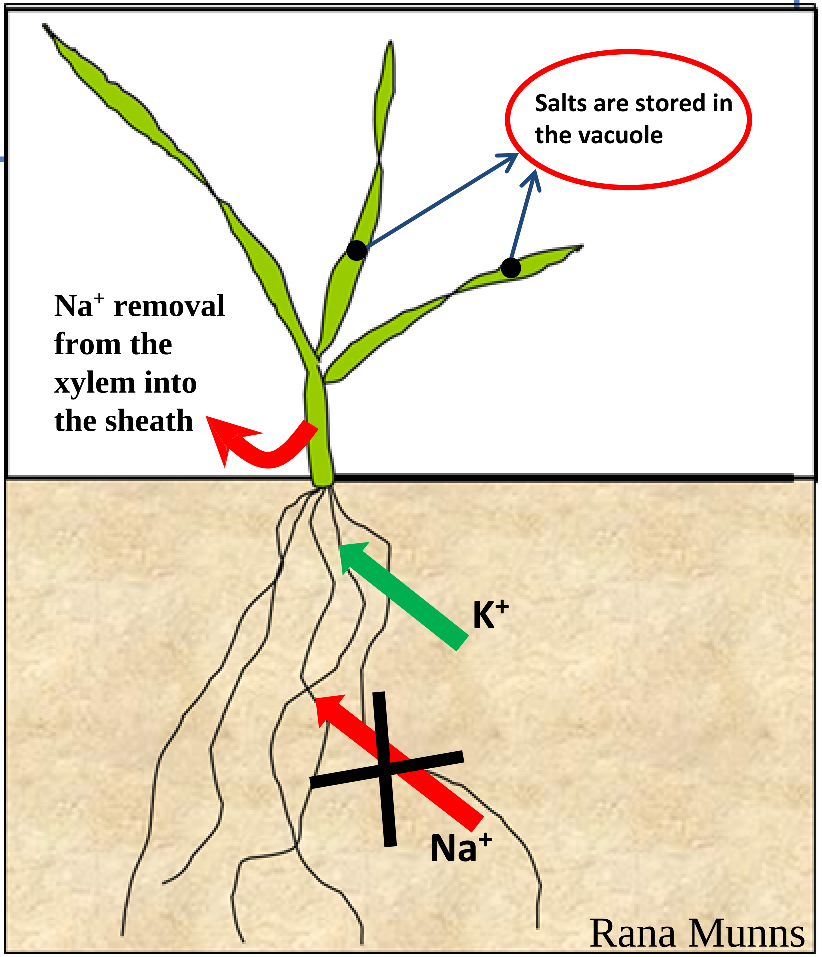
Crop traits to salinity stress - objectives

1. To identify new wheat genetic resources for salt tolerance
2. To identify QTL controlling ST using several agronomic, physiological & seed quality traits
3. Unravel the molecular mechanisms underlying salt tolerance

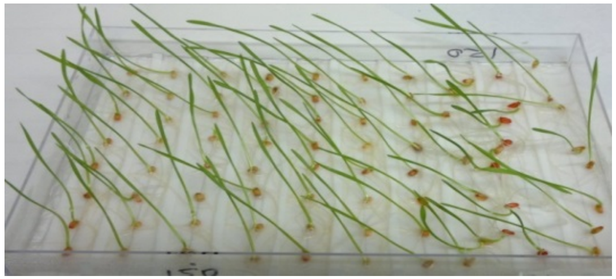
Salt affected Wheat farm in Karshi, Uzbekistan



Crop traits to salinity stress – approach

- **Germplasm: 150** wheat diversity panel (ICARDA, CIMMYT, TNP & C. Asian cultivars)

1. Germination



Salt-water flooding method

- **NaCl:** 0, 100, 150 200 mM/L
- **Na_2SO_4** : 75 and 100 mM/L

Traits: Germination scores collected 10 DAS

2. Seedling

Supported Hydroponics System

- **0 and 100** mM NaCl
- **0 and 75** mM Na_2SO_4

Traits: FRW, FSW, DRW & DSW after 25 DAS

3. Adult-field plant

Four field trials: Urgench, Karshi, Syrdarya (Uzbekistan) & Dongying (China)

- **Yield traits:** GY, PH, DTH, TKW, etc.
- **Seed quality traits**: Protein, Starch content

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Physiological characterization

❑ Leaf chlorophyll fluorescence using FluorPen FP100

❑ Readings were taken from the 3rd leaf after 25 DAS

❑ **Traits collected:**

- ✓ Extracted Fluorescence: F_o, F_J, F_m, F_v, F_v/F_m, F_m/F_o
- ✓ Quantum flux ratios: $PI_{(ABS)}$
- ✓ Specific fluxes per RC: ABS/RC, TRo/RC, ETo/RC & DIo/RC

❑ Shoot Ionic contents using Atomic Absorption Spectrum

❑ Shoot samples were separated 3rd leaf, shoot and RLP (remaining leaf parts)

- ✓ **K^+** and **Na^+** contents measured,
- ✓ **K^+/Na^+** ratio estimated

Analysis of some phenotypic traits across growth stages

Stage	Experiments	MS_G	MS_T	MS_{G*T}	CV $_{ST}$	h^2	Effect
	Germination score after 10 days of salt stress						
Germination	100 mM NaCl	0.56**	48.61**	0.08^{ns}	**2.87**	**0.85**	-
	150 mM NaCl	0.55**	564.20**	0.20**	5.12	0.76	-
	200 mM NaCl	0.49**	1862.09**	0.36**	7.94	0.58	-
	75 mM Na_2SO_4	0.44**	307.59**	23.5**	4.23	0.80	-
	100 mM Na_2SO_4	0.49**	1149.08**	0.40**	7.67	0.60	-
	Dry shoot weight (g/plant) after 25 days of salt stress						
Seedling	100 mM NaCl (**Exp. 1**)	716.74**	191.25**	91.01^{ns}	14.57	**0.42**	-
	100 mM NaCl (**Exp. 2**)	795.92**	3172.41**	357.04**	16.99	0.57	-
	75 mM Na_2SO_4 (**Exp. 3**)	583.50**	2104.01**	249.94**	14.74	0.63	-
	75 mM Na_2SO_4 (**Exp. 4**)	210.69*	1716.28**	125.23^{ns}	15.45	0.73	
	Grain yield (t/ha)						
Adult-field plant	Urgench	1054.07**	494.71**	281.33**	23.07	0.76	-
	Syrdarya	288.18**	-	-	16.41	0.50	-
	Karshi	747.00**	188.77**	437.95**	16.25	0.57	-
	Dongying	217.13**	1791.53**	199.11*	**71.60**	0.23	-

- ❑ Genotypes, salt treatment and their interactions showed significant effect in most traits across the three growth stages
- ❑ Trait showed moderately (**0.42**) to high (**0.85**) heritability estimates

Oyiga et al. (2016)

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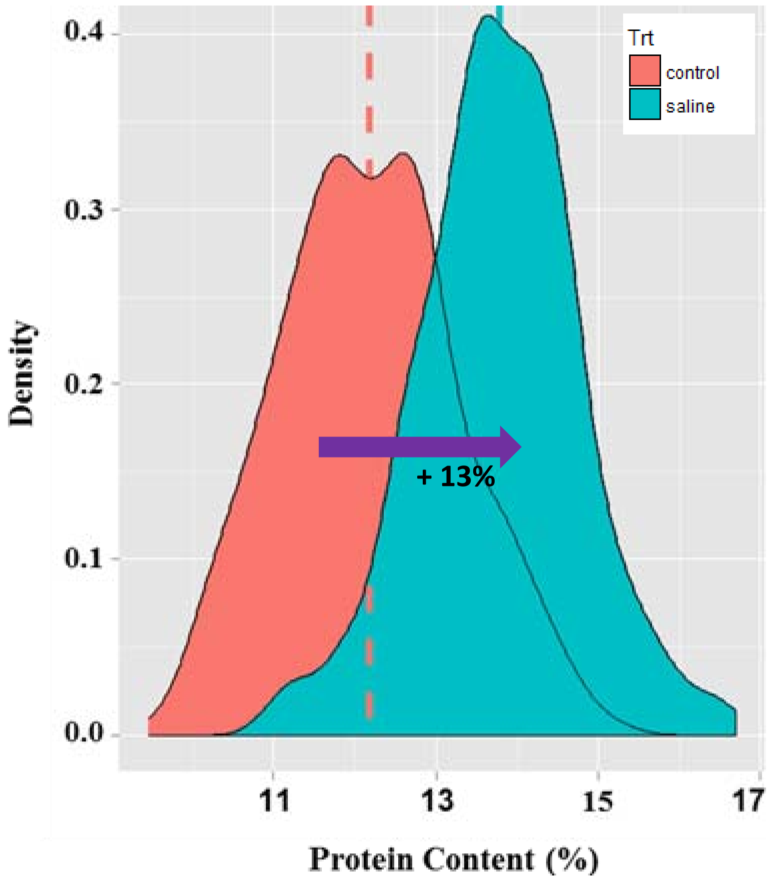
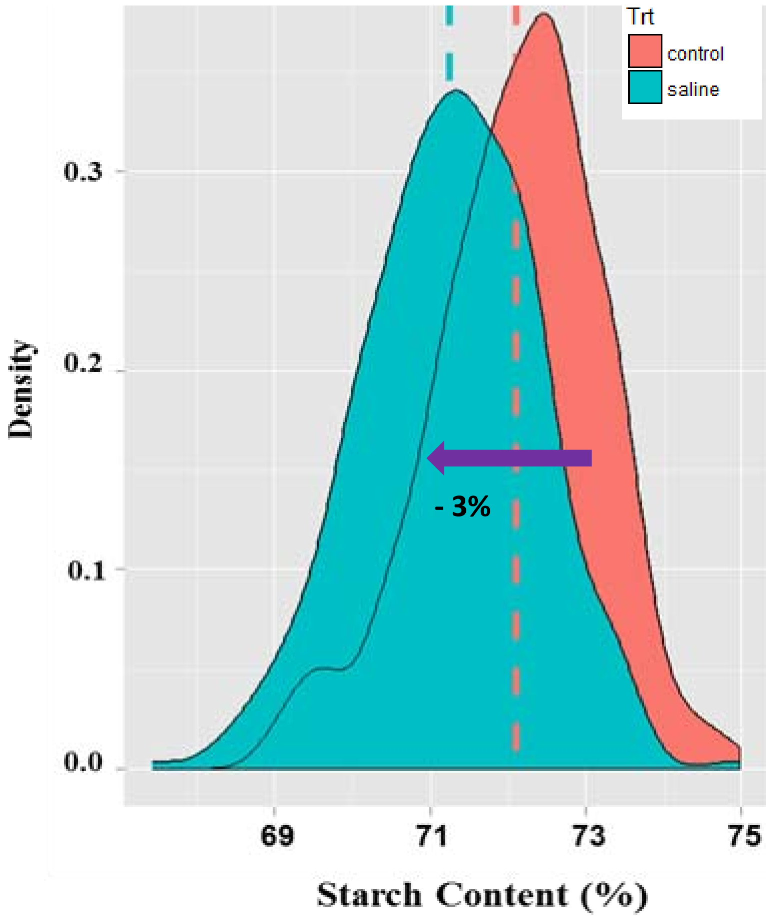
Effect of salinity on seed quality





❑ Salt stress increased grain protein content (+13%), while decreasing grain starch protein (-3%)

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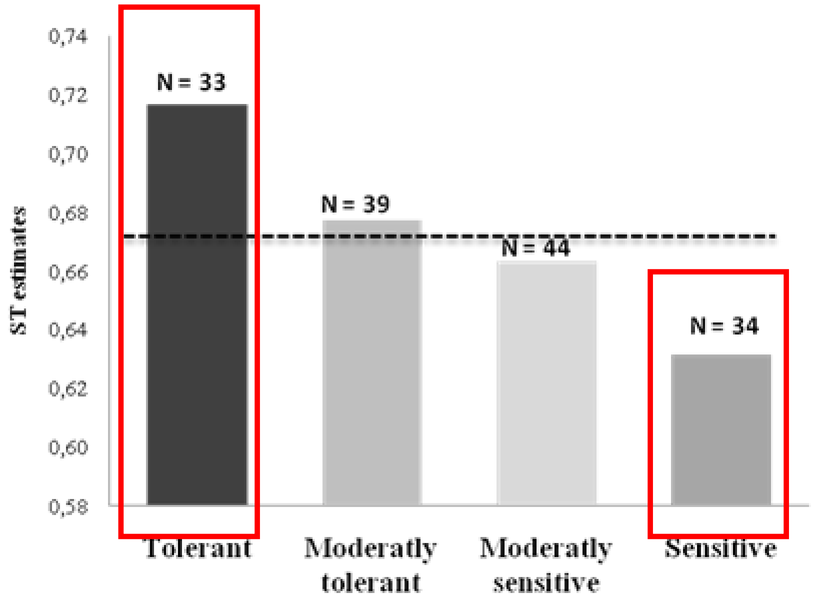
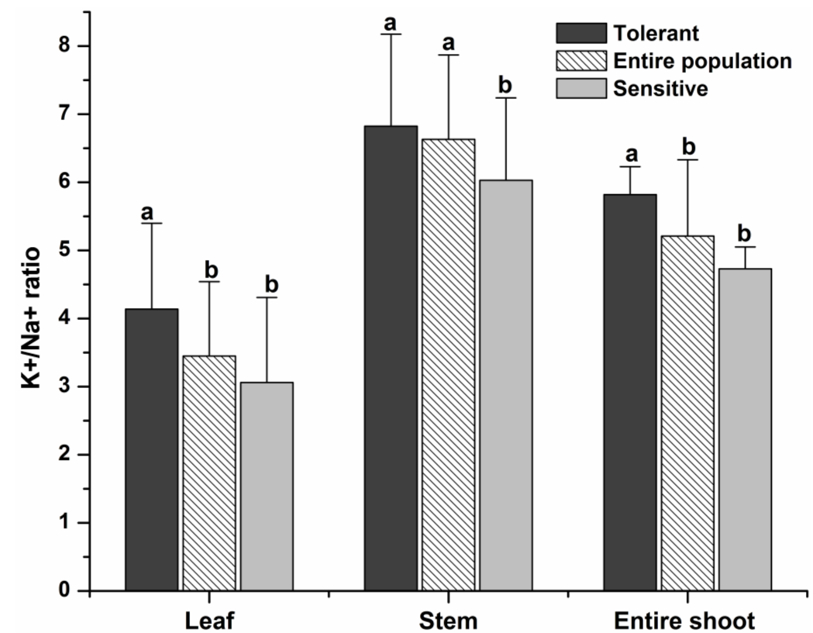
Characterization of ST status of the 150 germplasm





- ❑ High K^+/Na^+ ratio showed higher Na^+ exclusion and/or K^+ uptake mechanisms
- ❑ Thus, better ionic homoeostasis under salt stress

Oyiga et al. (2016)

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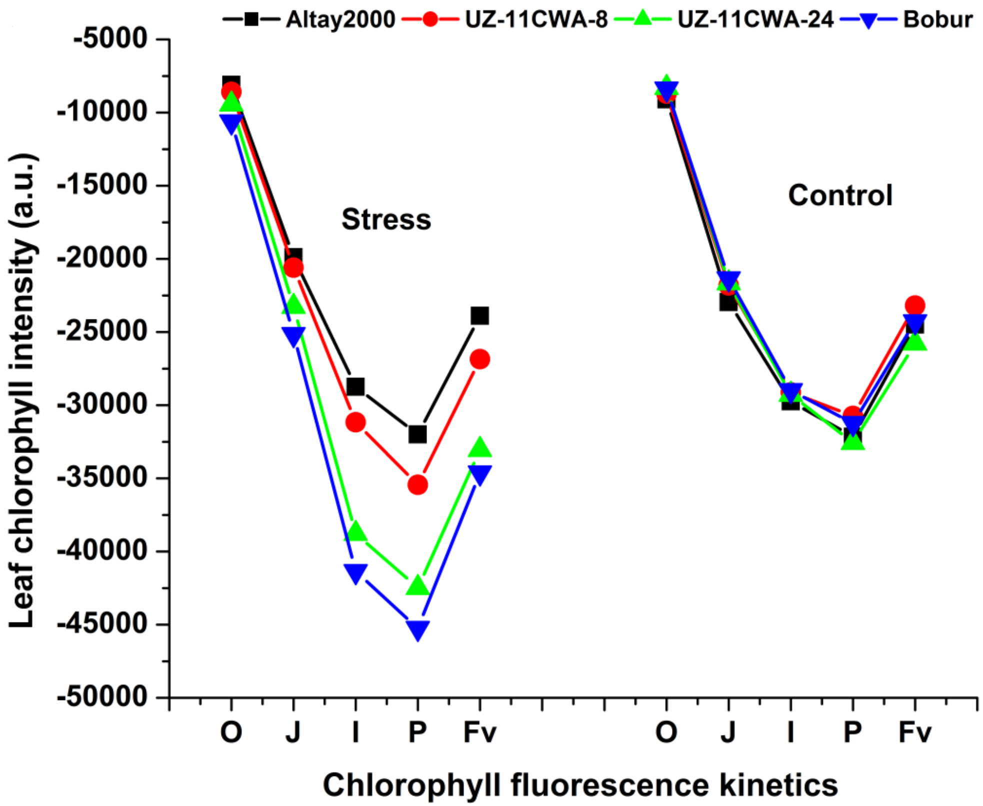
Leaf chlorophyll fluorescence of the contrasting ST genotypes



- Decrease in leaf fluorescence has been attributed to increased energy and photosynthesis pigment losses in plant under stress (Guidi *et al*., 2002; Bussotti *et al*., 2011)

Oyiga et al. (2016)

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Identified candidate genes in QTL chromosome regions

Associated traits	Associated Candidate genes
	Stress response
FRW	Two-component response regulator-like (**PRR1**)
Shoot Na^+	Leukotriene A-4 hydrolase homolog (**NCU06732**)
Vj	Calcineurin subunit B (**cnb-1**)
DSW	Zinc finger A20 and AN1 domain-containing stress-associated protein 8 (**SAP8**)
Seed hardness	Molybdenum cofactor sulfurase (**hxB**)