3rd CIGR Inter-Regional Conference on Land and Water Challenges – Tools for development

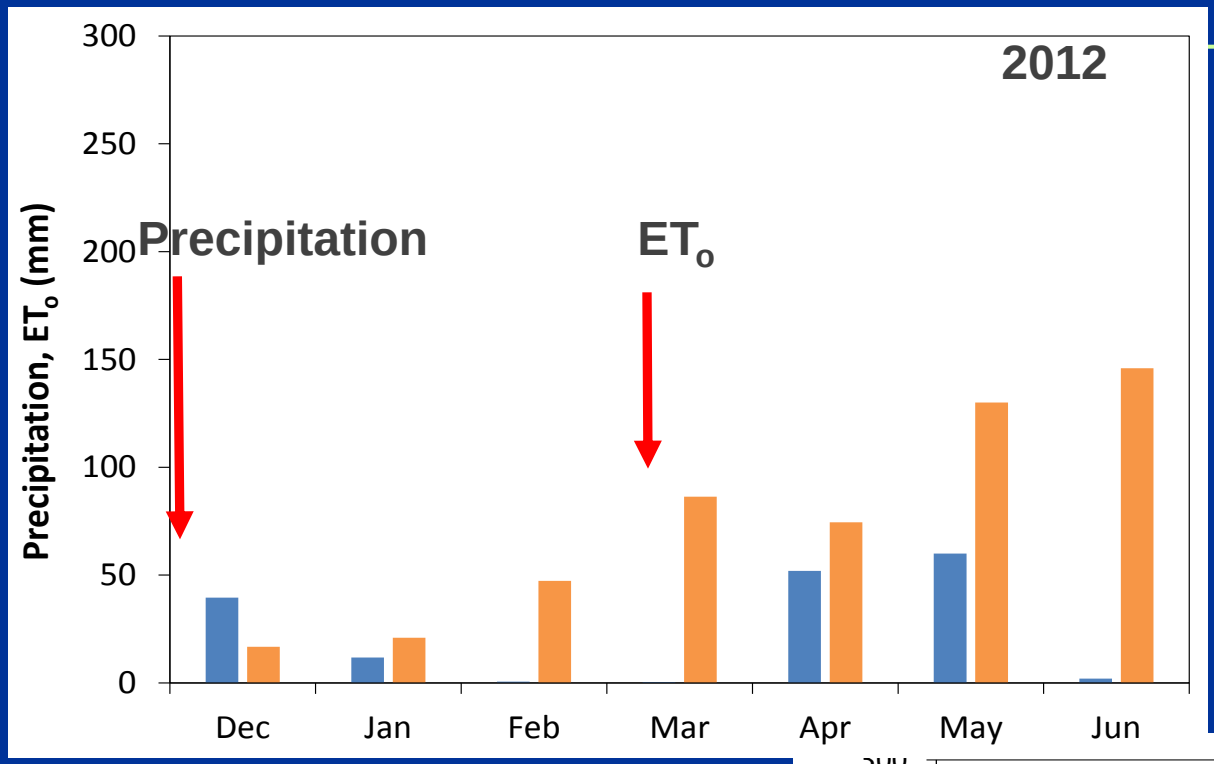
Predicting water use and malt barley yields to improve supplemental irrigation under water scarcity

P Paredes, GC Rodrigues, MR Cameira, MO Torres, Luis S Pereira

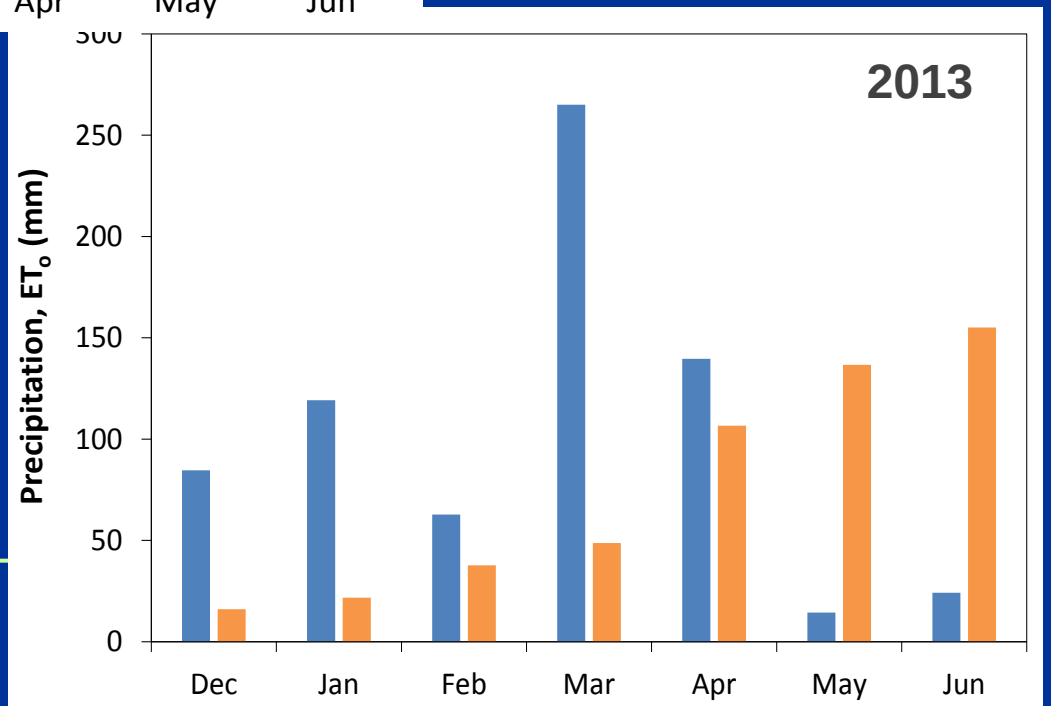
Colonia, Uruguay 28 to 30 September 2015

Objectives

1. calibration and validation of the SIMDualKc model, using data of a dry and a wet year;
2. assessing the accuracy of combining the SIMDualKc and the Stewart's models to predict barley yields;
3. assessing alternative sowing dates and supplemental irrigation schedules in terms of water use and water productivity



Main climatic characteristics of the studied crop seasons



Soil textural and hydraulic properties (loamy sand)

Depth (m)	Particle size (%) Sand	Loam	Clay	θ_{FC} ($cm^3\ cm^{-3}$)	θ_{WP} ($cm^3\ cm^{-3}$)
0.0-0.1	85	11	4	0.32	0.08
0.1-0.2	84	10	6	0.25	0.06
0.2-0.4	85	9	6	0.22	0.06
0.4-0.6	86	8	6	0.22	0.04
0.6-0.8	85	9	6	0.22	0.05
0.8-1.0	85	9	7	0.17	0.04

Dates of crop growth stages

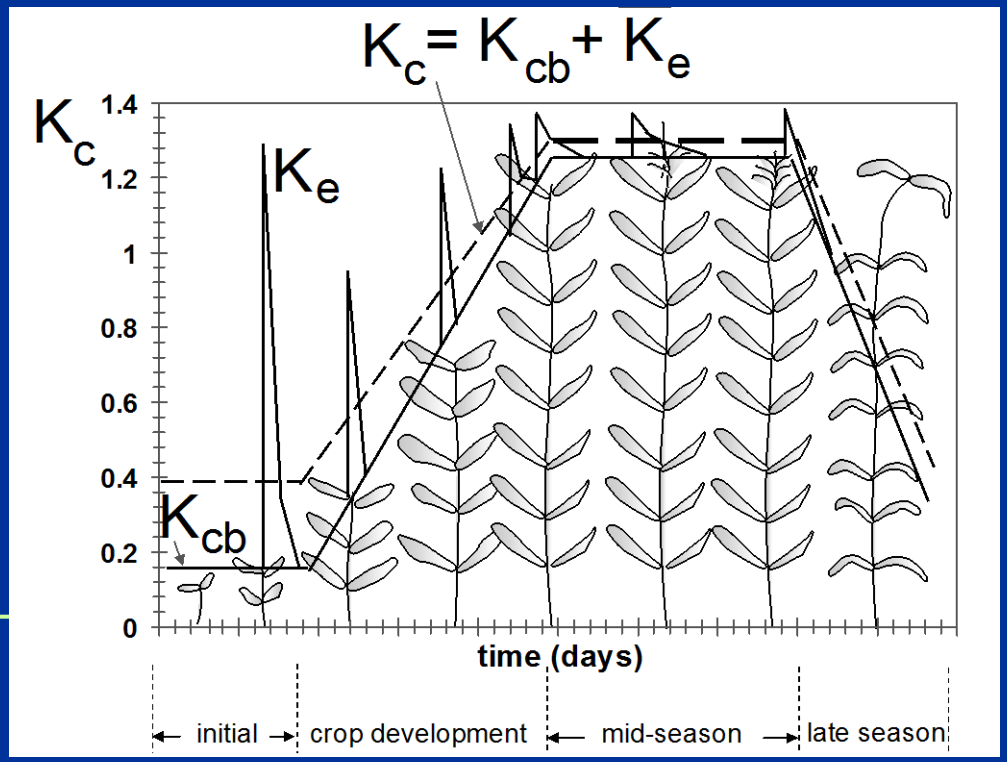
	Crop growth stages				
Year	Initial	Crop development	Mid-season	Late-season	Harvest
2012 dates	16/01 to 06/02	7/02 to 02/04	03/04 to 19/05	20/5 to 26/06	26/06
CGDD (°C)	210	896	1552	2315	
2013 dates	06/12 to 03/01	04/01 to 09/03	10/03 to 28/04	29/04 to 06/06	06/06
CGDD (°C)	302	984	1671	2331	

Modeling approaches

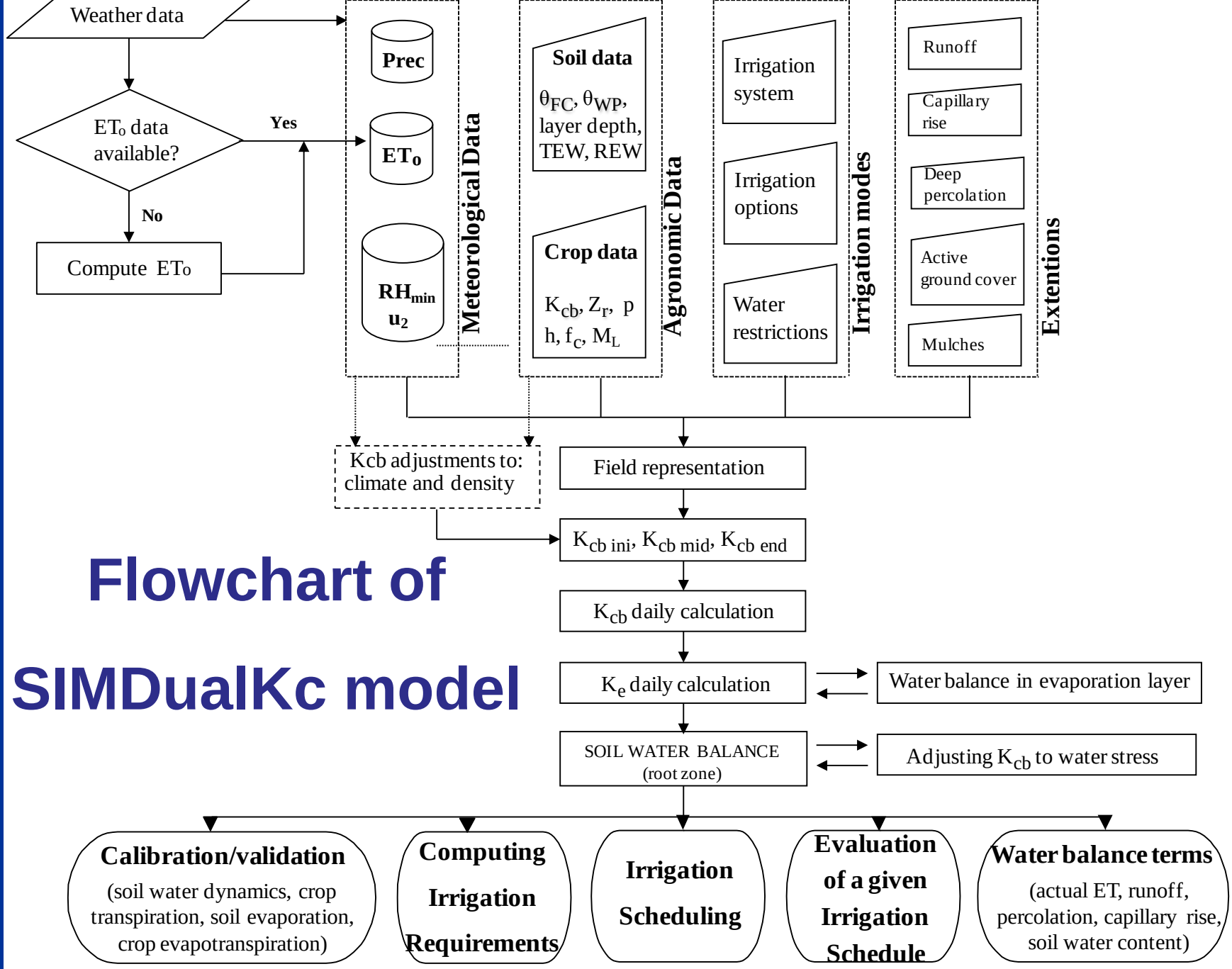
1. Soil water balance – SIMDualKc model

SIMDualKc allows computing separately soil evaporation and actual crop transpiration

$$ET_c = (K_s K_{cb} + K_e)\, ET_o$$



Flowchart of SIMDualKc model



2. Stewart water-yield approach

lit assumes that **relative yield losses** vary **linearly** with the **relative evapotranspiration deficits**

$$\left(1-\frac{Y_a}{Y_m}\right)=K_y\left(1-\frac{ET_a}{ET_c}\right)$$

Using transpiration data Ya; was

$$Y_a = Y_m - \frac{Y_m K_y T_d}{T_c}$$

Relative yield losses

$$RYL = K_y \frac{(T_c - T_{c\,act})}{T_c} \; 100$$

Water Productivity indicators

Total water productivity, ratio between the crop yield achieved, Y_a, and the total water use (TWU), expressed in kg m^{-3}:

$$WP = \frac{Ya}{TWU} = \frac{Ya}{P + CR + \Delta SW + I}$$

Economic Water Productivity Ratio .

$$EWPR_{\text{full cost}} = \frac{Value(Y_a)}{Cost(TWU)}$$

Alternative management scenarios

a) Rainfed
b) Full satisfaction of crop water requirements;
c) Very mild stress
d) Mild stress
e) Moderate stress

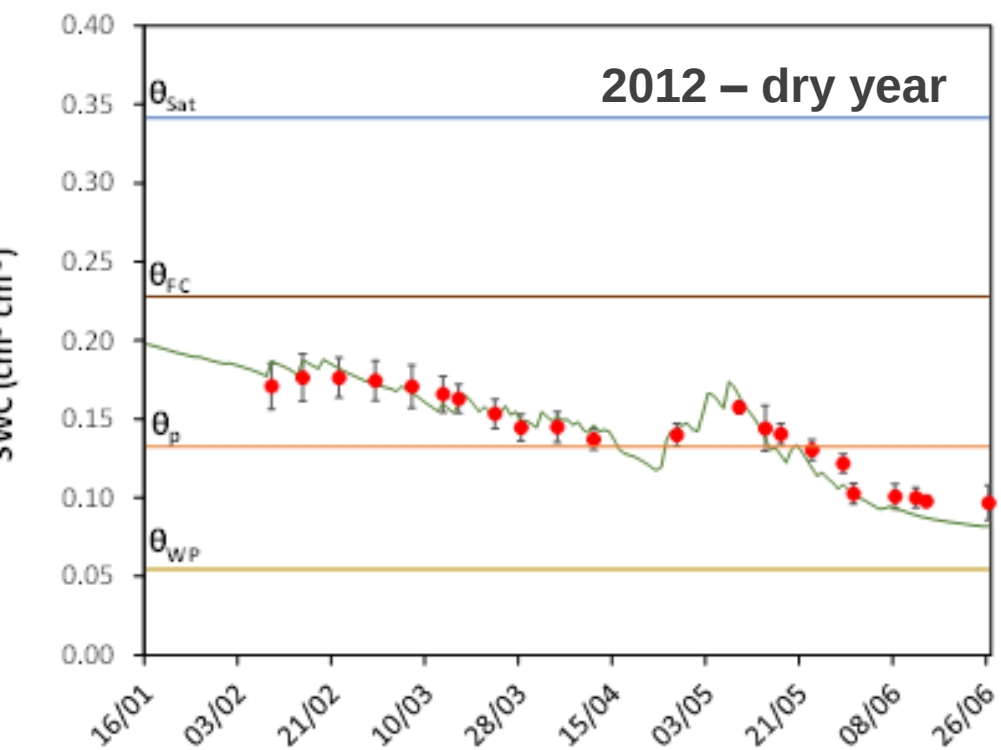
Alternative sowing dates

mid and late November,

early, mid and late-December

early and mid-January

Crop growth stages defined with cumulative growing degree days (CGDD)



Models calibration and validation using SWC observations

Crop Season	b_0	R^2	RMSE ($cm^3\ cm^{-3}$)	EF
2012	0.99	0.96	0.009	0.90
2013	1.00	0.85	0.015	0.85

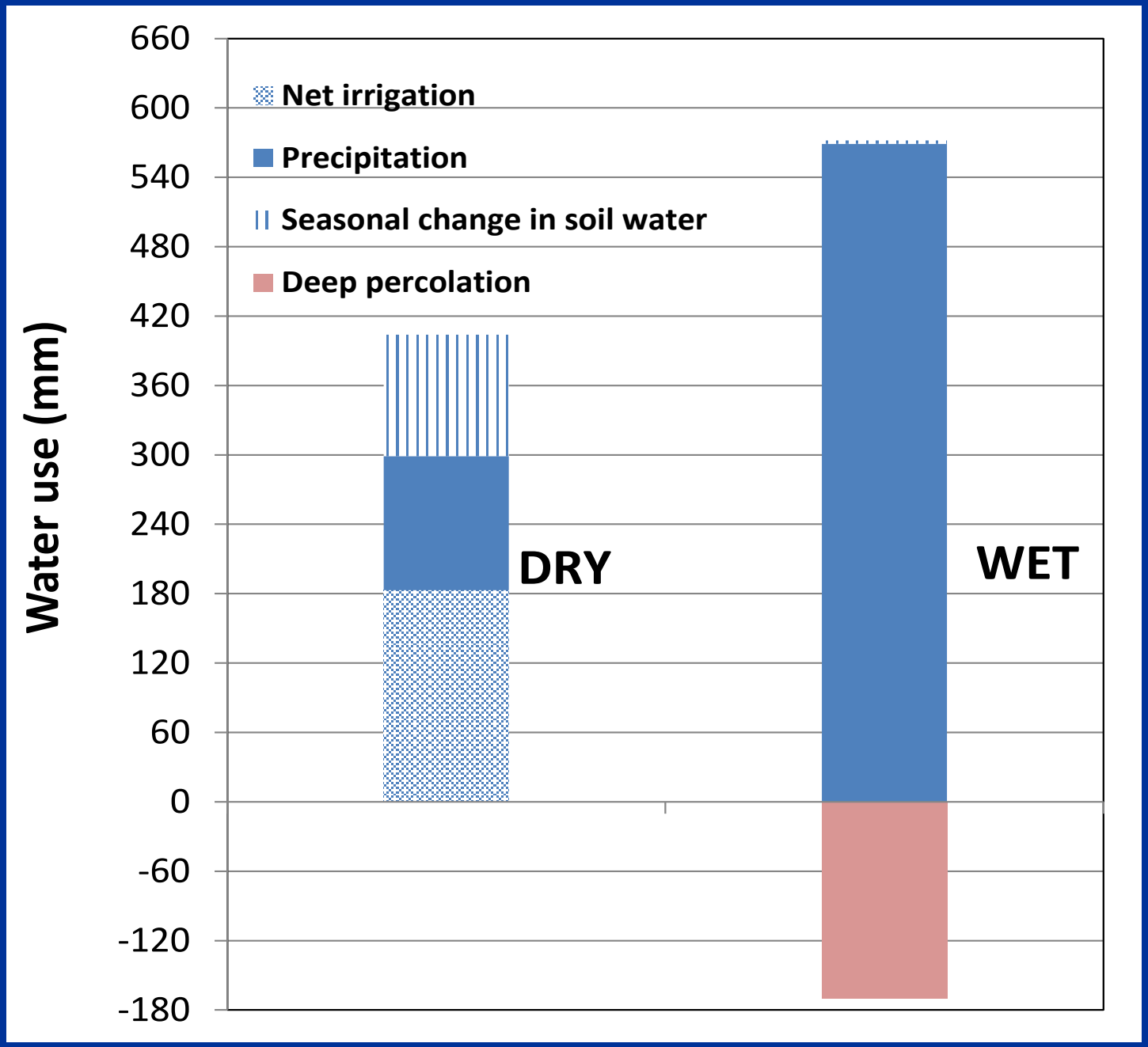
Results of SIMDualKc model calibration/validation

Model calibration relates with adapting parameters

Parameter	Values		
	Initial	Calibrated	
$K_{cb\ ini}$	0.15	0.15	**Related with crop characteristics**
$K_{cb\ mid}$	1.10	1.10	
$K_{cb\ end}$	0.15	0.10	
$p_{ini,\ mid,\ end}$	0.55	0.55	
REW (mm)	10	7	**Soil evaporation layer**
TEW (mm)	30	28	
Z_e (m)	0.10	0.10	
a_D	270	300	**Deep percolation**
b_D	-0.0173	-0.020	
CN	72	75	**Runoff**

SIMDualKc-Stewart's approach ability to predict barley yield

Season	Observed yields			SIM-STE model		
	Average	SD		Predicted	Deviation	
	(kg ha^{-1})	(kg ha^{-1})	(%)	(kg ha^{-1})	(kg ha^{-1})	(%)
Dry (2012)	6331	417	6.6	6638	**307**	**4.8**
Wet (2013)	5843	612	10.5	6465	**622**	**10.6**

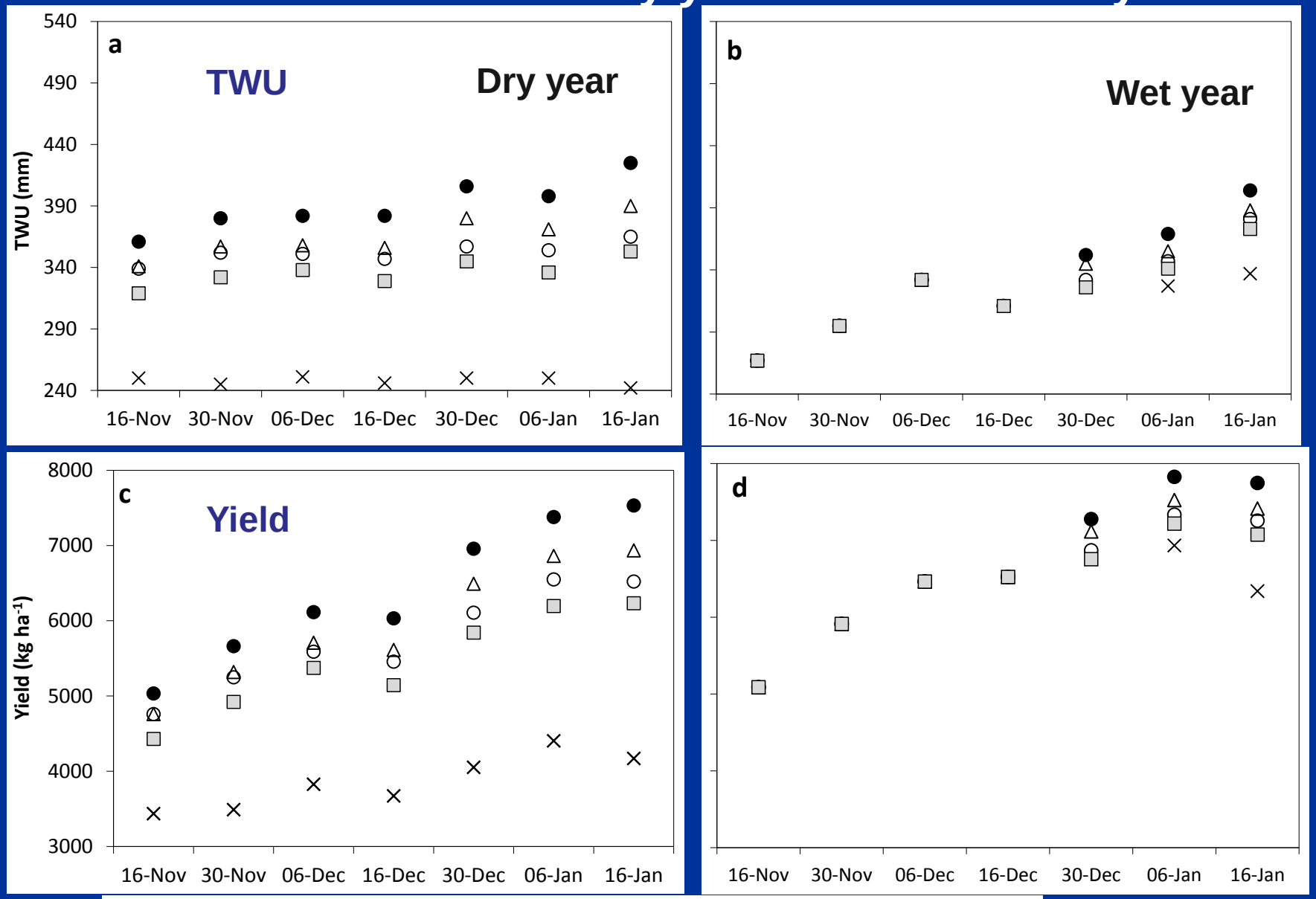

Water use (mm)
660
600
540
480
420
360
300
240
180
120
60
0
-60
-120
-180
Net irrigation
Precipitation
Seasonal change in soil water
Deep percolation
DRY
WET

Assessing alternative management scenarios for the studied years

	Dry year		Wet year
	Anticipating to early January		Postponing sowing date, mid-December
	Full	Rainfed	Full/Rainfed
Gross irrigation (GI, mm)	170	-	-
Total water use (TWU, mm)	398	250	311
Actual transpiration (mm)	304	207	246
Transpiration deficit (mm)	17	113	4
Potential yield (kg ha^{-1})	7886		6663
Predicted actual grain yield (kg ha^{-1})	7378	4405	6525
Physical Water Productivity (kg m^{-3})	1.85	1.76	2.10
Economical Water Productivity Ratio ()	1.5	0.94	1.39

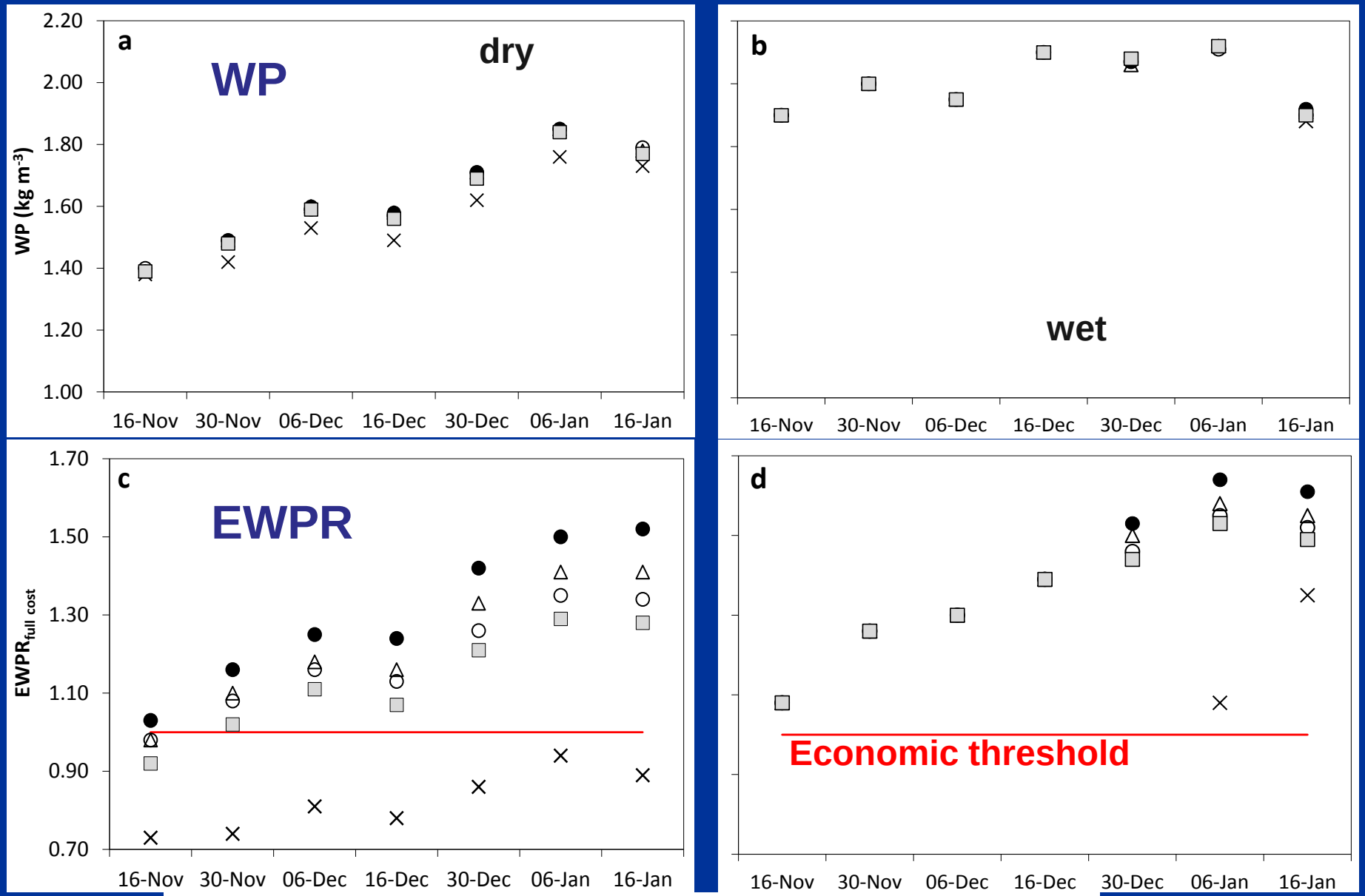
Increaseses both WP and EWP relative to the farmers

Assessing alternative sowing dates and management scenarios for the wet and dry years for TWU and yield



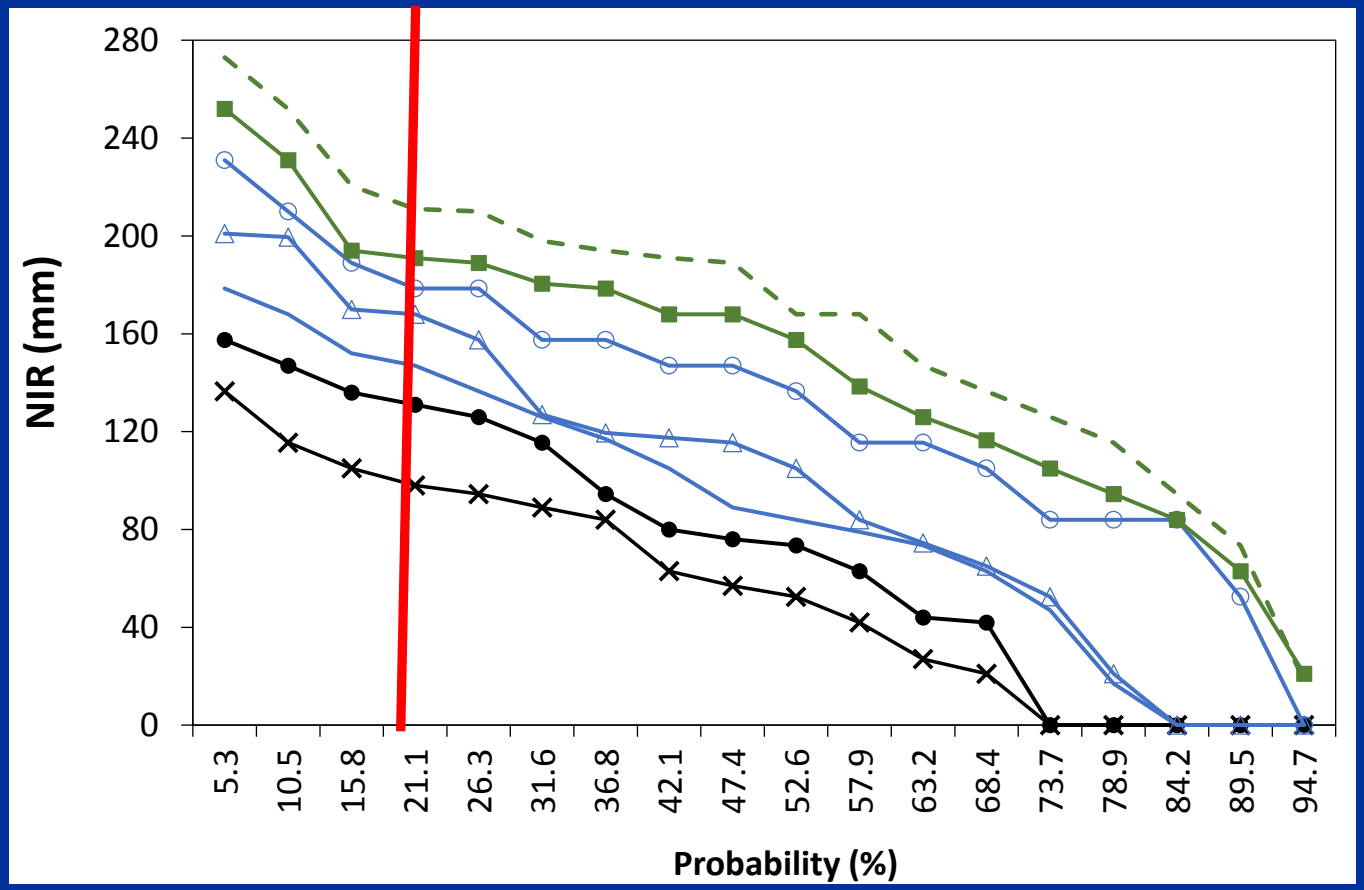
full (●), very mild (△), mild (○), moderate (▢) and rainfed (✕)

Assessing alternative sowing dates and management scenarios for the wet and dry years for WP and EWPR



full (●), very mild (△), mild (○), moderate (▢) and rainfed (✕)

Probabilities associated with net irrigation requirements for various sowing dates



Mid-November ( )

Late-November ( )

Early-December ( )

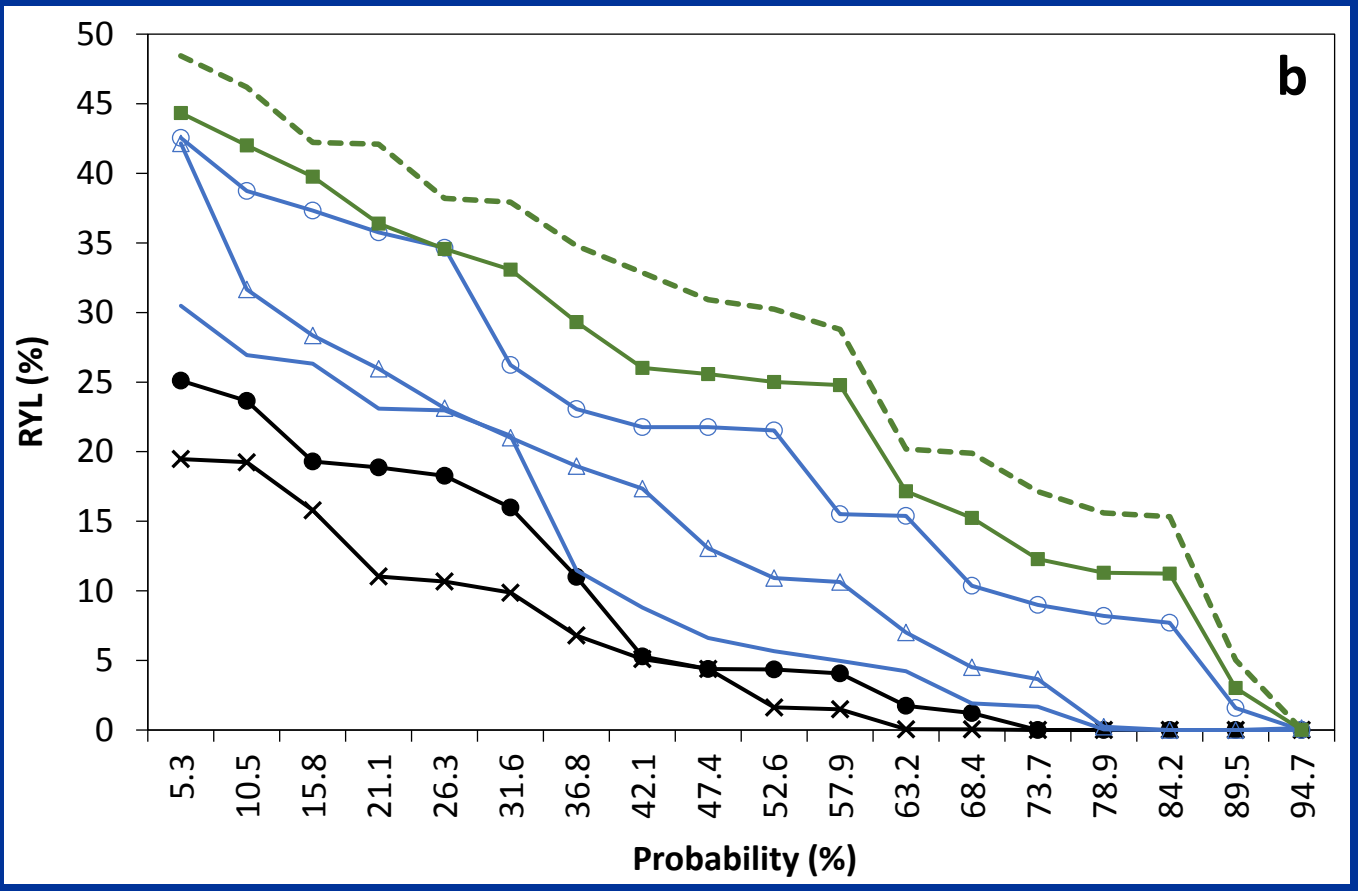
Mid-December ( )

Late-December ( )

Early-January ( )

Mid-January ( )

Probabilities associated with the relative yield losses (RYL) for various sowing dates



Mid-November ( )

Late-November ( )

Early-December ( )

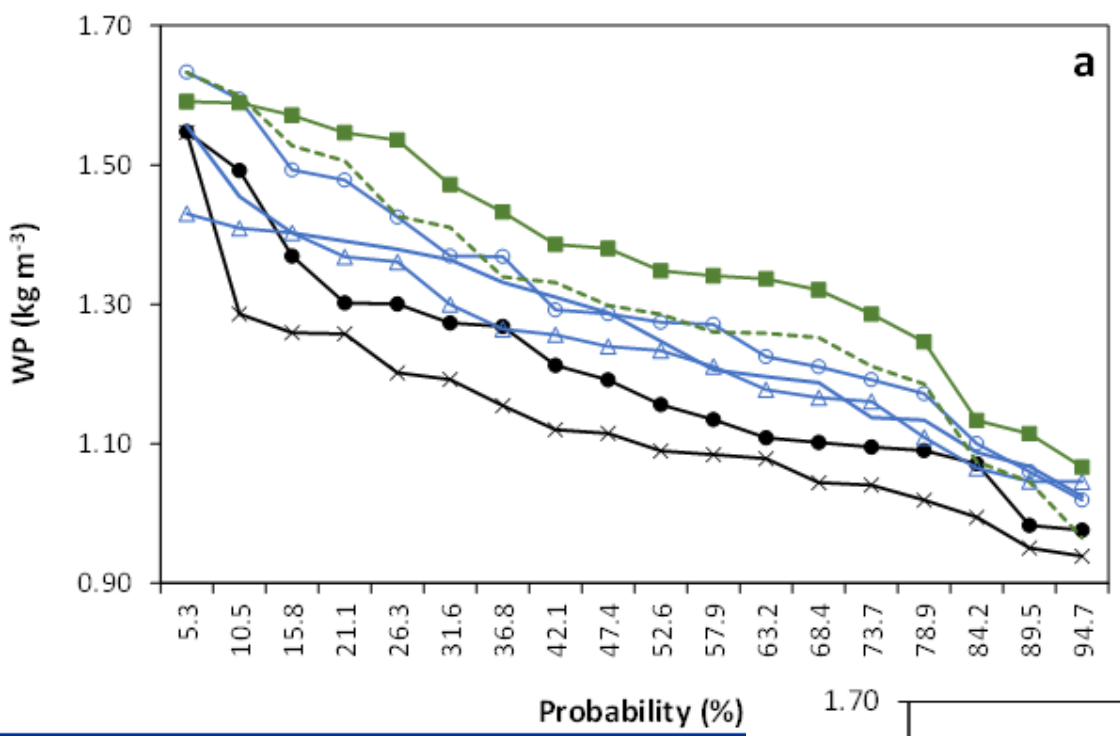
Mid-December ( )

Late-December ( )

Early-January ( )

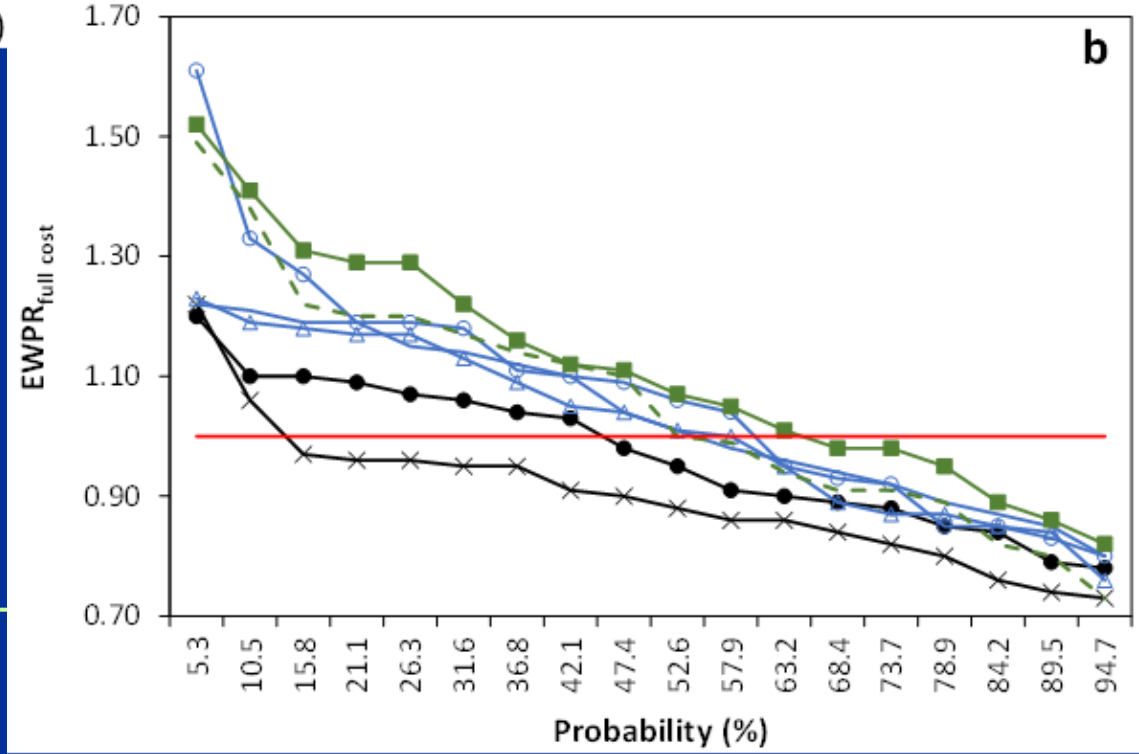
Mid-January ( )

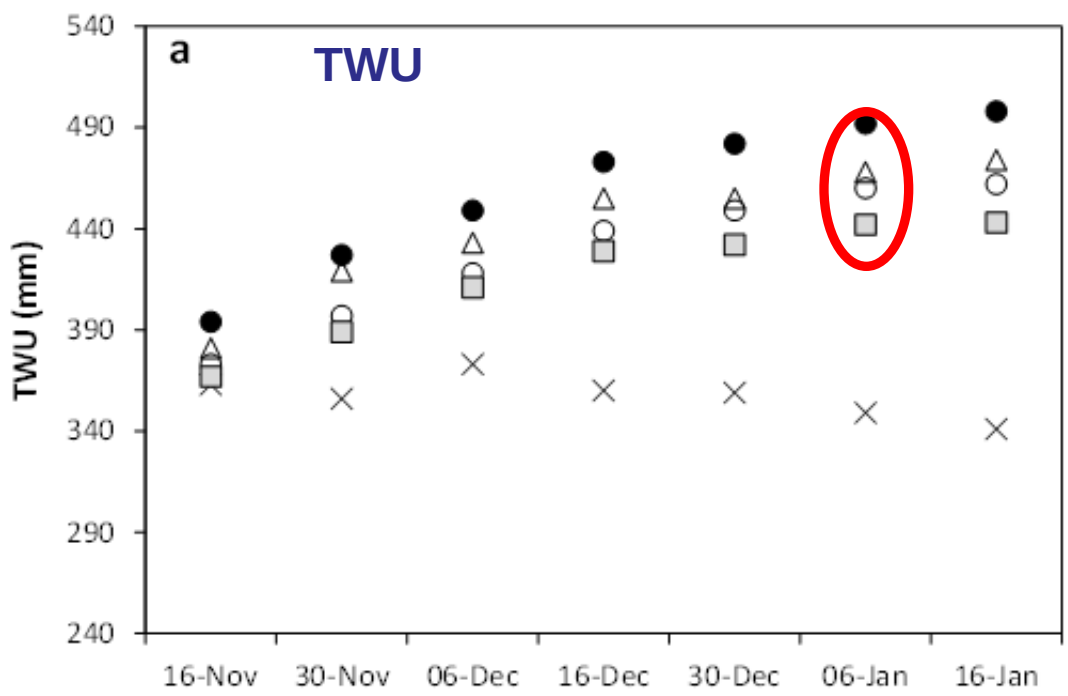
$$RYL = K_y \frac{(T_c - T_{c\,act})}{T_c} 100$$



Water productivity and Economic water productivity ratio (economic return) for rainfed barley

The economic feasibility threshold ($EWPR_{full\ cost}$ = 1.0) of rainfed barley

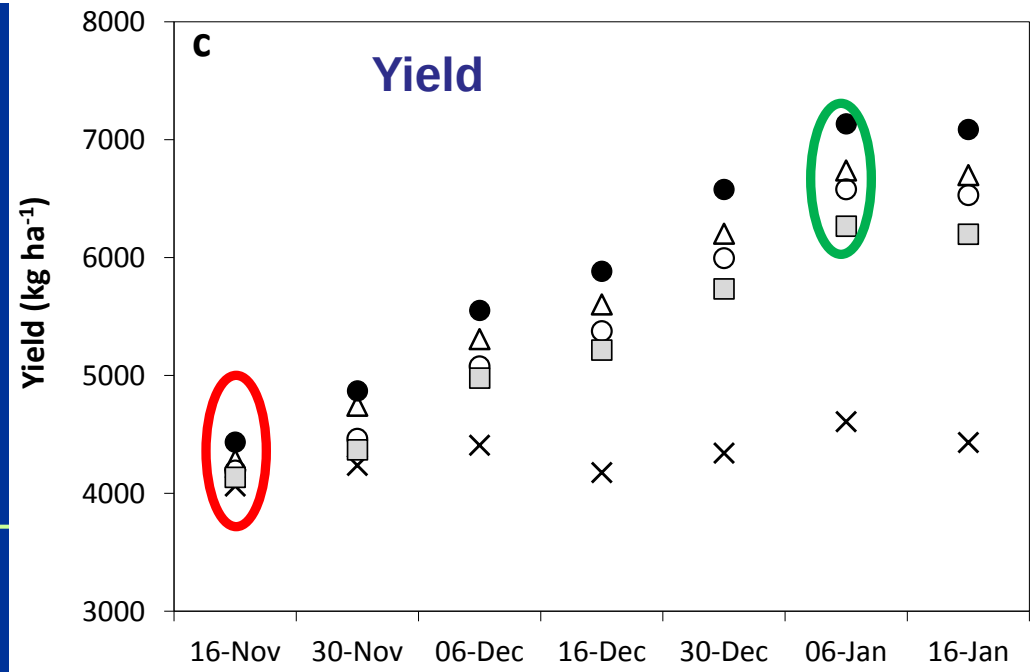


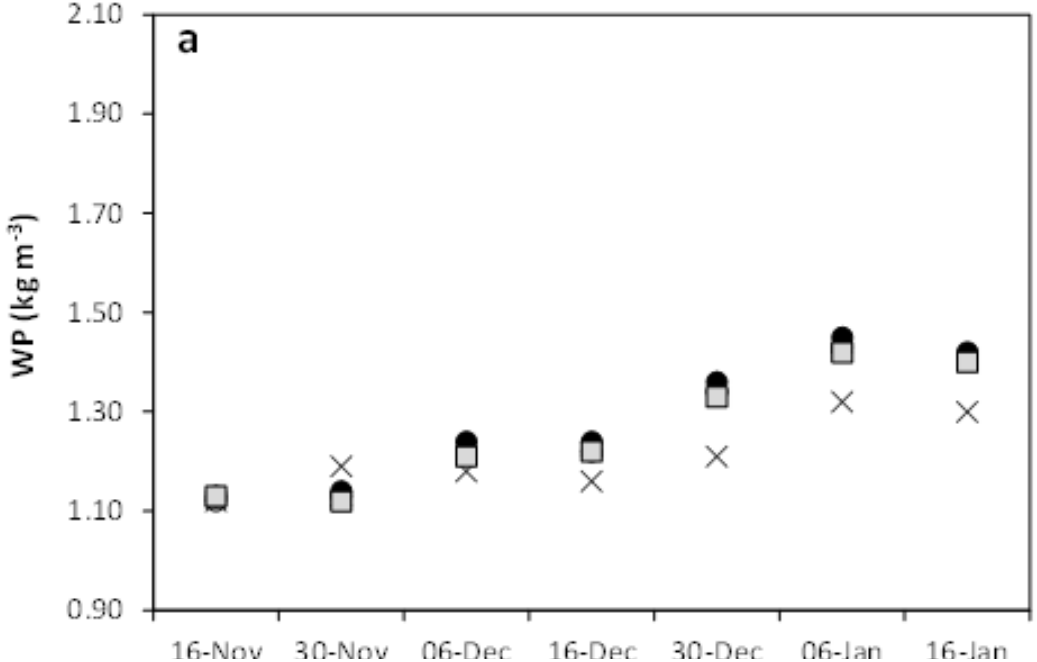


Barley water use and yield under dry climatic conditions

full (●), very mild (△), mild (○), moderate (▢) and rainfed (✕)

Not sensitive for rainfed



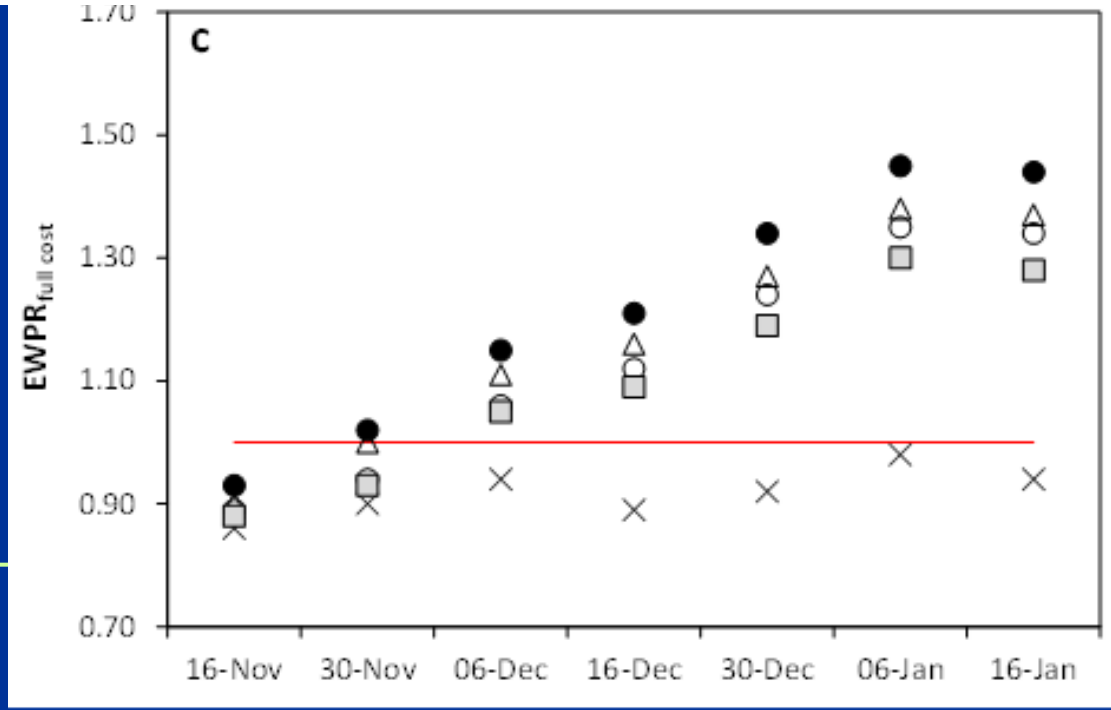


Barley water productivity and economic water productivity ratio under dry climatic conditions

full (●), very mild (△), mild (○), moderate (▢) and rainfed (✕)

Rainfed not feasible

Early sowing less to not feasible




THANK YOU