

*VIIeme Congrès International du Cactus et de cochenille  
&*

*VIIeme Rencontre Internationale de la FAO-ICARDA  
Réseau technique de coopération internationale*

# **Impact of irrigation cadences on the installation and the production of two forms of prickly pear (*Inermis* and *amyycleae*)**

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*Agadir (Maroc), du 17 au 22 Octobre 2010*

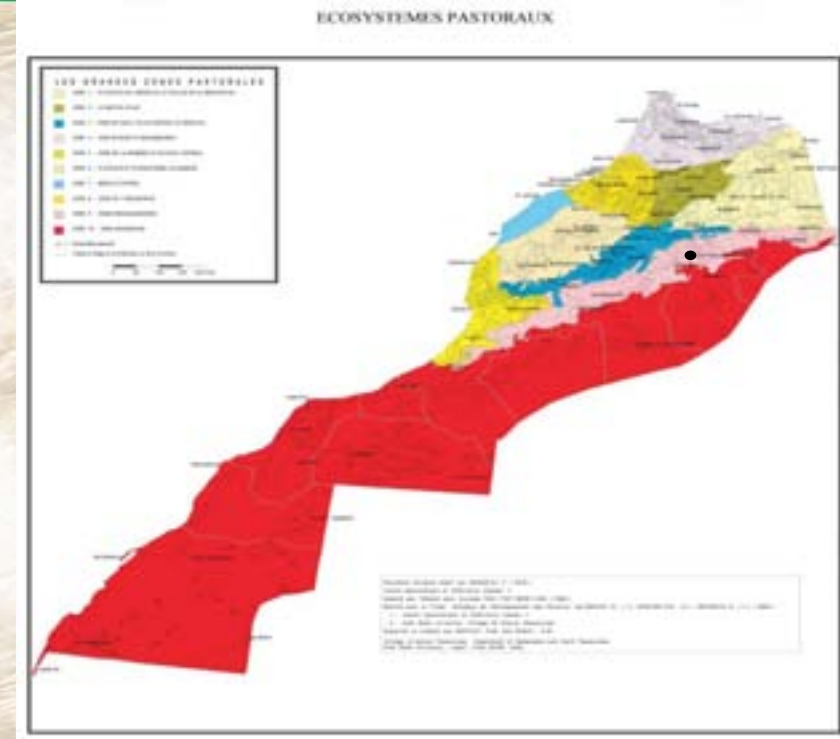


# Outline

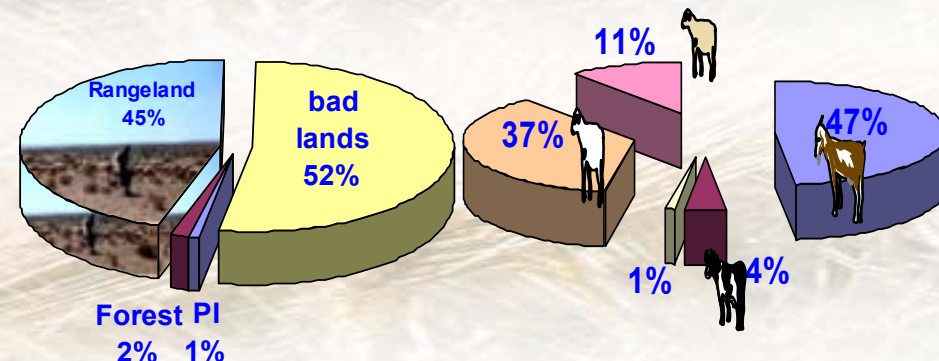
- General information
- General problematic of presaharan rangelands
- Specific problematic to our research
- Background of our study
- Materials and methods
- Results
- Conclusions and recommendations

# General information

- Presaharan zones South-Est of Morocco (South of the High Atlas);
- Area covered Presaharan (8%) ;
- Rainfall :100-250 mm;
- Livestock : main source of income;
- Livestock number (Presahara and Sahara) : 4.472.003 (94.5% Small ruminant) (MADRPM (1998) ;
- Tafilalet : 1.038000
- Rangelands contribution (Presahara) : more 70% feeding (Darfaoui, 1993; 1994);
- Carrying capacity not respected (Presahara classified n° 1 in charge : 1.8 head/ha) (MADREF, 1991)



## TAFILALET



# General problematic

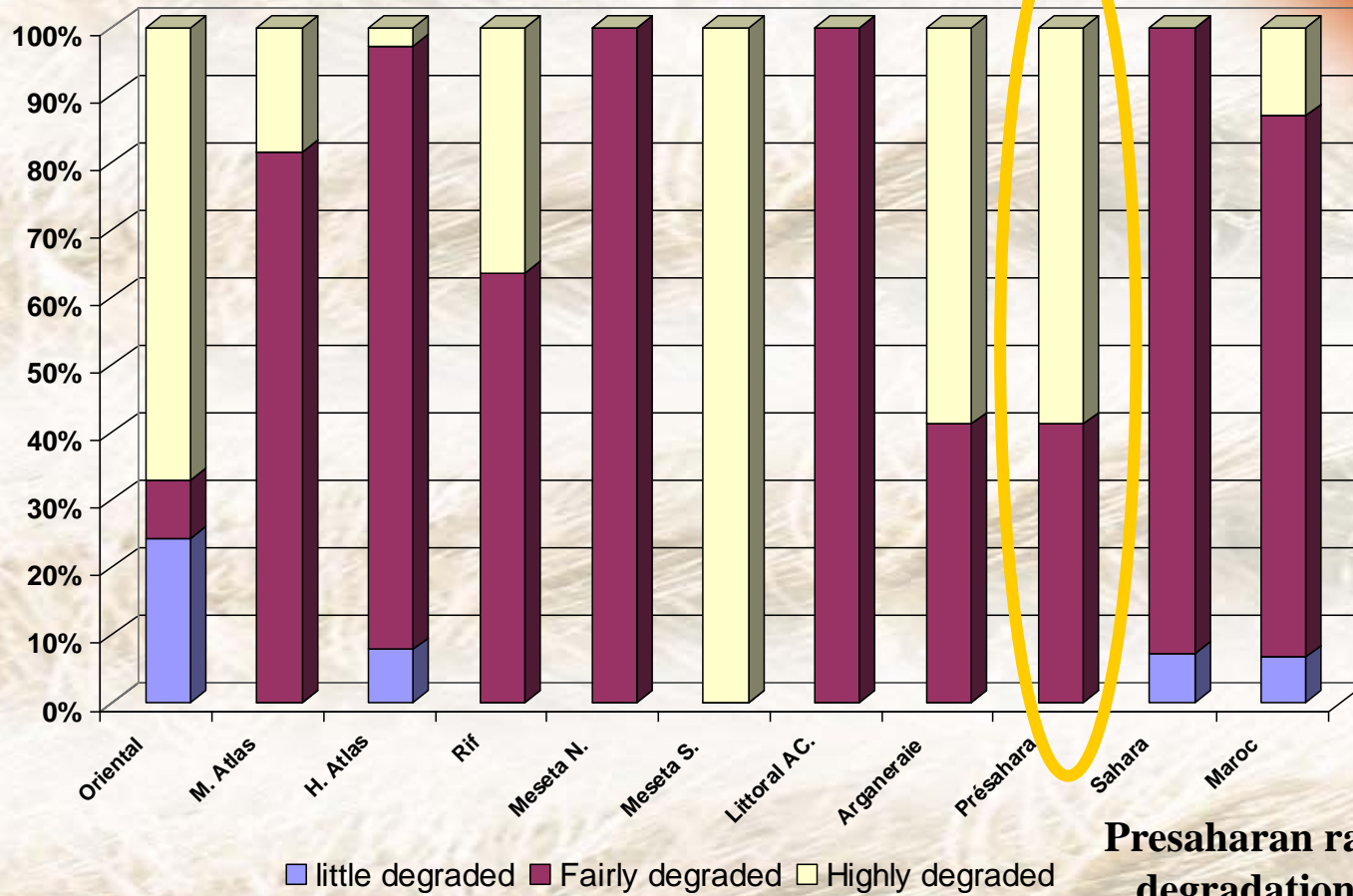


Figure : State of degradation by ecosystem

# Problematic : some facts

- Presaharan rangeland degradation due to biotic and abiotic factors (human intervention, Harsh climate, poor soils, overgrazing...)
- **Tentative of rehabilitation** : Fodder shrubs plantations and resting
- Fodder shrub plantations mono-specific
  - *Atriplex nummularia* : 91%, cactus : ~8%)
  - Presahara : 100% plantation based on *Atriplex nummularia* (Tafilalet 54% are succeed)
  - Failure of some plantation



# Choice of prickly pear

- Reintroduction of new adapted species is most used alternative for degraded rangelands (FAO, 1992)
- Diversify plantation on presaharan rangelands
- Chose adequate techniques for initial installation
- Chosen shrub : *Opuntia Ficus indica L. Mill.*

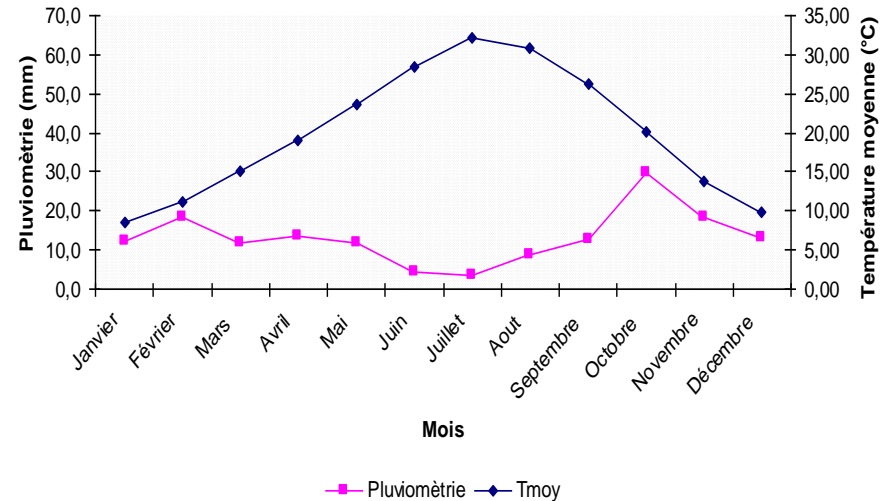
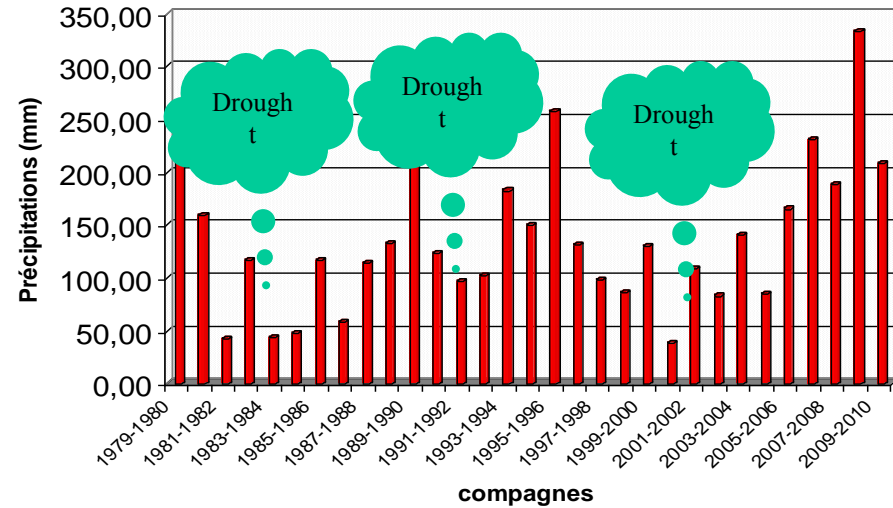


# Why Prickly pear?

- Drought resistant plant
  - (Photosynthetic pathway : CAM, Waxy skin, modified leaves as well as protection against animals, extraordinary root system...) : (Russell et Felker, 1987 ; Goldstein *et al.*, 1991 ; Barbera, 1995 ; Hills, 1995; Ben Salem *et al.*, 1996 ; Han and Felker, 1997 ; Reynolds and Arias, 2001; De Kock, 2001)
- **Fodder shrub** : Rich in energy and water but poor in energy ; complement *Atriplex nummularia* ((Monjauze et Le Houerou, 1965; Ben Salem *et al.*, 1996 ; Rakowitz, 1997 ; Boulanouar *et al.*, 2000; Nefzaoui *et al.*, 2000; Redjel et Boukheloua, 2000; Melo *et al.*, 2003 ).
- Other uses (Fruit, pads, seeds, flowers, fence, erosion control...)
- Low water requirement
- Adapted to the majority of soils
- Easy to install and low installation cost

# Specific problematic : Constraints to plantation

- **Low rainfall** : 138 mm (31 years), 150 mm (last 21 years)
- **Evaporation** : 3133 mm ; Evapotranspiration :  $E_{t0} PM.$  = 164 mm ;  $E_{t0} HG$  (2009/2010)= 1730 mm
- Frequent drought :
- Sandy skeletal soils : poor water holding capacity
- Root system not developed (First years)
- Cactus water requirement not defined : ~200 mm in deep sandy soils in Maghreb, (Le Houérou, 1996). Costal zones (100-150 mm).
- **Extra water**





# Aspects of our Study and background

- **Impact of irrigation cadences on the installation and the production of two forms of prickly pear (*Inermis* and *amycleae*)**
- **1. Irrigation cadences : Subject not studied before for cactus**
- **2. System of plantation (Singh et Singh, 2001 ; Kritch, 2003 ; Pareek *et al.*, 2003, Caloggero et Parera, 2004) : 1/3 cladode under soil, older cladodes than 12 months, direction plantation East-west, double cladodes rather one cladode**
- **Number of cladodes planted : Double and triple were not compared on those studies**
- **3. Genotypes : spineless (Form 1 : *inermis*) and prickly or armed (Form 2 : *Amycleae*)**
- **Studies comparing accessions or genotypes (Boujghagh, 2007; Felker, 1995 ; Mondragon & Bordelon, 1996 ; Bunch, 1996 ; Wang *et al.*, 1996 ; Pareek *et al.*, 2003 ; Reyes-Agüero *et al.* 2005a, b).**

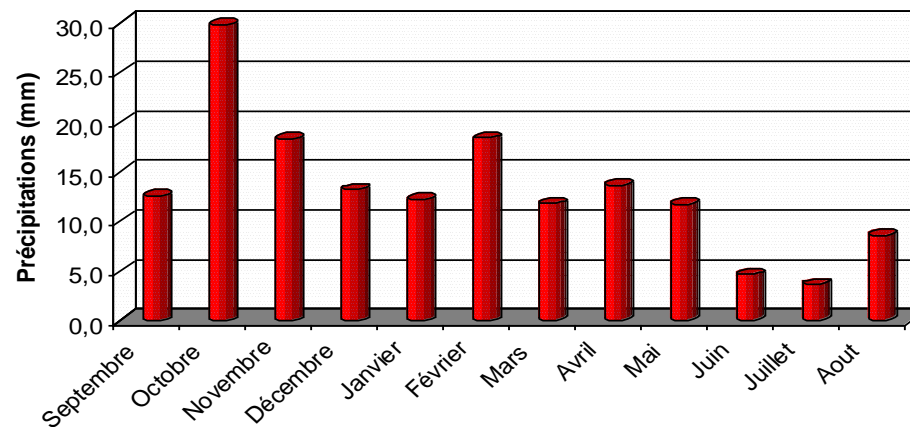
# Material and method

- Site study : Experimental station of Errachidia
- Date : october 2006
- Experimental design : RBD with 4 Reps  
(Experimental unite : 5 shrubs)
  1. **3 Irrigation cadences** :
    1. C1= 2/year;
    2. C2= 6/year and
    3. C3= 12/year. (quantity of 0.5 m<sup>3</sup> for every 5 shrubs controlled with stick of 5 cm) ;
  2. **Cactus form** = *Opuntia ficus indica* L. Mill.
    1. **Form1** = inermis (Spinless)
    2. **Form2** = Amycleae (Prickly).
  3. **Planting system** : triple cladodes (R3) and Double cladodes (R2)
    - **Density** 1.5 m x 4 (Basin dimension 10 m<sup>2</sup>) ~720 plant/ha

# Material and method

**Tableau : Calendar of irrigation**

Years	Months	1	2	3	4	5	6	7	8	9	10	11	12
year 1 (CA1)	Cadence 1-1												
	Cadence 2-1												
	Cadence 3-1												
Year 2 (CA2)	Cadence 1-2												
	Cadence 2-2												
	Cadence 3-2												



**Figure : Mean monthly precipitation (21years) Month**

# Material and method

- Measured parameters :
  - Survival rate,
  - Growth height,
  - Lateral growth,
  - Dry matter and
  - weight of fruit production
- Period of measurement : 2006-2010
- Statistical analysis : ANOVA using Newman et Keuls test  $p < 0.05$  (SPSS)



# Results

- **Survival rate : 98 %** (no significant differences)
- Planting system was very efficient basically on windy region
- Period of autumn seems to convenient



# Growth height

170 mm

$P < 0.001$

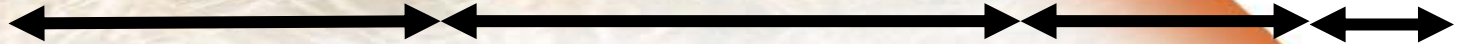
P=140mm

P=189mm

P=322.5mm

P=180mm

$P < 0.05$



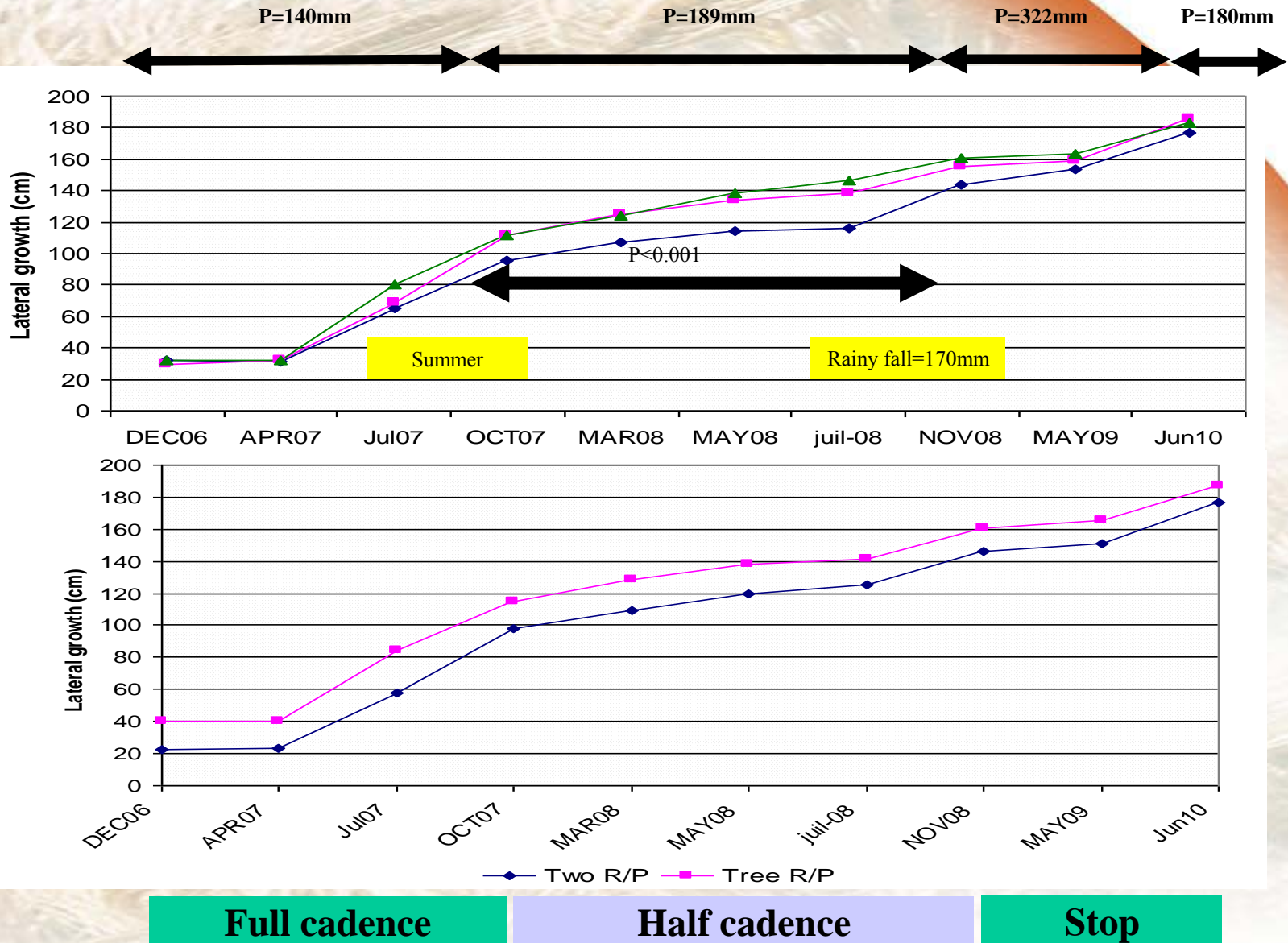
	DEC06	APR07	JUL07	OCT07	MAR08	MAY08	JUL08	NOV08	MAY09	JUN10
Two irrigations/year	36,04	38,51	51,53	63,57	63,22	61,57	58,80	92,37	83,65	107,52
SD	9,63	9,47	12,70	13,07	12,73	12,87	13,69	17,05	14,91	21,84
Six irrigations/year	36,44	36,58	54,54	67,96	67,44	67,46	71,68	96,92	86,68	107,14
SD	9,84	10,79	13,16	13,52	13,04	13,67	12,20	14,13	15,94	16,36
Twelve irrig./year	34,85	36,68	50,91	70,40	69,67	71,72	73,90	95,08	86,46	106,38
SD	9,23	9,91	14,29	14,01	14,60	14,08	12,92	13,95	14,85	18,16
Cactus inermis	34,20	36,03	52,82	68,73	68,53	68,62	69,83	96,09	87,93	108,12
SD	8,01	7,92	12,72	13,19	14,12	15,46	14,66	16,05	14,10	17,69
Cactus amycleae	37,36	38,48	51,85	65,86	65,00	65,17	66,37	93,48	83,25	105,92
SD	10,69	11,74	14,15	14,24	13,05	12,46	14,23	14,18	16,02	19,96
Double R/P	34,77	36,34	49,81	65,03	64,33	63,50	66,03	93,72	83,04	103,09
SD	9,08	10,08	13,62	13,59	12,70	12,63	13,57	14,73	14,69	19,31
Triple R/P	36,77	38,16	54,82	69,52	69,15	70,24	70,13	95,84	88,10	110,88
SD	9,94	10,02	12,82	13,64	14,23	14,74	15,19	15,58	15,42	17,63
Mean	35,78	37,26	52,33	67,30	66,76	66,89	68,10	94,79	85,59	107,02

Full cadence

Half cadence

Stop

# Lateral growth



# Dry matter of cactus phytomasse

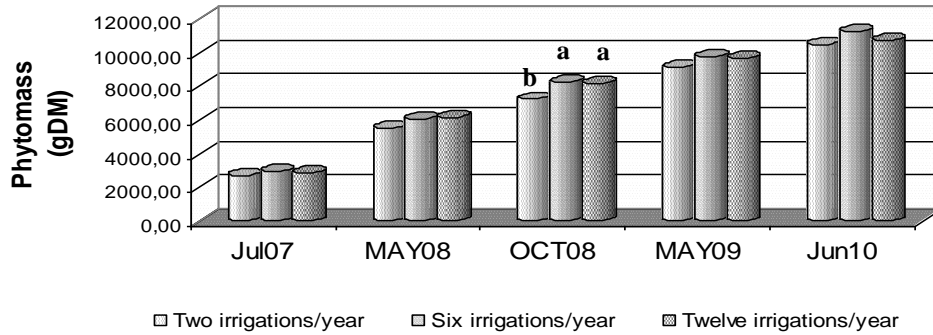


Figure 1 : Effect of irrigation cadences

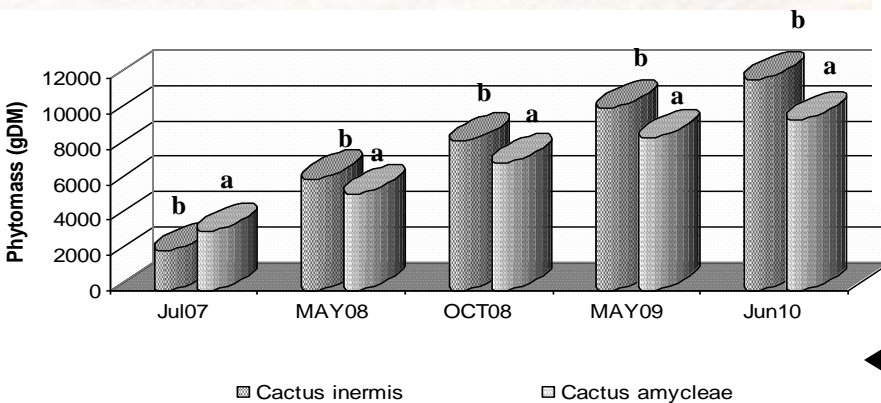


Figure 1 : Effect of cactus form

## Irrigation cadences

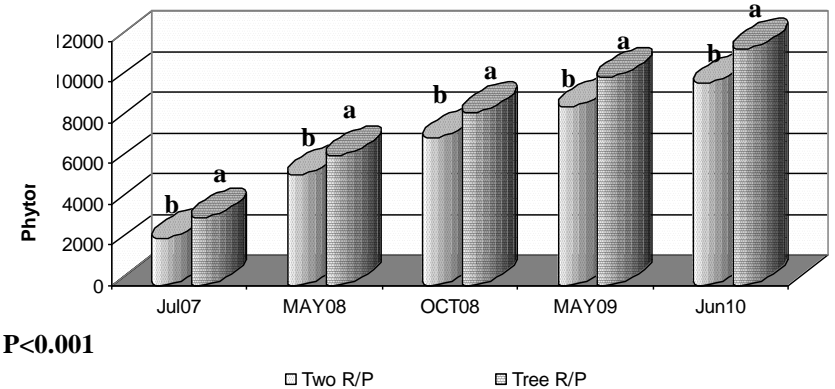


Figure 1 : Effect of planting system

## Planting system



## Cactus form

Full cadence

Half cadence

Stop



# Cladodes dynamic

**P<0.001**

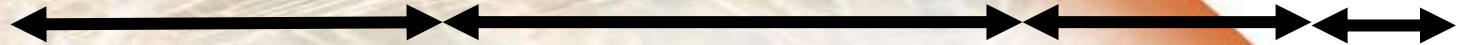
P=140mm

P=189mm

P=322mm

P=180mm

**P<0.05**



	DEC06	APR07	Jul07	OCT07	MAR08	MAY08	JUL08	NOV08	MAY09	JUN10
<b>Two irrigations/year</b>	2,73	3,34	7,82	12,63	12,77	20,53	19,89	29,03	38,94	46,92
Std. Deviation	0,73	3,35	2,99	4,77	4,78	10,48	6,35	9,36	11,62	16,49
<b>Six irrigations/year</b>	2,70	3,30	8,76	14,00	14,04	23,30	26,20	34,25	42,75	51,30
Std. Deviation	0,74	1,17	4,36	5,72	5,78	9,96	12,47	12,38	15,71	18,33
<b>Twelve irrigations/year</b>	2,70	3,06	7,67	13,05	13,22	23,86	26,18	34,54	42,18	48,06
Std. Deviation	0,72	0,82	3,80	5,36	5,50	10,55	10,94	14,47	15,61	16,40
<b>Cactus inermis</b>	2,72	3,20	8,44	14,04	14,26	24,64	26,48	35,62	45,97	55,35
Std. Deviation	0,76	0,93	3,75	5,44	5,44	10,22	11,81	12,24	14,76	17,80
<b>Cactus amycleae</b>	2,70	3,27	7,73	12,42	12,42	20,48	21,68	29,58	36,59	42,19
Std. Deviation	0,69	2,82	3,77	5,06	5,17	10,18	8,71	11,96	12,59	13,61
<b>Two R/P</b>	2,17	2,91	6,77	11,22	11,41	20,26	21,24	28,97	37,18	43,79
Std. Deviation	0,47	2,84	3,47	4,59	4,70	10,75	8,86	10,88	13,01	14,62
<b>Tree R/P</b>	3,25	3,56	9,38	15,20	15,24	24,82	26,87	36,17	45,32	53,66
Std. Deviation	0,49	0,75	3,62	5,24	5,33	9,53	11,50	12,90	14,75	18,05
<b>Mean</b>	2,71	3,23	8,08	13,23	13,34	22,56	24,08	32,60	41,28	48,77
	0,72	2,10	3,77	5,31	5,37	10,39	10,63	12,45	14,47	17,13

**Full cadence**

**Half cadence**

**Stop**

# Fruit production

P=322mm

P=180mm



Irrigation	2009	2010
Two irrigations/year	18,99	16,11
SD	7,49	10,92
Six irrigations/year	15,87	<b>24,28</b>
SD	7,46	13,34
Twelve irrigations/year	14,66	<b>25,57</b>
SD	8,75	8,72
Variety		
Cactus inermis	16,03	21,90
SD	8,76	11,44
Cactus amyycleae	16,99	22,08
SD	7,24	12,21
Number of cladodes planted		
Double R/P	14,47	17,72
SD	8,48	8,33
Triple R/P	<b>18,54</b>	<b>26,26</b>
SD	7,01	13,14



# Conclusions and recommendations

- Autumn period and starting plantation with 2 cladodes and more seems to assure good installation of cactus to presaharan context.
- For initial installation (first and second year) of cactus on presaharan rangelands : Two irrigations cadences per year (month 4 and 7).
- After initial phase : Economical production (beside oasis) : 6-3 cadences
- Ad mulching and water harvesting techniques (get more water and reduce evaporation)



**Thanks**

