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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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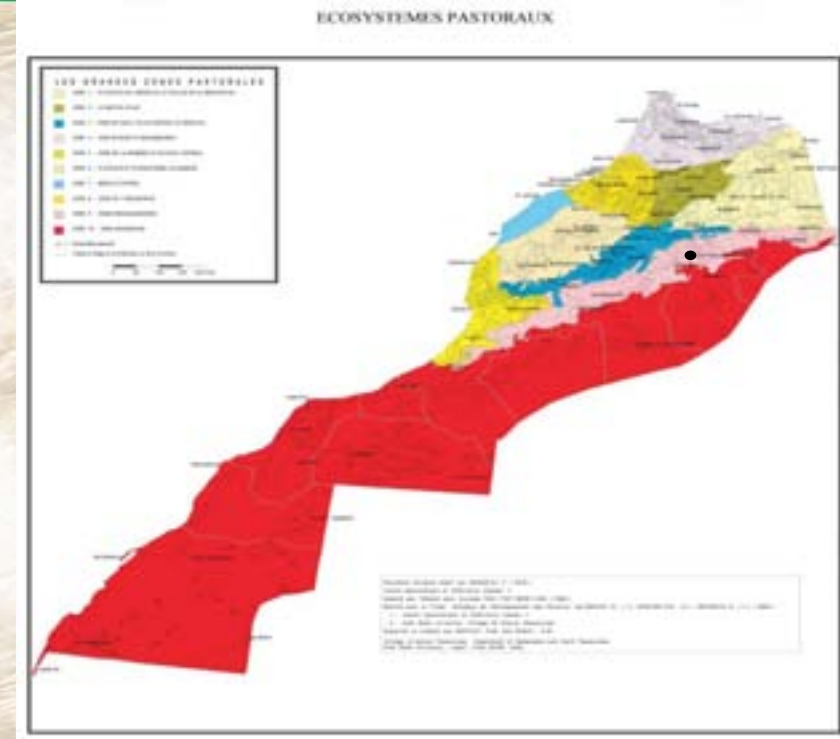
Agadir (Maroc), du 17 au 22 Octobre 2010

Outline

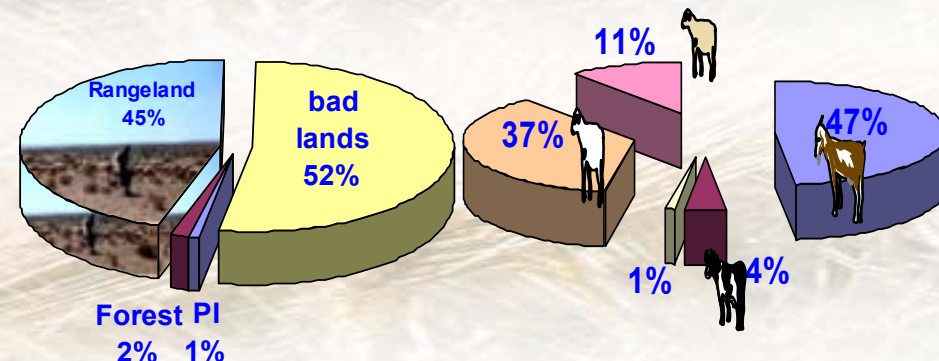
- General information
- General problematic of presaharan rangelands
- Specific problematic to our research
- Background of our study
- Materials and methods
- Results
- Conclusions and recommendations

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

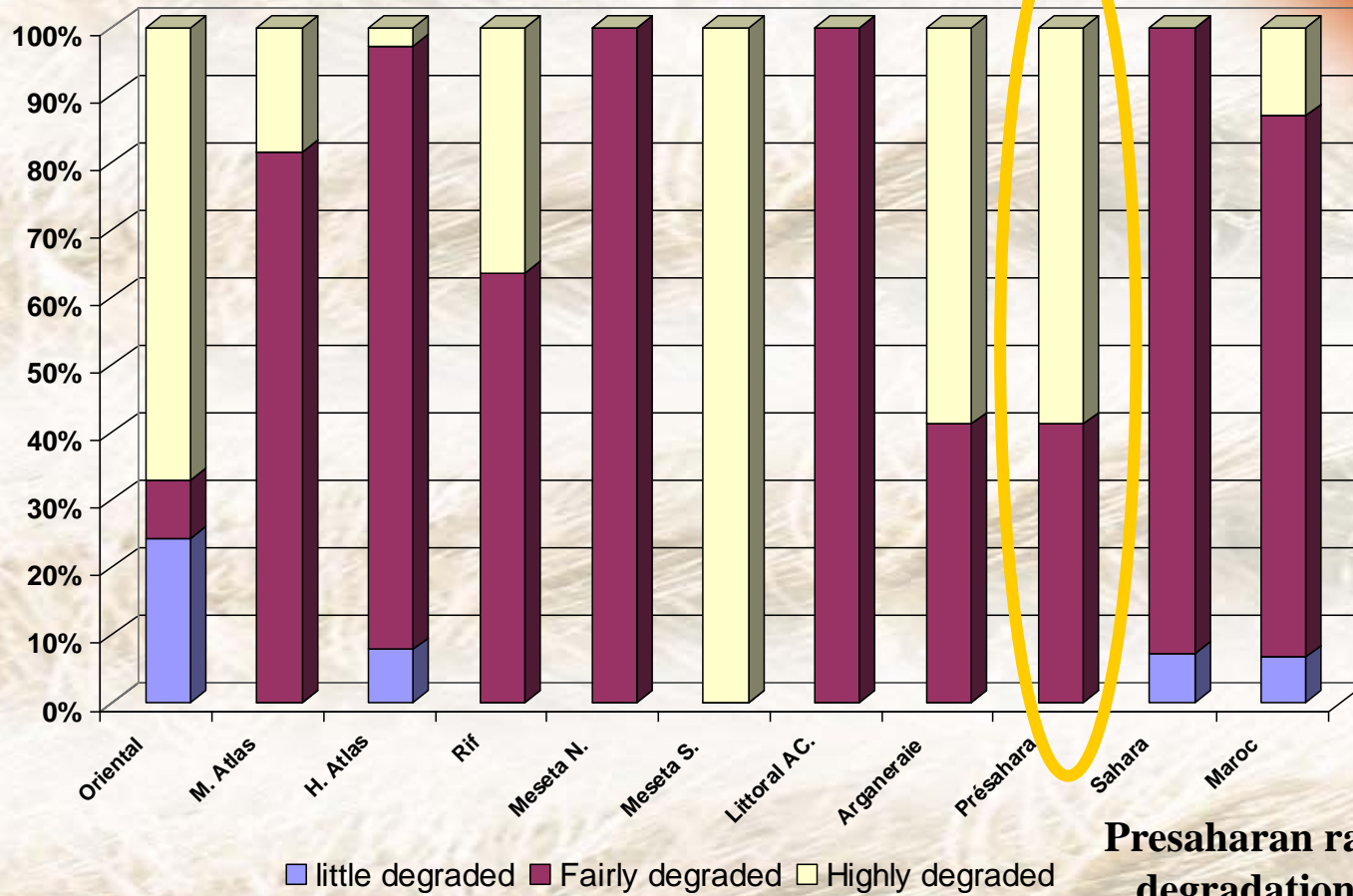


Figure : State of degradation by ecosystem

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.*

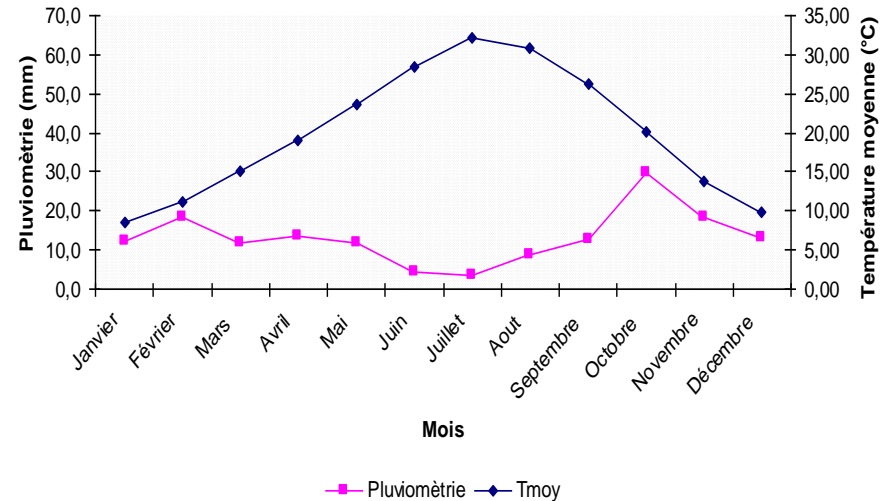
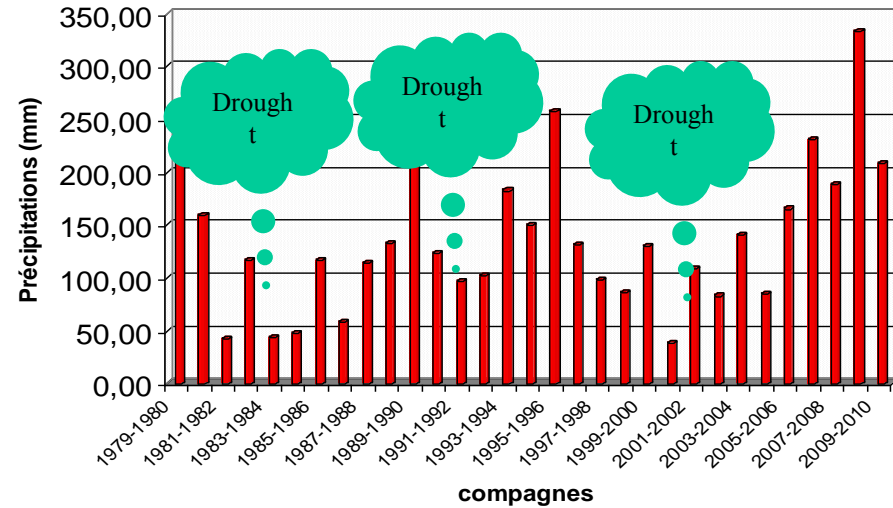


Why Prickly pear?

- 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 m³ 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 m²) ~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 | | | | | | | | | | | | |

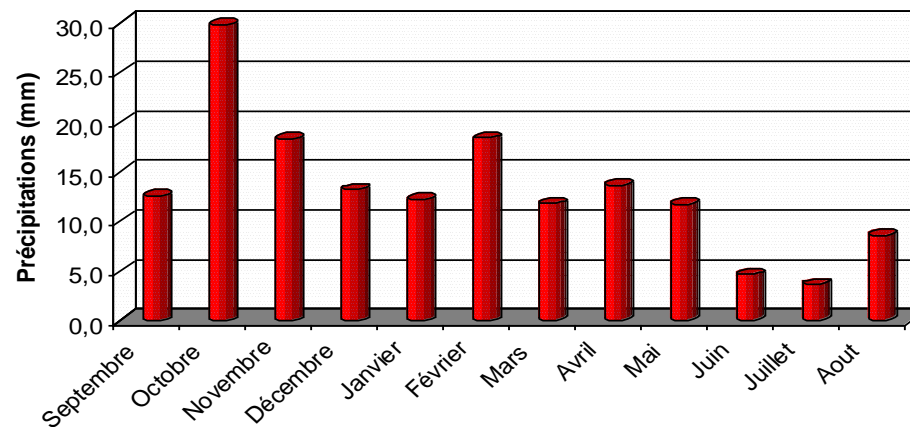


Figure : Mean monthly precipitation (21years) Month

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

$P < 0.001$

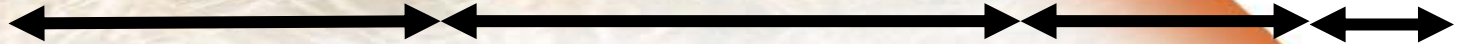
P=140mm

P=189mm

P=322.5mm

P=180mm

$P < 0.05$



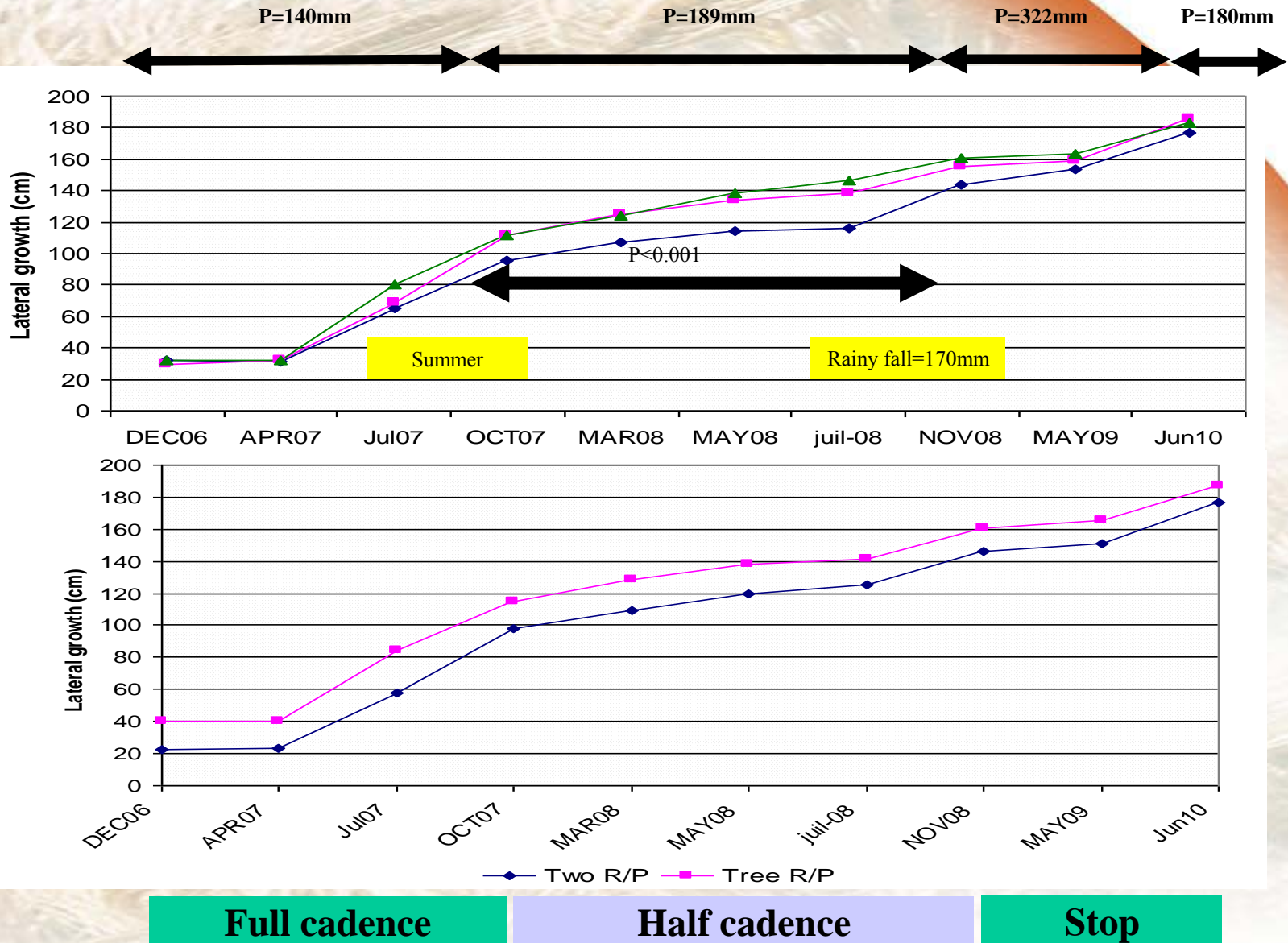
| | DEC06 | APR07 | Jul07 | OCT07 | MAR08 | MAY08 | JUL08 | NOV08 | MAY09 | JUN10 |
|----------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| Two irrigations/year | 36,04 | 38,51 | 51,53 | 63,57 | 63,22 | 61,57 | 58,80 | 92,37 | 83,65 | 107,52 |
| SD | 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

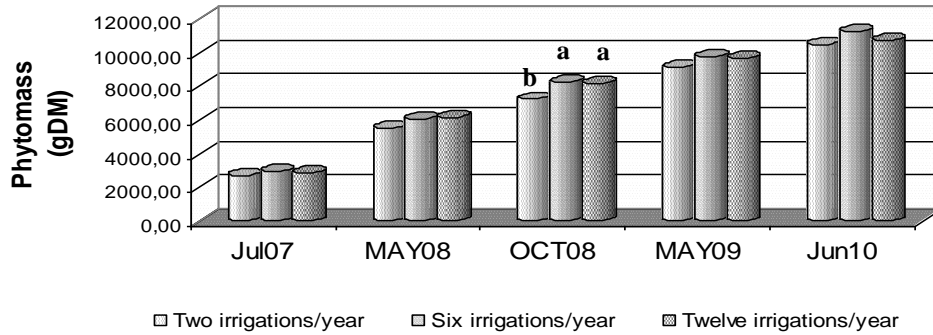


Figure 1 : Effect of irrigation cadences

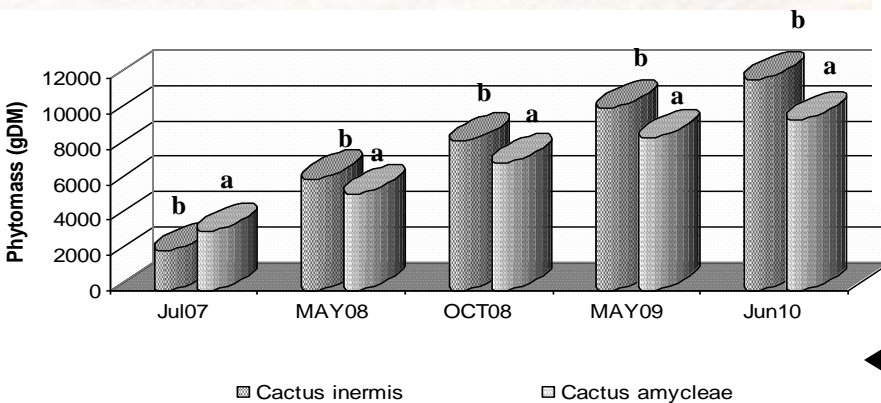


Figure 1 : Effect of cactus form

Irrigation cadences

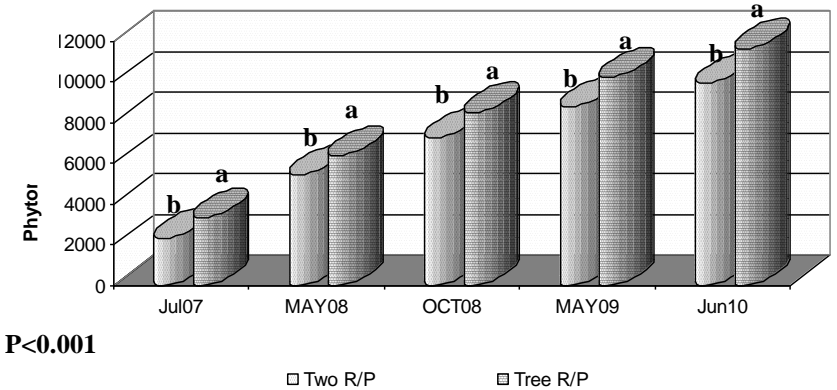


Figure 1 : Effect of planting system

Planting system



Cactus form

Full cadence

Half cadence

Stop

Cladodes dynamic

P<0.001

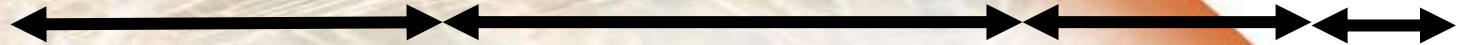
P=140mm

P=189mm

P=322mm

P=180mm

P<0.05



| | DEC06 | APR07 | Jul07 | OCT07 | MAR08 | MAY08 | JUL08 | NOV08 | MAY09 | JUN10 |
|--------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Two irrigations/year | 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 |
| Six irrigations/year | 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 |
| Twelve irrigations/year | 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 |
| Cactus inermis | 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 |
| Cactus amycleae | 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 |
| Two R/P | 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 |
| Tree R/P | 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 |
| Mean | 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 | 24,28 |
| SD | 7,46 | 13,34 |
| Twelve irrigations/year | 14,66 | 25,57 |
| 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 | 18,54 | 26,26 |
| 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

