Effect of Biotic and Abiotic Stress on the Development and Production of *Calligonum Polygonoides* Subsp.*Comosum* Grown in Tunisian Arid Conditions

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Abstract: ***In recent decades, pre-Saharian Tunisian consequences of desertification have gradually become a major environmental problem. We are witnessing the continuous degradation of natural vegetation, due to various human activities. These activities often lead to overgrazing, due to the decline in the size of the course (after cultivation) and increased grazing pressure, manifested by the degradation of the vegetation cover. Such quantitative and / or qualitative degradation is accompanied by irreversible changes in the flora and, therefore, plants are threatened by the dominance of numerous species of animals. To study the effects of seasonal drought and grazing on the parameters of vegetative growth and floristic diversity in canopy, several cuts were made and transects were installed in an experimental plot located in the region of El Ouara (southern Tunisia). Recovery and floristic density were measured during two seasons (fall and spring) with the use of the point quadrat method. The main results of this study show that: For physically undisturbed plants, high productions were recorded in spring and summer. However for physically disturbed plants, that is to say, cut twice, the species showed in irrigated and dry higher capacity spring regrowth (cut in February-March). In general, a significant difference of biomass (B) between the two regimes was observed in spring. Grain production was limited to spring in both water regimes. The annual / perennial ratio is more influenced by seasonal drought and the effect of grazing in the sense of a reduction of vegetation cover is more remarkable in the fall. The overall recovery of the vegetation may be considered a good indicator of the structural state of the ecosystem. Alpha and beta diversity is in turn good indicators of ecosystem structure that should be followed in similar studies.***

Keywords: *Calligonum*, Desertification, Tunisian desert, rehabilitation, water points

1. Introduction

In recent decades, pre-Saharian Tunisia consequences of desertification have gradually become a major environmental problem. We are witnessing the continuous degradation of natural vegetation, due to various human activities. These activities often lead to overgrazing, because of the decline in the size of the course (after cultivation) and increased grazing pressure, manifested by the degradation of the vegetation cover. Such quantitative and qualitative degradation is accompanied by irreversible changes in the flora and, therefore, plants are threatened by the dominance of numerous species of animals (Tarhouni, 2006) species. The water deficit in the soil is the main factor limiting forage production in the pre-Saharian regions. It affects almost all processes of plants growth and development (Hsiao, 1973). In these regions, drought seriously affects forage production and seasonal availability (Medrano et al., 1988).

The duration of the drought can vary from few months in spring and summer for successive years. This is frequently accompanied by overgrazing, causing the soil degradation or even the disappearance of certain species such as buckwheat, which are the main fodder resources in arid zones (Le Houérou, 1959). In this sense, in arid and dry soil generally, fodder shrubs such as buckwheat are excellent resources appetites with high nutritional value (Singh, 2004) and easy to integrate into agro-pastoral systems (Le Houérou, 1993).

The reduction in forage production under water stress has been reported for several herbaceous and woody forage species (Medrano et al., 1998). Limitations of physiological order, such as the reduction of photosynthesis and the transfer of assimilates, affect the growth and the development of the plant induces morphological changes such as reduction in leaf mass, number of stems, branching and grain yield. These large changes depend on the kind and degree of water stress and are adopted as alternative indicators of stress (Escos et al., 2000). The reduction of available water in the soil reduces leaf growth (Hsiao, 1973 and Barker, 1991.) and accelerates senescence of adult leaves (Irigoyen et al., 1992) which is a tolerance mechanism observed in the tree of the *Calligonum* species (Dhief et al., 2009). These changes reduce the surface and length of leaves per plant to reduce water losses by transpiration mechanism adopted by plants in arid climates. Forage production also depends on driving style and operating the plant. Thus, the direct use of animals (or cut) and the type of livestock are key factors of this production. Richards, (1993) believes that cutting is a limitation for carbon resources and strongly affects the physiology and the distribution of these resources in the plant. Instead Papanastasis et al. (1999), however, say that the cuts in the spring promote high recovery during the dry period, resulting from reduced transpiration leaf area, a limited effect of water stress (Escos et al., 2000) a reduction in the production of grain and late leaf fall (Lizot and Dupraz, 1993). Similarly, several authors have asserted that defoliation, cutting and direct exploitation of plants improve the water status of the plant and increase its photosynthetic capacity and therefore support growth (Caldwell et al., 1981; Toft and al., 1987; Dyer et al., 1991and Páez y González, 1995). The validity of this conclusion is based on the fact that growth is the overall result of various processes such as photosynthesis, respiration; availability of water and nutrients, and distribution of assimilates between the different organs of the plant (Poorter and Garnier, 1999). The production of shrubs also depends on the year of initiation of the operation and status of plant growth (cut or not) which depends on the environmental conditions (Papanastasis et al., 1997 and 1999).

A field trial was initiated in an experimental plot located in the ElOuara area near Bir Lathla to study the response of one of the three species of *Calligonum* genus (*Calligonum comosum* L'Herit), towards screw biotic and abiotic stress. The main objectives are: (1) Studying the development of irrigated and dry *Calligonum comosum*;(2) Studying the effect of soil water deficit on growth, dry matter distribution and production of both physically disturbed and undisturbed plants;(3) Studying the interaction between water availability in the soil and cutting production and its components.(4) Study of the physiological response (dosage of minerals) of this species under the two conditions.(5) Study the amortization of mineral elements in the soil during the experiment.

2. Materials and Methods

The plant development of *Calligonum comosum* (older than two and a half years) has been studied in the fields in an experimental plot located in the ElOuara area near Bir Lathla (figure 1). The first part of *Calligonum comosum* 330 m^2 interspersed surface lines (3m/3m) was kept under permanent irrigation system to keep the soil at field capacity (control), another part of the same size was maintained under a water regime equivalent to the average annual rainfall and a third part was maintained under rainfed (unirrigated) months between July 2007 and April 2008.

Studying the growth, the distribution of dry matter and the plant production that haven't suffered physical disturbance (not suffered a cut) before (PNP), six plants were randomly selected every 45 days to cut their aerial part, the main stems (very woody) don't form part of this biomass.

To investigate the ability of regrowth along the years in this species in irrigated and dry air part developed on the same plants PNP after each sampling, was turned off after 60 days (PC) according Corleto et al. (1993) again. Representative three stems per plant were selected randomly to measure their lengths, as the leaves of each rod as well as the number of branches. Drying plant masses were carried out in a ventilated oven at a temperature of 85 ° C for 48 hours.

The dry weight of green stems (leaves) (SDM g / plant), total plant dry (PDM g / plant) weights were calculated. The total seed weight (Y, g / plant) was measured during the period of seed maturation using a precision balance. Stem length, branching and rate of leaf senescence (defoliation) were also measured. The soil water moisture was measured at different depths (20, 40, 80 and 100 cm). The fresh weight (FW) was measured in situ by a balance of land and the dry weight was measured after drying the soil in an oven at 105 ° C for 24 hours. Climatic data were recorded daily at the meteorological station of the region of Remada (Figur2). Analysis was performed using SPSS statistical logiciel 17 and the experimental model is a fixed factorial. Six shrubs of *Calligonum comosum* were tracked. For each plant the large diameter (D) and the smallest diameter (d) and the height of the mat were measured just before the cutting. These descriptors were used to determine the average diameter (Dav). (Dav (m) = (D + d) / 2) and biovolume by simulating the tuft to a sphere (V (m 3) = 4/3 π R3). To evaluate the vegetative growth of shrubs *Calligonum comosum*, monitoring of vegetative growth in stem length of cut feet (March 2007), was conducted for ten rods. Measures of the elongations of these rods were made during the second year of planting. For the determination of the ground phytomass, we conducted the direct method (cut: 14 June 2007) that remains the most accurate despite the physical effort and time it requires in addition to the destruction of vegetation. The study method used for the characterization of the state of vegetation cover that points quadrats as defined by Daget et Poissonnet (1971). Practically, a double tape measure was stretched between two poles materializing different transects, a metal needle was placed vertically down into the vegetation every 20 cm along the strip, which allowed us to obtain 100 reading points at each transect. At each point we can read the type of contact (plant species, litter, hardpan, stones, wind sailing, *etc*.), the data of each line were reported on a recording schedule. Measurement lines were implemented in this plot in mid spring (April) 2007. Permanent transects (4 transects) were placed in each type of management (plot planted and control).

The main vital attributes used to evaluate the impact of planting native shrubs on the dynamics of vegetation relate to the following aspects: (1) the state of the ground surface; (2) the overall recovery of the vegetation and the annual (Ra) and perennial (Rp); (3) the floristic richness at each water regime; (4) the density of perennial and annual species was determined in plots of 20 m^2 each area. The study of all of these parameters helps to understand the dynamics of vegetation cover due to the planting of native shrubs.

3. Results

The figure (3 and 4) shows the variation of the dry weight of the biomass (B) along the year for physically undisturbed plants (PNP). A seasonal variation of B was marked especially in irrigated ($p<0.001$). And low yields (<50g/plant) were observed in December-January-February, with minimum temperatures around 10-15 ° C, and high productions were recorded in spring and summer (April-May- June). In spring, this production increased to its maximum 350g/plant for irrigated regime and 200g/plant for dry regime and then gradually decreased during the following months and vanished in July. Maximum production differences between the two regimes were observed between the months of April and May. Reductions in available water in the soil to a depth of 40cm in autumn values (fig.5) and almost was severely affected by the biomass (B) for the rainfall regime along the studied seasons. In fact, the mean values of (B) did not exceed 150 g / plant for this plan (0.099 ton / h).

As to physically disturbed plants (PC), that is to say, cut twice, the species showed higher irrigated and dry capacity in spring (cut in February-March). The maximum production was 350g/ irrigated plant (0.17ton/ha) against 122g/ dry plant (0.058ton/ha). This ability of re-growth coincided with average maximum temperatures varying between moderate 23.2 ° C and 29.1 ° C and average values of moisture in the air between 25.6% and 27.7%. The low values of B were observed in winter (cuts in September-October-November) and summer (cuts in May-June). The response of *C. comosum* irrigated and dried (un-irrigated) was limited by the average temperatures (13 ° C in January and 34 ° C in summer). Dry, reducing the available water in the soil, from October to May at the two depths (40 and 80cm), also participated in the reduction of B. The maximum values did not exceed 50g/plant for cuts in the months of May-June (0.024 ton / ha). In addition, the values of B in irrigation were also very low in summer and winter. In general, a significant difference between the two regimes (B) was observed in spring.

Rain production was limited to spring in both water regimes. Flowering started in the month of February (Fig. 5). Statistical analyzes showed significant differences in terms of grain yield between the two water regimes. (Y) was higher in individuals with dry cut in autumn and winter with an average maximum value of 121.81g/plant while this value did not exceed 92g/ irrigated plant (Fig.6). Only the cuts made in early spring (March) have produced a maximum average grain of the order of 350 g / plant for two water regimes. So, the water deficit in the soil during the fall and major part of winter has no effect on grain yield for the dry regime.

The figure 7 shows that the size of the seeds of irrigated plants (b) is almost two times higher than the grain size of the dry plants (a).

Figure8 illustrates the variation of biovolume during the study period of the species which shows that this parameter is at its maximum in the winter and by the dry regime against this parameter to a minimum during the same season and at their peak during the hottest time of the year under irrigation. Therefore we can say that the dry shrubs *C. comosum* allow regeneration of their aerial part and therefore a better persistence of plants and sustainability of populations following a rational and moderate grazing.

According to figure 9 (b), the mean values (LAR) are continuously variable over the period of the test in terms of water supply. They evolve (0.42 leaves / day) at baseline to 48 days after reaching a maximum value (2leaves / d) at the end of the test (0.5 leaves / d).

The differences between the two water regimes are observed from the 41th day showing that the water deficit largely affected (LAR). During the length of the test, this parameter varies little and the average values are limited between (0 0.26 leaves / d) with a maximum (0.85 leaves / d) after 48 days and a minimum (0 leaves / d) after 124 days. Examination of the results related to the cumulative number of leaves (Figure 9 a) that appear throughout the test confirms the curves of evolution (LAR). Thus, significant differences in leaf production are observed along with the test.

These two tables show that the recovery rate is relatively high at all transects (irrigated and dry) of the plot and at the level of control (excluding land). However, this parameter is a good indicator of the dynamics of vegetation that resulted in the installation of native shrubs.

The recorded surface states of the different soil transects show that the latter varies from0.54to8.45%in autumnand1.59to15.46% in the spring.This increasein the recovery of the latter is mainly due to debris and annual foliage *C.comosum*. The area covered by the wind sail area is the largest collection of the soil surface during the two seasons.

The results for recovery are shown in Figure 10. They show that the recovery varies from one irrigation system to another and relative to the control. It is 27.62% at the planted plot and 13.11% in the control, for perennial. The low recovery in the control clearly shows the advanced state of degradation of the latter due to trampling and overgrazing. The high recovery in the planted plot proves that these plantations have generated a good dynamic of vegetation cover.

This shows that the total density varies between the inside and outside of the parcel. It is 10 plant / m^2 at the planted plot and 4 plant / m^2 in the control. There is a high contribution density of the annual species with a considerable share (94% for planted plot), due to the favorable conditions created by irrigation indigenous shrubs. The annuals density of the planted plot is far higher than in the control due to overgrazing and to the biological unfavorable conditions during the year 2007.

Tables (1, 2, 3 and 4) show that the floristic richness of surveyed species varies between the two types of management. In the planted plot where conditions are favorable it is of 15 species and it is of only 5 species in the control. Planting native shrubs is accompanied by a floristic providing and good biological diversity in these degraded sites.

4. Discussion

For physically undisturbed plants (control) (PNP), a seasonal variation of the dry biomass (B) was marked especially in the irrigated periods throughout the year. High productions were recorded in spring and summer. In spring, this production increased to its maximum 350g/plant for irrigated regime and 200g/ plant for dry regime. The results are similar to other work on *Medicago arborea* in the south of Italy and Spain rainfed conditions (Correal 1993 and Martiniello et al., 1993). Thus, this species is characterized by dormancy in summer and spring cuts are the most productive of biomass. Maximum production differences between the two regimes were observed between the months of April and May. Reductions in available water in the soil severely affected the production of biomass for rainfed. Producing shrubs depends on the initiation year of the operation and plant growth status (cut or not) which in turn depend on the environmental conditions (Papanastasis et al., 1999) Leaf dry weight was reported as a sensitivity to water stress for several perennial forage species such as *Lolium perenne*, *Trifolium repens* and *Festuca arundinacea* (Karsten and MacAdam, 2001). The biomass is woody especially in summer, where the plants suffer a total leaf senescence. This character is to prevent water deficit (Levitt, 1972 and Ludlow, 1989). Indeed, the average values of (B) did not exceed 150 g / plant for this plant (0.099 ton / h). As for physically disturbed plants (PC), that is to say, cut twice, the species showed a higher irrigated and dry regrowth capacity in spring (cut in February-March). The maximum production was 350g/ irrigated plant (0.17tonne/ha) against 122g/ dry plant (0.058tonne/ha). This ability of regrowth coincided with average maximum temperatures varying between moderate 23.2 ° C and 29.1 ° C and average values of moisture in the air between 25.6% and 27.7%.

According Pic et al. (2002), the reproductive phase plays a crucial role in triggering leaf senescence. Which causes a reduction in the size and in the leaf area in spring and summer?

In general, a significant difference (B) between the two regimes was observed in spring. According to Lefi, (2003), the general pattern of variation in growth and production and its components depend largely on the availability of water in the soil, the crop and its mode of action. According to the same author, dry aboveground biomass of cut plants *Medicago arborea* and *Medicago citrina* irrigated weight, peaks in spring, invariable in summer and decrease in winter, while in rainfed conditions, the soil water deficit has affected all the parameters studied for cut plants *Medicago* between March and September and the dry weight of the biomass is similar for both species.

The reduction in forage production under water stress has been reported for several herbaceous and woody forage species (Medrano et al., 1998 and Lefi, 1999). Lefi, (2003) reported that in irrigation and after cutting plants *M.arborea* are characterized by a slow growth following the ferric chlorosis. Grain production is limited to spring in both water regimes. Although flowering starts in the month of February. Statistical analyzes showed significant differences in grain yield between the two water regimes. (Y) was higher in individuals with dry cut in autumn and winter with an average maximum value of 121.81g/dry plant while this value did not exceed 92g/ irrigated plant.

Only the cuts made in early spring (March) have produced a maximum average grain of the order of 350 g / plant for two water regimes.

Papanastasis et al. (1999) showed that under conditions of water stress, shoot dry weight and grain yield depends on the leaf mass per plant. Limitations of physiological order, such as the reduction of photosynthesis and the transfer of assimilates, affect the growth and development of the plant and which induces morphological changes like reduction in leaf mass, the number of stems, branching and grain yield. These changes largely depend on the kind and degree of water stress and are adopted as alternative indicators of stress (Escos et al., 2000). Lizot and Dupraz, (1993) showed that the cuts in the early spring, with shrubs such as *Amorpha fruticosa* L. and *Colutea arboresces* L., improve leaf production following a reduction in the production of grains and late leaf fall. The size of the seeds of irrigated plants (b) is almost two times higher than the grain size of the dry plants (a). Several authors have argued that defoliation cutting and direct exploitation of plants improve the plant water status and increase its capacity and photosynthethic growth (Caldwell et al., 1981; Toft et al., 1987 ; Dyer et al., 1991a, 1991b, 1991c and Páez and González, 1995). The validity of this conclusion is based on the fact that growth is the overall result of various processes such as photosynthesis, respiration; the availability of water and nutrients, and distribution of assimilates between the different organs of the plant (Poorter and Garnier, 1999). The variation of biovolume during the study period of the species shows that this parameter is at its maximum in winter and at their peak during the warm irrigated period. Therefore we can say that the dry shrubs *C. comosum* ensure regeneration of their aerial part and therefore a better persistence of plants along with a sustainability of populations following a rational and moderate grazing. Richards, (1993) believed that cutting is a limitation for carbon resources and strongly affects the physiology and distribution of these resources in the plant. Papanastasis et al. (1999) argue that the cuts in the spring promote high recovery during the dry period as it results in a reduced leaf area of sweating and a limited effect of water deficit (Escos et al., 2000). A reduction grain production and delayed leaf fall (Lizot and Dupraz, 1993). The mean values (LAR) are continuously variable over the period of the test in terms of water supply. They evolve (0.42 leaves / day) at baseline to 48 days after reaching a maximum value (2 leaves / d) at the end of the test (0.5 leaves / d). The differences between the two water regimes were observed from the 41th day showing that the water deficit was largely affected (LAR). The length of the test and this parameter varied in addition average values were limited between (0 0.26 leaves / d) with a maximum (0.85 leaves / d) after 48 days and a minimum (0 leaves / d) after 124jours. Examination of the results related to the cumulative number of leaves (figure 9a) that appear throughout the test confirms the curves of evolution (LAR). Thus, significant differences in leaf production were observed along with the test. The reduction of available water in the soil reduces leaf growth (Hsiao, 1973 and Barker, 1991) and accelerates senescence of mature leaves (Irigoyen et al., 1992). This is a known mechanism of tolerance in some shrub species (Andrés et al., 1997and Pic et al, 2002). The recovery rate is relatively high at all transects (irrigated and dry) of the plot at the level of control (excluding land). However, this parameter is a good indicator of the dynamics of vegetation that resulted in the installation of native shrubs. The surface states recorded at different soil transects showed that the litter varies from 0.54 to 8.45% in autumn and 1.59 to 15.46% in spring. This increase in recovery of the litter is mainly due to debris and annual foliage *C.comosum*. The area covered by the wind sail area was the largest collection of the soil surface during the two seasons. It is 27.62% at the planted plot and 13.11% in the control, for perennial. The low recovery in the control clearly shows the advanced state of degradation of the latter due to trampling and overgrazing. The high recovery in the planted plot proves that these plantations have generated a good momentum of vegetation cover. The total density varies between the inside and outside of the plot. It is 10 plant / m^2 at the planted plot and 4 plant / m^2 in control.

The density of the annual species is considerable (94% for planted plot), due to the favorable conditions created by irrigation. The annual density in the plot is far higher than in the control due to overgrazing and to the biological unfavorable conditions of the year. The floristic richness of species varied between the two types of management. In the planted plot where conditions are favorable it is 15 species and it is only 5 species in the control. Planting native shrubs is accompanied by a floristic and good biological diversity in these degraded sites (fig.10, 11 and 12). The roots are mostly shallow roots to dry diet to enjoy the humidity that exists in the surface layers of soil, while the in irrigated regime swivel and shallow roots are found (fig.13). These results are consistent with what has been observed by (Dhief et al., 2009).

5. Conclusion

In the desert ecosystem, quantitative and qualitative degradation is accompanied by irreversible changes in the flora and, therefore, plant faces marked by the dominance of abandoned species by animals. To study the effects of seasonal drought and grazing on the parameters of vegetative growth and floristic diversity in canopy of *C.comosum* , several cuts were made and transects were installed in an experimental plot located in the region of El Ouara (southern Tunisia). Recovery and floristic density were measured during two seasons (fall and spring) with the use of point quadrat method. The main results of this study showed that: For physically undisturbed plants, high productions were recorded in spring and summer. For physically disturbed plants, that is to say, cut twice, the species showed irrigated and dry capacity and higher spring regrowth (cut in February-March). In general, a significant difference of (B) between the two regimes was observed in the spring. Grain production was limited to spring in both water regimes.The annual / perennial ratio was more influenced by seasonal drought the effect of grazing in the sense of a reduction of vegetation cover was more remarkable in the fall. The overall recovery of the vegetation may be considered a good indicator of the structural state of the ecosystem. Alpha and beta diversity is in turn good indicators of ecosystem structure that should be followed in similar studies. Planting native shrubs was accompanied by a floristic and good biological diversity in these degraded sites.

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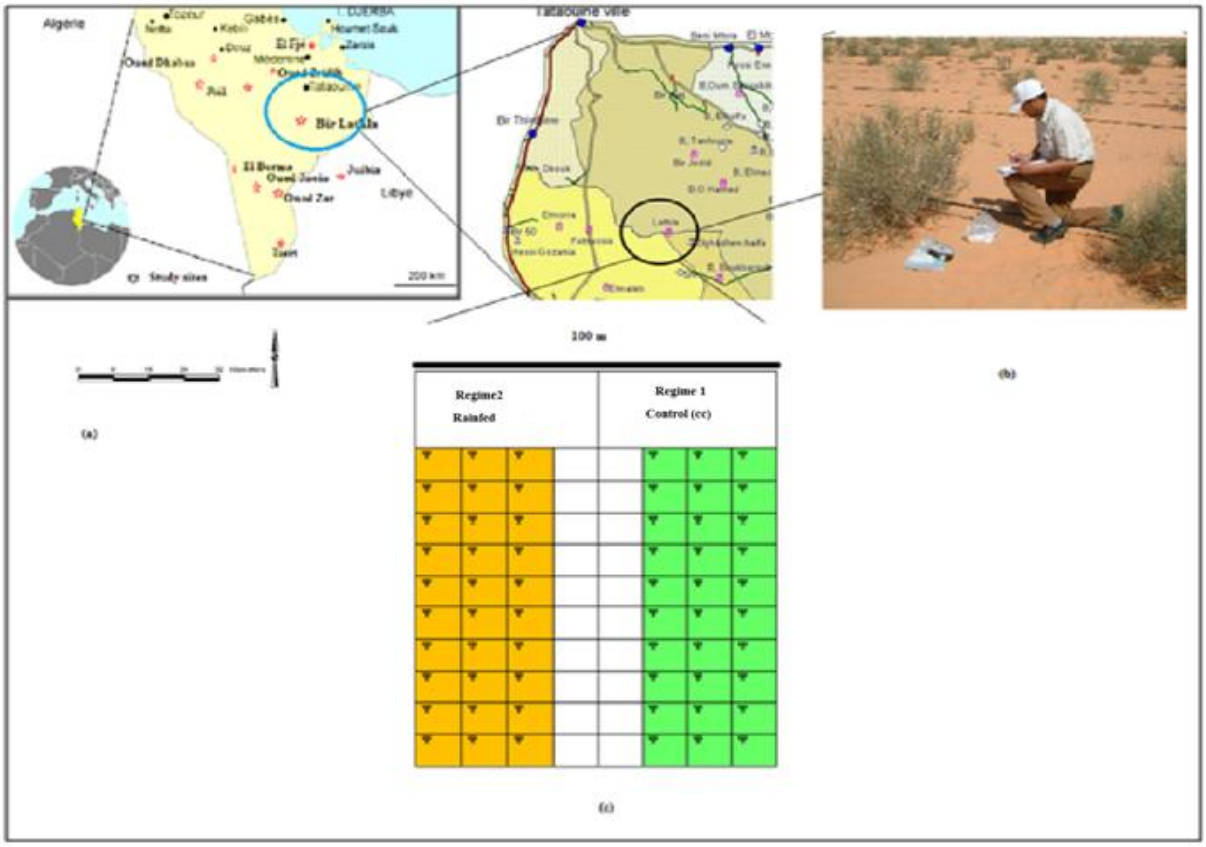


Figure 1: Location of the study area (a) and panoramic view of the experimental plot of Bir Lathla (b) plan and plot (c).

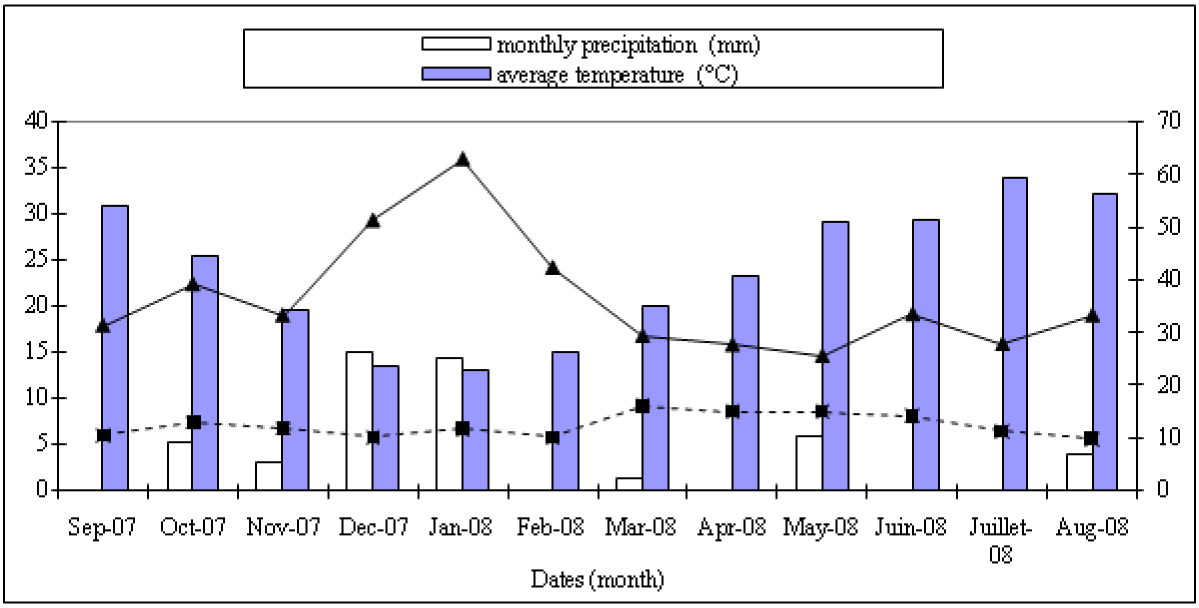


Figure 2: Variation of monthly precipitation (mm), the average monthly temperature (° C), humidity of the monthly average air (%) and the average monthly wind speed (Km / h).

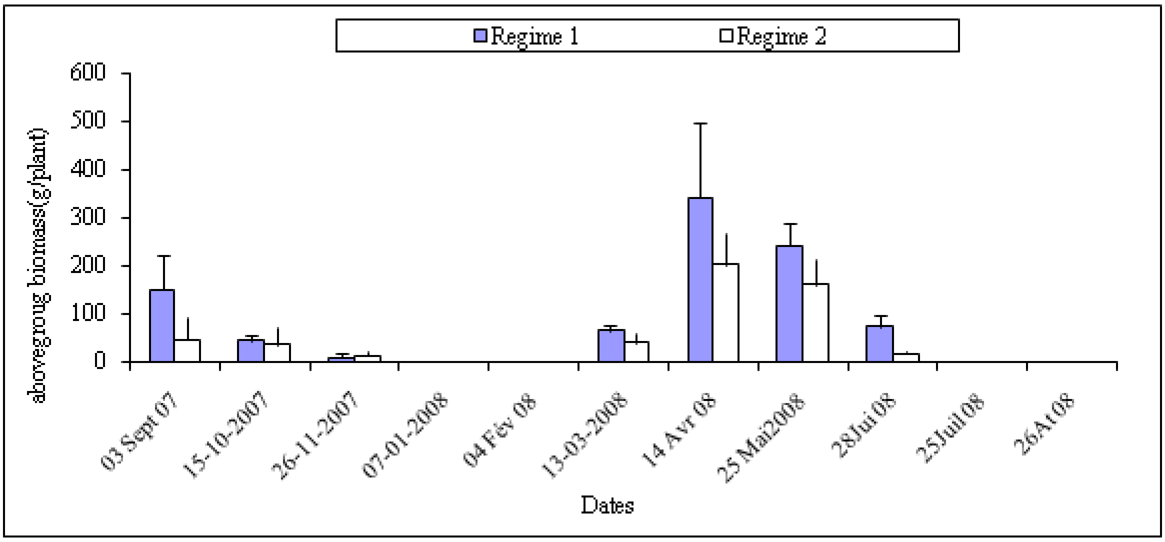


Figure 3: Variation of the dry weight of aboveground biomass (B) for undisturbed physically (a) irrigated ( ) and dry plants ( ) in *C. comosum*. Each value is the average of six replicates and the vertical bar represents the standard error. For each sample (b) two months represent the regrowth period of 60 days.

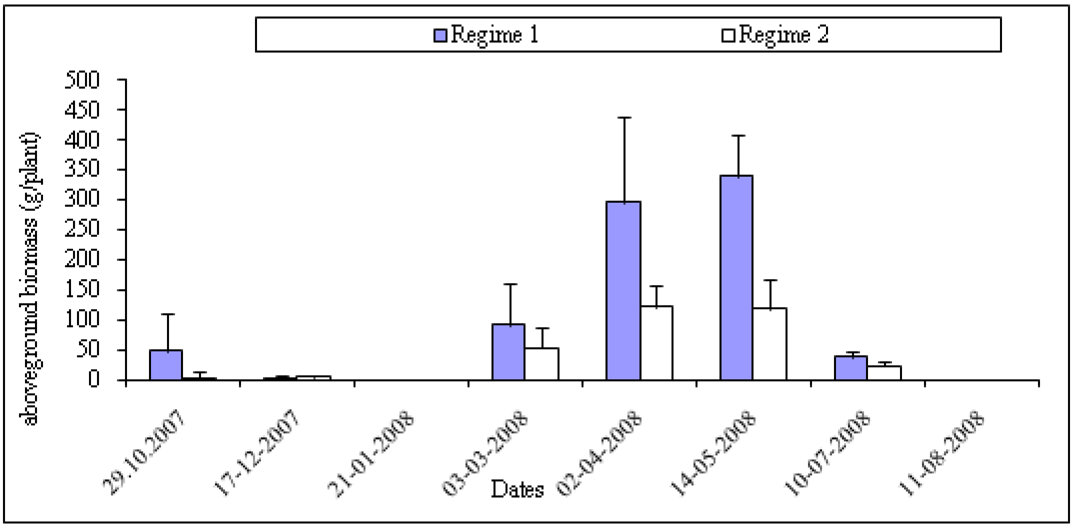
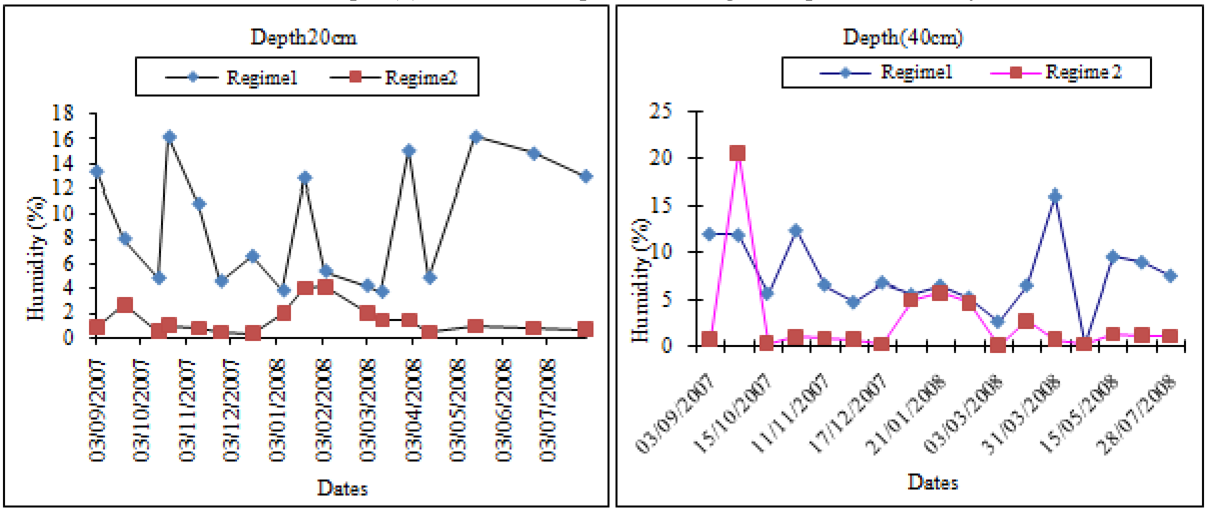


Figure 4: Variation of the dry weight of aboveground biomass (B) for plants that have undergone section (b) irrigated ( ) and dry ( ) to *C. comosum*. Each value is the average of six replicates and the vertical bar represents the standard error. For each sample (b) two months represent the regrowth period of 60 days.



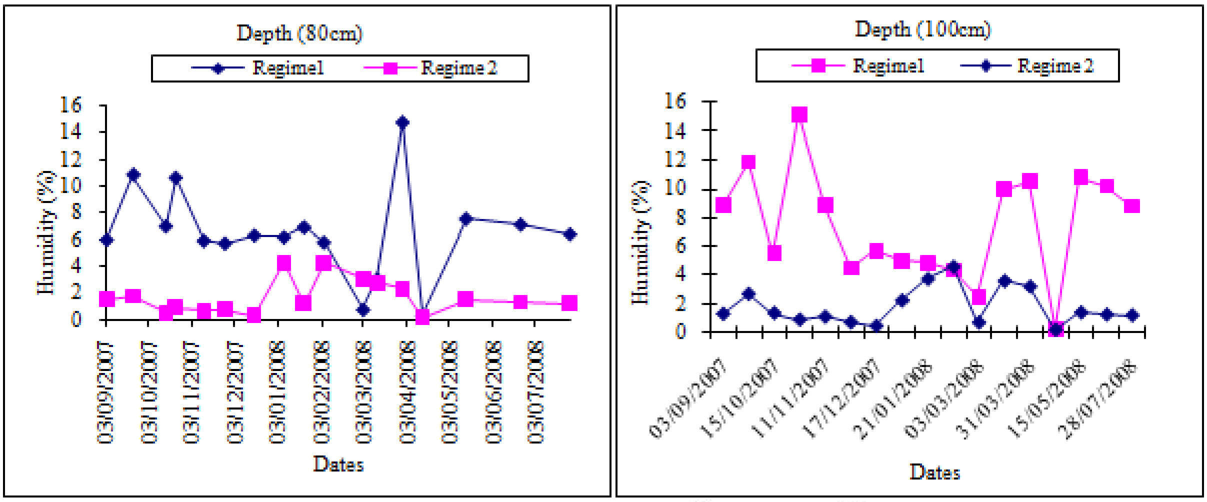


Figure 5: Variation of the relative soil moisture (H%) in irrigated (◆) and dry (◇) to *C. comosum*. Each value is the average of six replicates and the vertical bar represents the standard error.

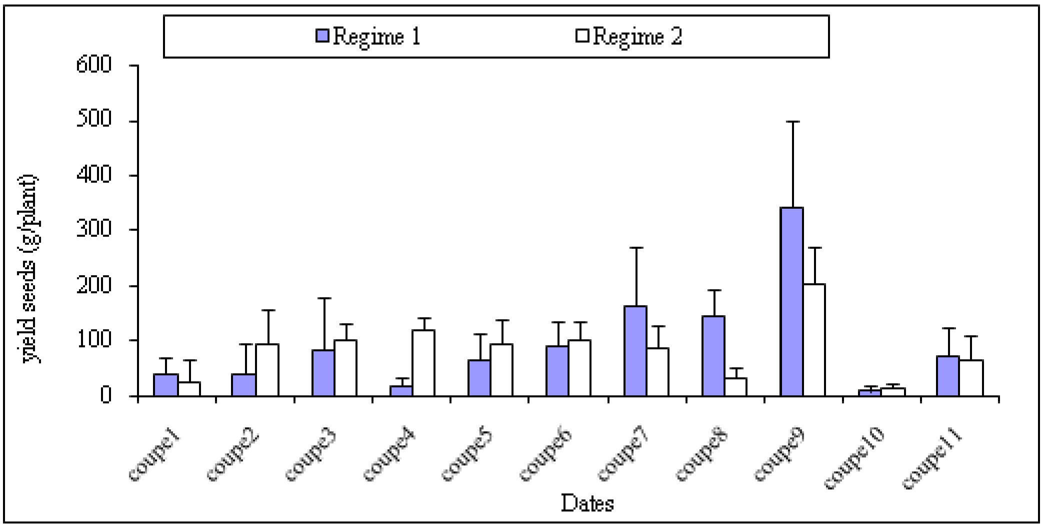
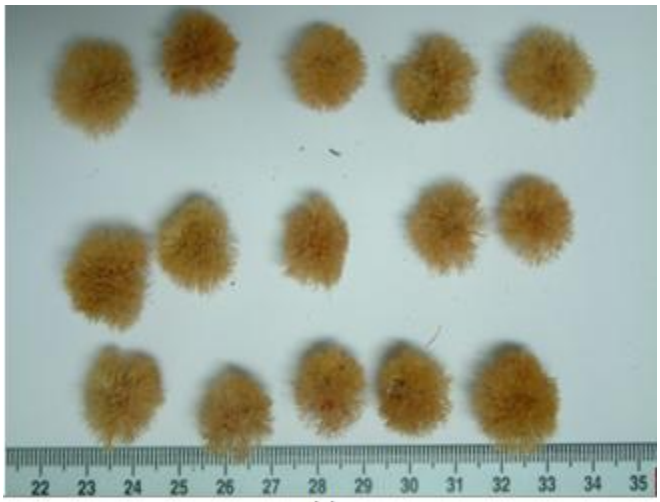
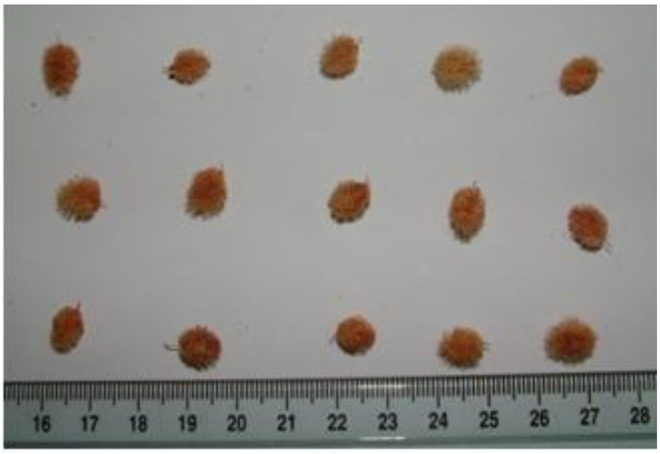


Figure 6: Grain yield (Y) plants irrigated (◪) and dry (▩) to *C. comosum*. Each value is the average of six replicates and the vertical bar represents the standard error. For each sample (b) two months represent the regrowth period of 60 days.



(a)



(b)

Figure 7: Photos showing the grain size in irrigated (a) and dry (b).

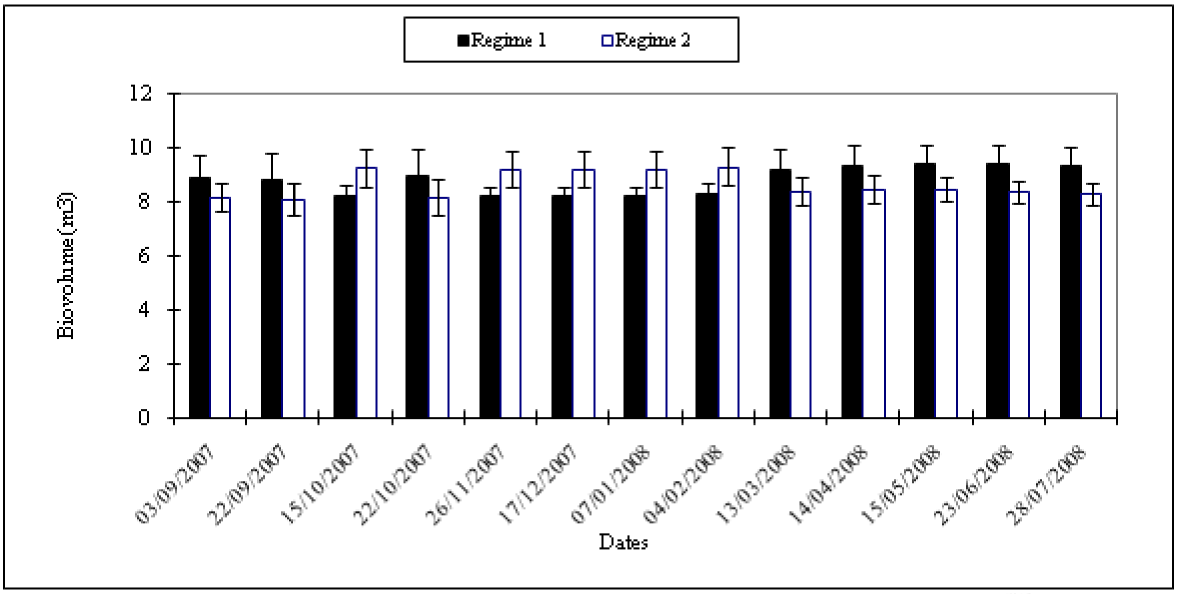
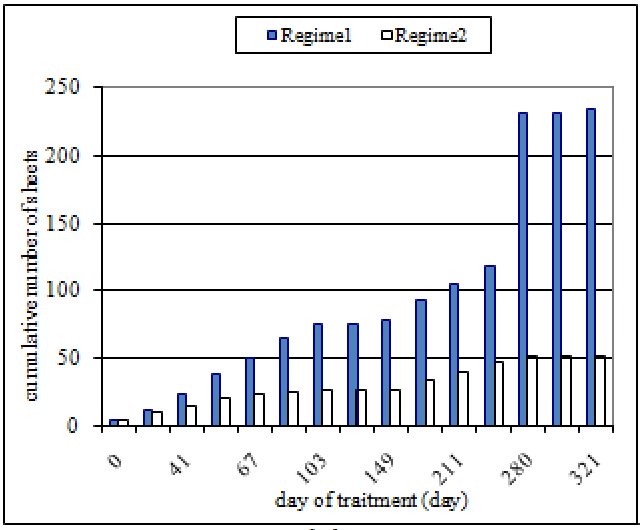
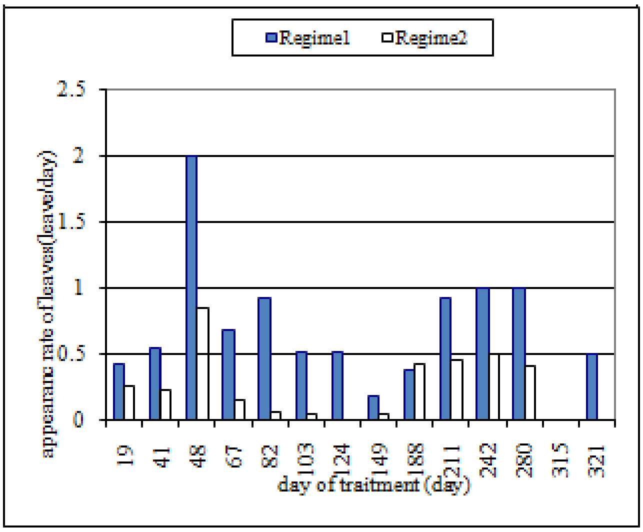


Figure 8: Change biovolume (m3) plants that have undergone section (b) irrigated (■) and dry (□) for *C. comosum*. Each value is the average of six replicates and the vertical bar represents the standard error. For each sample (b) two months represent the regrowth period of 60 days.



(a)



(b)

Figure 9: Evolution of the cumulative number of leaves (a) and the rate of appearance of leaves (LAR) (b) stem plants *C.comosum* irrigated (■) and dry (□).

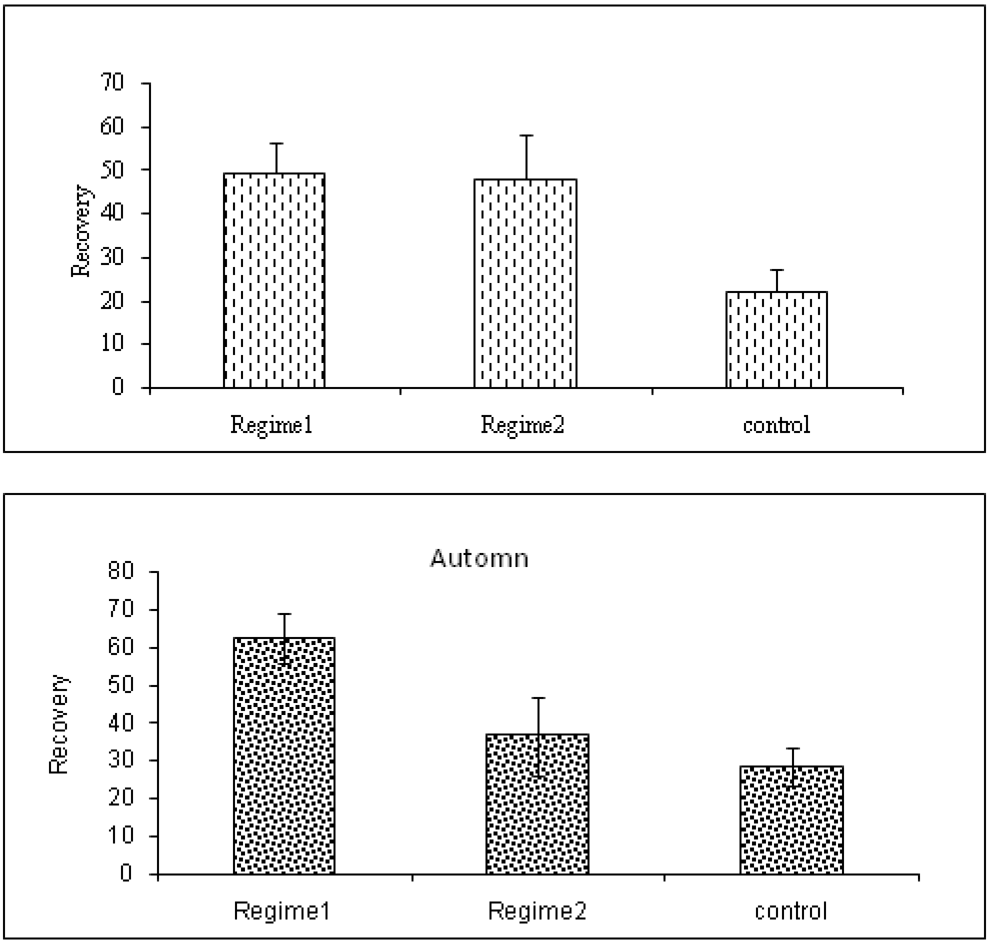


Figure 10: Recovery at two water regime and at the witness during the two study seasons

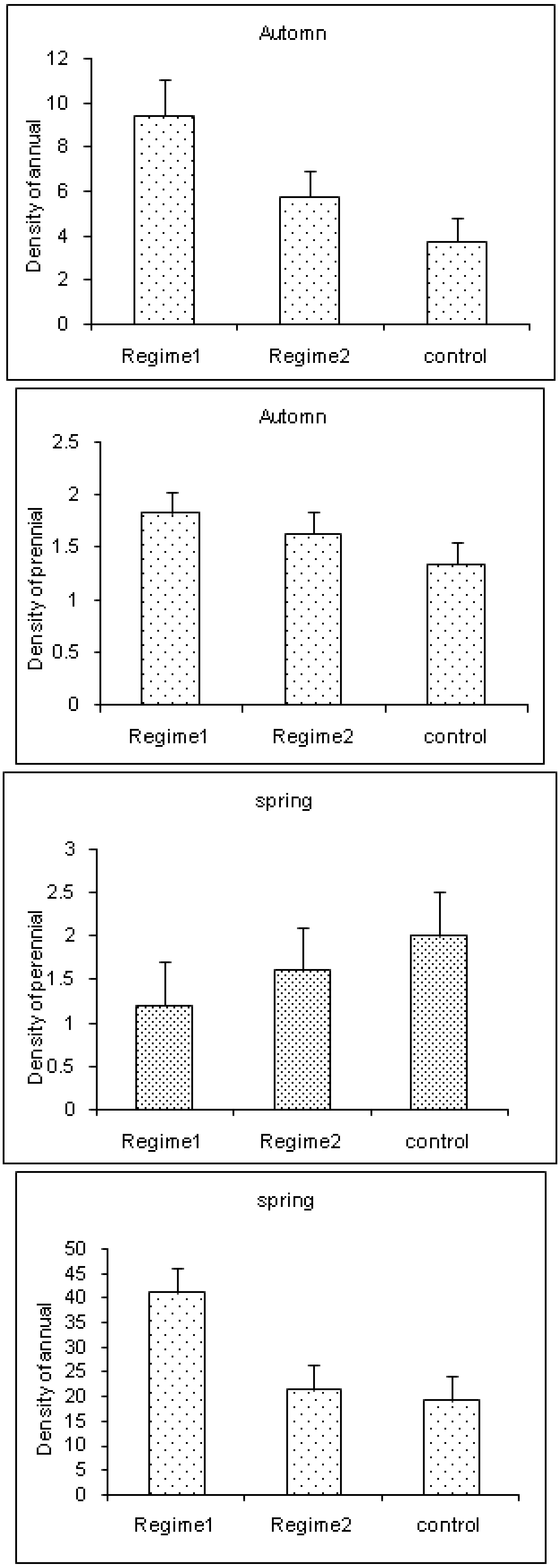


Figure 11: Density of annual and perennial level inside the parcel and at the witness.

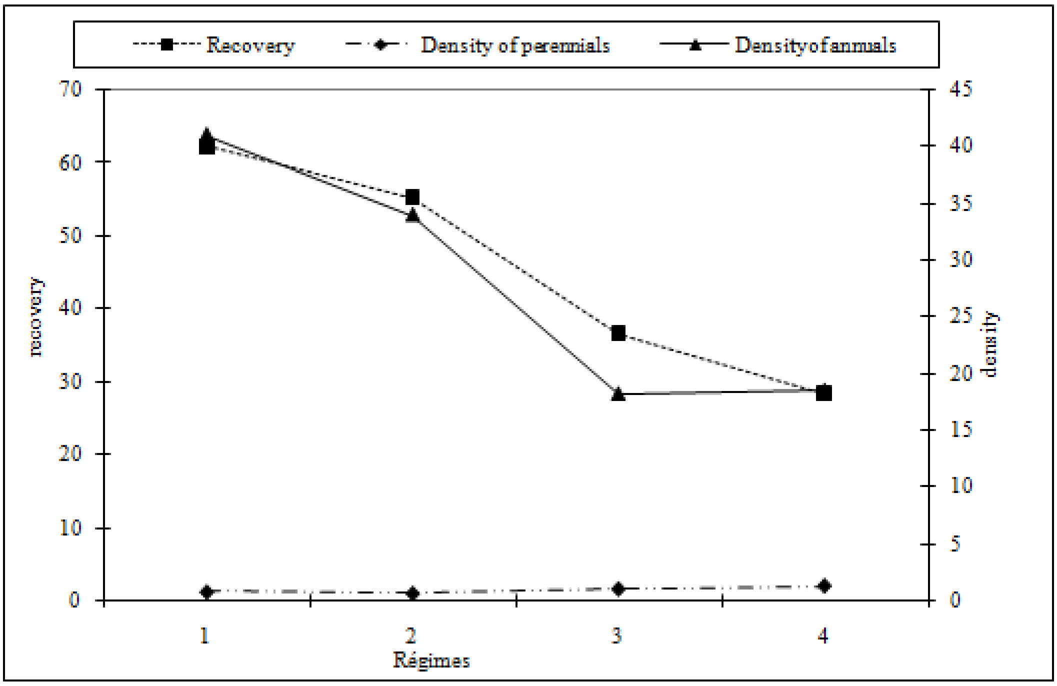


Figure 12: Recovery, density of annual and perennial inside the parcel and at the witness.

(a) (b)

Figure13: Photos showing root architecture in irrigated (a) and dry (b).

Table 1: Recovery rate and surface states of the fall recorded for each type of irrigation and the control (planted and control) soil

	Control	*irrigated*	*Dry*
Recovery (%)	22.11	49.61	48.23
veil	98	90.51	91.37
litter	0.54	8.45	6.27
pebbles	1,46	1.04	2,36

Table 2: Recovery rate and surface states of the spring recorded for each type of irrigation and the control (planted and control) soil

	Control	irrigated	dry
Recovery (%)	28.33	62.33	36.66
veil	98	83.54	89.32
litter	1.59	15.46	9.22
pebbles	0,41	1	1,46

Table 3: Change in species richness in autumn

Species	*Control*	*Plot Planted*
Calligonum Comosum		*
Hamada schmittiana	*	*
Helianthemum lippii	*	*
Hernaria fantanesii		*
Plantago albicans		*
Rhus tripartitum		*
Launea residifolia		*
Argyrolobium uniflorum	*	*
Fagonia glutinosa		*
Retama raetam	*	*
Salsola vermiculata		*
Stipagrostis pungens	*	*
Total	5	12

Table 4: Change in species richness in spring.

species	*Control*	*plot planted*
Calligonum Comosum	*	*
Hamada schmittiana	*	*
Helianthemum lippii	*	*
Hernaria fantanesii		*
Rhus tripartitum		*
Launea residifolia		*
Argyrolobium uniflorum	*	*
Fagonia glutinosa		*
Retama raetam	*	*
Salsola vermiculata		*
Stipagrostis pungens	*	*
Bassica muricata	*	*
Cutandia dicotoma		*
Daucus cyrticus		*
Euricaria pinnata		*
Fagonia cretica		*
Filago germiniaca		*
Helianthemum sessiliflorum		*
Malava aegyptiaca		*
Mathiola longipitala		*
Neurada procumbens		*
Schismus barbatus		*
Traganum nadatum		*
Total	7	23