

Conservation agriculture: A dynamic approach for continuing biomass production under rain-fed conditions of the Mediterranean climate

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Introduction

Under rain-fed conditions, farmers of the South Mediterranean experience difficulties in getting adequate economic returns with conventional agricultural techniques which require costly inputs for a relatively low and unstable yield of a (generally) single crop. Water resources are also becoming increasingly scarce and arable land is under continuous pressure from growing urbanization, leaving little room for farmers to adjust. Sarkiss et al. (1994) reported that rain-fall in the Tunisian climate is variable year-to-year, regardless of the agro-ecological zone, but this not the case for temperature. Rain variability within and between seasons can be observed within the same year, and Stewart (2007) showed that practices that work well one year may not work nearly as well in an the next. There is a growing need for a change in management of the soil-plant-atmosphere continuum, and conservation agriculture (CA) proposed since the 1970's as an alternative system of natural resource management has the potential to reduce production costs and crop yield variability, while offering the possibility of continuous biomass production under rain-fed conditions and improved water efficiency under irrigation.

Farmers need to adopt alternative techniques to better cope with climate variability by adapting crop rotations to varying season conditions, especially with regard to highly variable rainfall. They would therefore be no real purpose in adopting one crop sequence, such as cereal/legume. A farmer might instead grow silage, hay, grains, cover crop, 'catch' crop, or any suitable combination of thereof. This flexible mode of crop management would be better suited to cereal-legume/animal (sheep) based production systems, and this dynamic approach to crop production depends on appropriate agronomic sequencing (Ben-Hammouda et al., 2009) rather than a fixed rotation. Such systems need a comprehensive and integrative agro-climatic characterization of the environment, including periods of water deficits (Gardner et al., 1985), and active vegetative growth, probability of opening and late rains, monthly and seasonal rains, soil water dynamics, soil organic matter, etc. in relation to crop production requirements.

Material and Methods

Field experimentation was conducted on a loam soil (Donahue et al., 1983) in the Oued-Zergua/Beja-Governorate (Lat: 36°43'37.10"; Long: 9°27'09.33"). This is a semi-arid zone of Tunisia that receives an annual average rainfall of 363 mm with 26 % variability over the last 4 years (Figure 1). A monthly rain diagram was used to properly identify early and late rains, together with the growth cycle of crops, including potential legumes (Figure 2). Periods of potential active vegetative growth of grazing crops were determined using an ombro-thermic diagram (Dupont and Compère 1997). An equal mix of oat (*Avena sativa* L.) and fenugreek (*Trigonella foenum-graceum* L.) was sown Mid-October 2008 at a seeding rate of 100 kg/ha and harvested for silage in early April 2009. Immediately following silage harvest, lucerne (*Medicago sativa* L.) was sown at a seeding rate of 25 kg/ha. After an opening rain (35 mm) in September 2009, a 200 sheep flock grazed the field. In late-October 2009, bread wheat (*Triticum aestivum* L.) was sown into the lucerne residues at a seeding rate of 170 kg/ha. For a legume/legume relay cropping, lucerne was sown in late-March 2009 after 40 mm of rain on peas (*Pisum sativum* L.), grown from late-January/09 at 68 cm interrow spacing and 120 kg/ha seeding rate. Standard cultural practices for semi-arid production (weed/fungal disease

control, nitrogen and phosphorus application, insect/pest management, etc), were applied for all crop sequences in this CA package.

Results and Discussion

Since the 08/09 growing season, continuous and sometimes relay cropping of these cereal/legume and legume/legume systems has been successfully practiced in rain-fed conditions of this semi-arid climate. The mix of oat and fenugreek sown in Mid-October/08 was harvested as silage in early-April 2009, with a biomass yield of 12 t/ha. Lucerne which was sown the same day as silage harvest yielded 4 t/ha Late-July 2009. After an opening rain (35 mm) in September 2009, a 200 sheep flock grazed the field for 5 days for 2 h/day/ha, and taking advantage of an Early-October rain an additional 5 ha were cut before sowing bread-wheat. In late-October 2009, bread wheat sown on lucerne as a cover crop yielded 2.8 t/ha, 0.2 t/ha less than a 1 crop/year bread-wheat/bread-wheat CA rotation. Continuous biomass production of bread-wheat/lucerne system continues at the same rate for the 10/11 growing season. In legume/legume relay cropping, lucerne sown on peas yielded 6.0 t/ha in late-May 2009, and has been grazed with a 200 sheep flock for 5 days at 2 head/ha. A 3.7 t/ha additional biomass of lucerne was harvested following an early-fall of 40 mm rain in September 2009 at the start of a promising 09/10 cereal growing season. This legume/legume scenario is an important break from the typical one crop a year mode frequently encountered under rain-fed conditions in semi-arid regions.

The continuing cereal/legume or a relay cropping in the case of a legume/legume sequence were possible with the early and late rains of October and April-May, respectively (Figure 2). The accumulation of heat units also appeared to be well matched with the rainfall (Figure 3), making a continuous biomass production a reality for this farm system. These examples of dynamic agronomic sequencing are among much attempts to apply the opportunity cropping concept, properly developed and adjusted for the Mediterranean climate characteristics of Tunisia (Ben-Hammouda et al., 2009). This approach to increasing biomass production should encourage farmers to invest in CA farm research and the specialized equipment, particularly the no-till drill that could have many annual uses and pay off its cost much more rapidly than the conventional drill used in a one crop/year conventional agriculture system.

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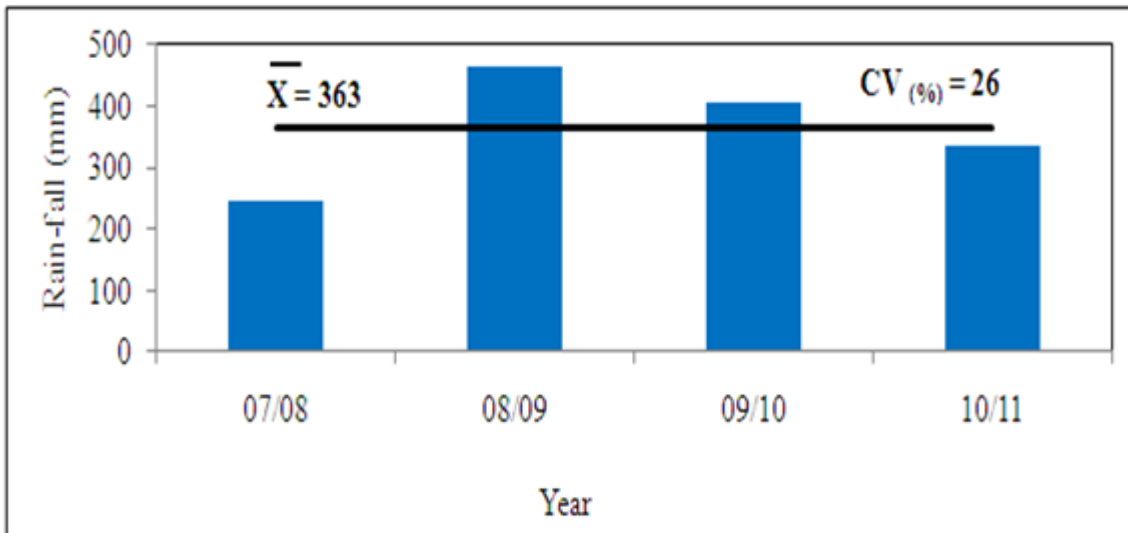


Figure 1. Yearly rain-fall for Oued-Zergua, over 4 growing seasons.

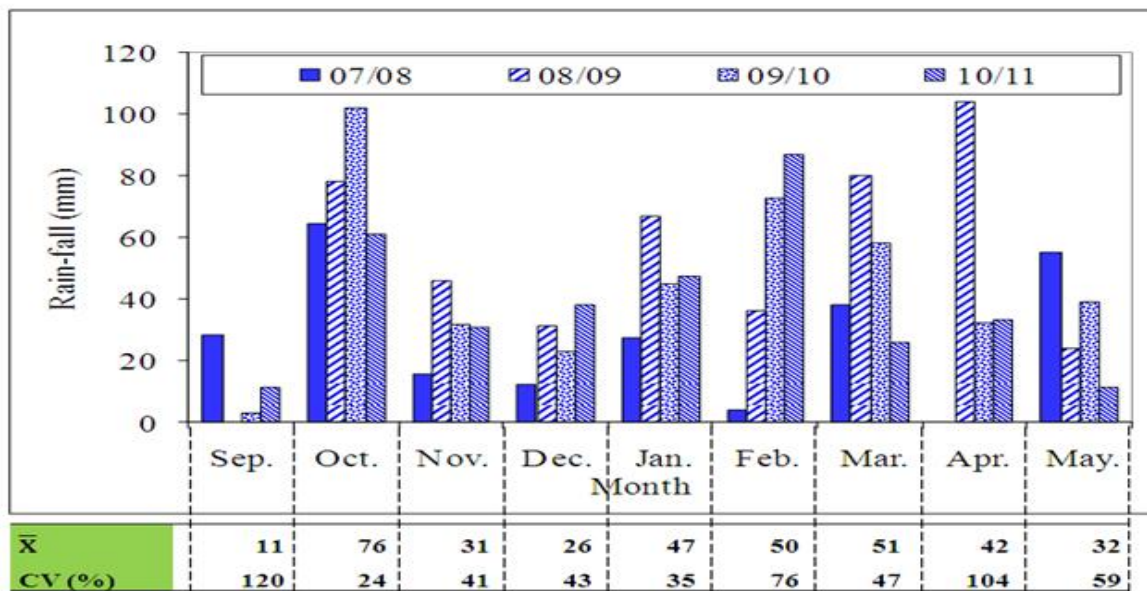


Figure 2. Monthly rain-fall for Oued-Zergua, over 4 growing seasons.

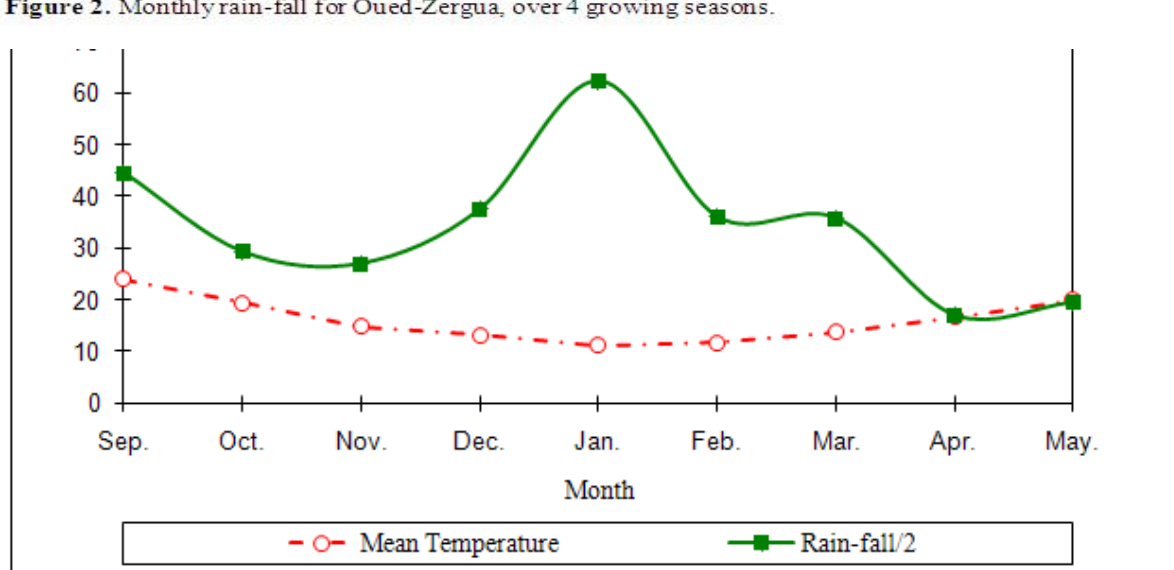


Figure 3. Ombrothermic diagram for Oued-Zergua, over 4 growing seasons.