

## **Improving cotton yield under water limiting conditions in Argentina**

Marcelo PAYTAS

INTA EEA Reconquista. Ruta 11 km 773 (3560) - Reconquista (Santa Fe), Argentina

e-mail: [mpaytas@correo.inta.gov.ar](mailto:mpaytas@correo.inta.gov.ar) [marcelo.paytas@uqconnect.edu.au](mailto:marcelo.paytas@uqconnect.edu.au)

### *Global view*

Cotton production forms one of the world's most important agricultural cash production systems. The lint is universally used as a textile raw material, while cottonseed is the second most important source of vegetable oil; further, cottonseed cake is a rich source of quality protein for incorporation in animal feeds (Eisa, 1994).

The production of cotton, like most major agricultural crops, is negatively impacted by moisture deficit stress. About 53 % of world cotton production is from irrigated conditions, while the remainder is produced under rainfed conditions (Hearn, 1994).

Almost all production under 'Mediterranean' or 'desert climates' is from fully irrigated cropping environments, and includes almost all production in Spain, Greece, Morocco, Israel, Egypt, Turkey, Syria, China, India, Pakistan and the Central Asian Republics, together with extensive areas in the west of North and South America (Hearn, 1994). In tropical and subtropical summer rainfall zones, including much of Sub-Sahara, Africa, Central and South America, cotton is more commonly grown under rainfed conditions (Hearn, 1994).

### *Argentinean cotton production*

In Argentina, the highest proportion of farming systems among the cotton belt is under rainfed conditions. About 90% of the cotton was sowed under rainfed and 10% under irrigated systems during the current season (2009-10). The cotton growing area is about 470.000 Has in the whole country. There is a significant increased in terms of sowing area compared with the previous crop season (2008-09) with 292.920 has. Argentina has 11.5 million ha of potential land and climate conditions to produce cotton, however only once reached a peak of production of 1.100.000 ha during 1997-08 (SAGPyA, 2009).

The province of Chaco has the highest cotton growing area during the current season (336.200 ha), concentrating about 70% of the national area. It is followed by Santiago del Estero (61.970 ha), Santa Fe (45.000 ha) and Formosa (18.000 ha). Smaller areas are extended to Corrientes, Salta, Cordoba, Catamarca, Entre Rios and San Luis (SAGPyA, 2010).

Argentina has been traditionally an exporting cotton fiber country, mainly since 1995. The average over the last 34 years is 81.000 tons per year. After 1991, the production of cotton in Argentina felt significantly due to low prices, adverse climatic conditions and competition with soybean production, and nowadays exportation is reduced to minimum and not significant amounts. Southeast Asia is our main importer of cotton fiber. Argentina became an importer country of cotton in the last few years, since the domestic production decreased due to climatic conditions and the amount of fiber for the local textile industries was not enough. For example, during 2008 the importation of fiber increased to 37.974 Tn. Brazil is our mainly provider (97%). The domestic consumption of cotton in Argentina is

about 140.000 Tn of fiber. The current capacity of gins is over 2 million tons of raw cotton in the whole country (SAGPyA, 2009).

Cotton is one of many crops that have been genetically modified to increase their performance with respect to weed, insect pest and disease control, the modifications being aimed on improved tolerance of pests and diseases, together with better weed control, and thereby reduce the need for application of synthetic pesticides and herbicides (Constable, 2004; Jackson, 2003). During the current summer season in Argentina, about 15% of cotton farms are sowed with conventional varieties (mainly from INTA) while the rest (85%) are genetically modify seeds (Bt, RR).

#### *Water availability as limiting factor affecting GM cotton yield*

The incorporation of biotechnology for the development of transgenic crops like cotton, has greatly improved the productivity and sustainability of agricultural systems. The introduction of genetically modified cotton to farming systems is one of the technological advances that have improved tolerance to pests and diseases, and allowed better control of weeds. Despite these improvements, issues relating to water management in both, rainfed and irrigated systems, have yet to be improved. There is strong interest in the Argentinean cotton industry in the improvement of water use efficiency, to ensure the sustainability and profitability of production under conditions of increased limitations to inputs such as water. Water availability is potentially one of the most limiting factors to profitable cotton (*Gossipium hirsutum* L.) production. Cotton appears to be well adapted to the production of lint under a range of water regimes (Hearn, 1979), and is therefore able to be grown in areas throughout the world with variable rainfall and limited water for irrigation. However, adequate soil moisture through the correct timing of irrigation or precipitation events is essential for successful commercial production of cotton.

#### *Rainfed cotton production*

The management of rainfed cotton production is challenging and it is a high risk activity given the erratic pattern of rainfall during the growing season. The amount and distribution of water from rainfall is variable each year, thus some agronomic management practices should reduced run off and increase the efficiency of capture for crop use to improve cotton yield.

The main rainfed region is in the north east of Argentina. Depending of the area, the annual rainfall can reach 1000 to 1200 mm, mainly concentrated from September to April coinciding with the cotton crop season. However, the distribution may vary year to year. For example, during the last two seasons (2007-08, 2008-09), soil water deficit was found during January and February when cotton is between first flower and last effective flower, reducing seed cotton yield. These types of soils are not able to accumulate more than 50 mm of available water due to a shallow soil profile (most of these soils has a strong clay layer which is a physical impediment for roots growth and development reducing the opportunity to access to water).

Some possible solutions to be considered to improve Argentinean cotton yields would be:

- Correct choice of varieties (days to maturity, degree of indeterminacy, higher water use efficiency) and date of sowing (drought escape through crop growth coinciding with favorable water conditions or quick maturing genotypes)
- Consider useful crop rotations (soil physics and organic matter) and fallow managements (weed control, stubble mulch). A significant number of farmers in Argentina produce cotton under zero tillage systems, and follow some programs of fertilization.
- Plant population (distance between rows and density). Nowadays, the narrow-rows and high density cotton systems are becoming very popular in Argentina, but should be considered the plant population in relation with soil available water to each plant in each crop season.
- Develop a crop simulation model using historical weather data, basic soil parameters and agronomical management options to give estimates of potential cotton yields.
- Irrigation systems to apply necessary amounts of water in different and critical phenological stages.

#### *Irrigated cotton production*

The north west of Argentina is the region where cotton is produced under irrigated conditions, mainly furrow and sprinkler irrigation. Limitations of improving yields are mainly related to timing of irrigation considering new varieties with higher yield potential (Bt, RR) than conventional varieties.

Depending of the timing of water stress, the growth of cotton can be potentially affected in different ways. Soil water deficits during critical growing stages, such as reproductive stage, can significantly affect growth and yield (Kaur and Singh, 1992; Kock et al., 1990; Marur, 1991; Rosenthal et al., 1987; Turner et al., 1986), as well as early growth stages, particularly for high retention Bt RR cotton (Anac *et al.* 1999; Grimes 1994). Therefore, to achieve the higher yield potential of the genetically modified varieties, changes in some aspects of crop management need to be investigated to ensure the sustainability and high productivity of cotton production systems.

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