1593 Quantitative and Qualitative assessment of two new Argentine cotton cultivars in a narrow row production system under irrigation

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The narrow row production system of cotton requires cultivars adapted to the new management conditions. Recently, two new cultivars of cotton, Guazuncho 3 (normal leaf) and Oroblanco 2 (okra leaf), were introduced in the Argentine market. The qualitative and quantitative productive features of these two cultivars were evaluated under a narrow row (distance = 0.75 m) and irrigation system in the Río Dulce irrigation area (Santiago del Estero, Argentina). Features assessed were: percent of solar radiation intercepted, aerial biomass production, harvest index, seed and fiber yield and technological parameters of fiber quality. Guazuncho 3 intercepted more solar radiation, produced a greater amount of aerial biomass, had 9% increase in cotton seed and fiber yield, and a greater fiber length and resistance. On the other hand, Oroblanco 2 had a greater harvest index. These results suggest that Guazuncho 3 would be the best alternative for a narrow row production system. Due to that Oroblanco 2 has a better light interception in the plant inferior leaf layers, would be better suited for ultra narrow production systems with high plant density.

Key words: aerial biomass, harvest index, intercepted radiation, narrow row cotton, cultivars, yield, fiber quality.

INTRODUCTION

The net productivity of a crop is defined by the integration of factors that determine the plant growth and the production of dry matter. The latter is proportional to the amount of solar radiation, the fraction of that radiation intercepted by the crop, and the efficiency with which it is used by the photosynthetic system of the plant to reduce CO_2 and transform it into carbohydrates (Andrade et al., 1996; Mondino, 2000). Yield is determined by the crop efficiency to partition dry matter between the harvestable organs and the rest of the plant. This partition efficiency is called harvest index (Landivar, 1991; Mondino, 2000). High yields are obtained trying to maximize the interaction between environmental factors and cotton genotypes (Mondino, 2000).

The solar radiation that reaches the upper portion of a crop is relatively constant and difficult to modify. On the other hand, the amount of energy that the crop canopy is able to intercept is a function of the geometric disposition of the foliage in the plants profile, the number and type of leaves, characteristics exclusive of genotypes (Hay and Walker, 1989).

Factors like environment, type of management and genotype produce differences in the biomass production. Therefore, for the same environment and type of management, the amount of total biomass produced will be related to the genotype. Novick (2001) commented that there is not a single cultivar adapted to all the situations and conditions of climate and soils of Argentina.

Cotton is produced in the province of Santiago del Estero (Argentina) under different environments differing in the type of soils and water availability. For this reason it is not likely for a specific cotton cultivar to respond to these differences in the same manner. The introduction in the market of two new cotton cultivars, Guazuncho 3 (GZ 3) and Oroblanco 2 (OB 2), emphasized the necessity to know the interaction between these genotypes and the environment. The objective of this work was to evaluate the different qualitative and quantitative characteristics of these two cotton cultivars in narrow row production (distance = 0.75 m) systems under irrigation.

MATERIALS AND METHODS

The study was carried out at the La María Experimental Field, Estación Agropecuaria Santiago del Estero, Instituto Nacional de Tecnología Agropecuaria (INTA), Santiago del Estero, Argentina (28º 03' LS; 64º 15' LW; 169 m.s.n.m) from 2004-2005 to 2005-2006. Soils were Torriorthentic Haplustoll, La María series (Angueira y Zamora, 2000).

In the statistical sense, Guazuncho 3 (GZ 3), and Oroblanco 2 (OB 2) were considered treatments. These genotypes were chosen to represent different types of leaves: GZ 3 is a genotype of short cycle, normal leaf, with fiber yield superior to Guazuncho 3, and a better fiber length and resistance. It has no nectaries in the main leaf nerve. OB 2 has okra leaf, produces greater fiber yield, has greater gin percentage and better fiber strength than its predecessor, Oroblanco. It has short cycle and it presents nectarines in the main leaf nerve.

The plots were planted October 30th 2004 and November 4th 2005 at high rates. When the seedlings had approximately four true leaves, they were hand-thinned to a density of ten plants per meter of row (133.000 plants ha^{-1}). During the growing seasons, insects and weeds were properly controlled, and irrigation applied as recommended to minimize plant stress and optimize yield.

The statistical design was a complete random block with four replications of each treatment. The experimental unit was 12 rows (distance = 0.75 m), 10 m long (90 m^2), with two central rows for mapping, two more external rows as borders, and the remaining eight rows, four rows for destructive plant sampling and four rows used to determine yields.

The interception of solar radiation was estimated between 11.30 and 14.30 hs. in sunny days, by a 1.0 m long LI-COR 191 SB radiometer (LI-COR, Inc., Lincoln, NE, USA) adapting the surface of the sensor to the distance between rows by covering 12.5 cm in both ends of the bar. The radiometer was placed perpendicular to the direction of the rows, the center of the bar being placed on the row (Gallo and Doughtry, 1986). Every 15 days, 5 measurements were made per experimental unit and were composed by 2 readings: one over the crop canopy to estimate the incident radiation (Rinc) and another in the base of the plants under the leaf cover (Rint). The RFA intercepted was calculated by applying the following formula:

RFA (%) = [100* (Rinc-Rint)]/Rinc (Mondino, 2000). [1]

Aerial biomass was sampled every 10-15 days. On each harvest date, the aerial portions of the plants in a row length = 2 m were harvested and separated into vegetative (leaves + stem + petioles) and reproductive (squares + blooms + bolls) organs. Samples were dried with forced air for 72 h at 70ºC, and dry weights registered. Aerial biomass was calculated and expressed using formula [2].

Dry matter (g m^{-2})=((Vegetative dry matter + Reproductive dry matter)* 1,33) [2]

Plant sampled from a row 3 m long were harvested at random for mapping in order to determine plant height (cm), number of nodes and of fruit branches. The average internode length of the main stem was calculated by the relationship between plant height and node number. The harvest index was estimated as ration between seed cotton/aerial biomass. The cotton seed was ginned to estimate fiber yield. The index seed was the weight average of 5 samples of 100 seeds of ginned cotton. Fiber quality was assessed by micronaire and maturity index, fiber length (mm), fiber strength (g tex = mass (g) of 1000 m textile yarn) and elongation (%) which were analyzed by H.V.I (High Volume Instrument for fiber testing), model Spectrum I in the Cotton Fiber Laboratory, Facultad de Agronomía y Agroindustrias, Universidad Nacional de Santiago del Estero.

The data were analyzed by ANOVA. The least significant test (LSD) was used to compare treatment means. Differences between treatment means was considered significant if $p<=0,05$. The statistical program MSTAT-C 2.10 (Crop and Soil Science Department, Michigan State University, 1990) was used for calculations.

RESULTS AND DISCUSSION

The studied cultivars no intercepted up to 95% of solar radiation (SRI) at the time of the flowering. GZ3 reached this value at the end of the flowering period, while OB2 did reach this point 15 days later (Figure 1). During the vegetative stages the SRI percent for both cultivars did not differ, but during the flowering and maturation stage GZ3 had higher values of SRI. Shortening distances between rows and increasing the plant density are management practices used to increase the likelihood of reaching this point at earlier stages 95% of ISR (Mondino, 2000). For OB 2 these management practices should be of the highest magnitude, e.g. minor distance, and high densities (Mondino *et al.,* 2006).

Throughout the season, the production of aerial biomass for both cultivars exhibited the typical sigmoid growth curve, but with differences between them (Figure 2). Both cultivars showed slow growth during the earlier stage, which lasted around 40 days. After this "lag" phase, a great increment in growth was observed when the first bud appeared, a phase that extended 123 days after planting date (DAP). Next, as a result of the aging of the leaves and the presence of open bolls, the aerial biomass began to descend. OB2 quickly accumulates aerial biomass during the first days, and is more precocious than GZ3 (Figure 2). Seventy DAP, OB2 had produced almost a 18% more aerial biomass than GZ3 and had already 50% of the total OB aerial biomass produced in the entire growth season. When the spacing between rows is shortened and the plant density increased, OB2 has an important growth in the first stages of development, suggesting great precociousness. However, at DAP = 85 days, the aerial biomass production of GZ3 is greater than the OB2 aerial biomass production, suggesting that GZ3 has a slower metabolic process and therefore a greater length of growth cycle than OB2. Both cultivars registered at DAP = 115 the maximum magnitudes of aerial biomass production, showing GZ3 a 19% difference in relation to OB2. The time of occurrence of the maximum magnitudes of aerial biomass production agree with data presented by Wells and Meredith Jr. (1984) who found that the maximum aerial biomass production registered by almost all cultivars evaluated occur at DPA = 117. Despite the smaller values of ISR that could be attributed to the form of leaves, which allow the passage of light between the lobes, OB2 produces a greater amount of dry matter in early stages of growth. OB2 has better sunlight interception in the middle and lower parts of the plant. Mondino (2000) mentioned that some genotypes allow a better sunlight penetration in the vertical part of canopy reason why greater amounts of energy can reach the middle and lower portions of the plant, thus increasing the photosynthetic contribution of these layers and improving the production of dry matter.

The plant height, node numbers, mean length internode and fruit branch numbers are very simple indicators of how cotton is growing under a certain type of management. The cultivars tested presented differences in height, node numbers, and mean internodes length. During harvest time, the plants of OB2 reached a greater height than GZ3 with a smaller node number because of the mean internode length. However, there were no significant differences observed in the number of fruit branches (Table 1).

Although the magnitude of the mean internodes length of OB2 was higher than 4.5 cm, threshold considered optimal by Mondino *et al*. (1999), the smaller aerial biomass production observed in this cultivar compensate the possibility of an excess of vegetative growth.

The aerial biomass production and the seedcotton yield present significant differences in favor of GZ3, with a 7.6% more yield, which represents approx. 417 kg ha^{-1} (Table 2). The higher yield obtained by GZ3 was the result of a greater number and weight of bolls in relation to OB2 (data non presented).

The primary objective of crops production is to convert a high proportion of aerial biomass in the harvestable plant parts. The harvest index of OB2 reached a high magnitude despite of presenting smaller magnitude of aerial biomass (Table 2). Wells and Meredith (1984) reported that certain precocious genotypes (as OB2) produce an harvest index higher than those of longer cycle. This is a characteristic that can enhance yield in a situation of smaller aerial biomass production. In this study the greater proportion of aerial biomass obtained by GZ3 was balanced by the OB2 harvest index.

The percentage of fiber of both cultivars did not present statistical differences. However, when fiber yield was analyzed a difference in favor of GZ3 was observed (Table 2). Mondino y Peterlin (2005) in a study made under irrigation with these cultivars obtained the same type of response, although with greater percentage of fiber.

The analysis of the technological properties that define the fiber quality shows a significant difference in favor of Guazuncho 3 only for fiber length and strength, while micronaire index, maturity index and the elongation did not present statistically significant differences (Table 3). The magnitudes of the different fiber technological properties were considered satisfactory by national textile industry standards.

CONCLUSIONS

Throughout their growth cycle, GZ3 intercepted more solar radiation than OR2. Nevertheless, both cultivars reached 95% of radiation interception at the end of flowering stage. This fact suggest a certain degree of inefficiency in the use of solar radiation, which could be improved with better crop management practices as well as the reduction of the spacing between row and by increasing plant density.

During the early vegetative stages and first weeks of flowering and considering the same measurement times, OB2 produced a greater amount of aerial biomass due to a greater speed in its initial growth, which could be explained by a difference in the distribution of sunlight in the canopy profile. Nevertheless, in medium flowering stages GZ3 intercepted more radiation during greater time, and accumulated a greater amount of dry matter, and therefore produced greater yield in spite of presenting a minor harvest index than OB2.

The high cottonseed and fiber yield was obtained for Guazuncho 3. Nevertheless, as much GZ 3 as OB 2 present equal fiber percent. All fiber quality properties show adequate values for the industry. GZ3 presented better fiber length and strength than OB2.

Both cultivars adapt to the 0,75 m narrow-row cotton production. GZ 3 presents better performance than OB2 in this system. OB2 performance could improve for reduce distance between rows and/or increasing plant density.

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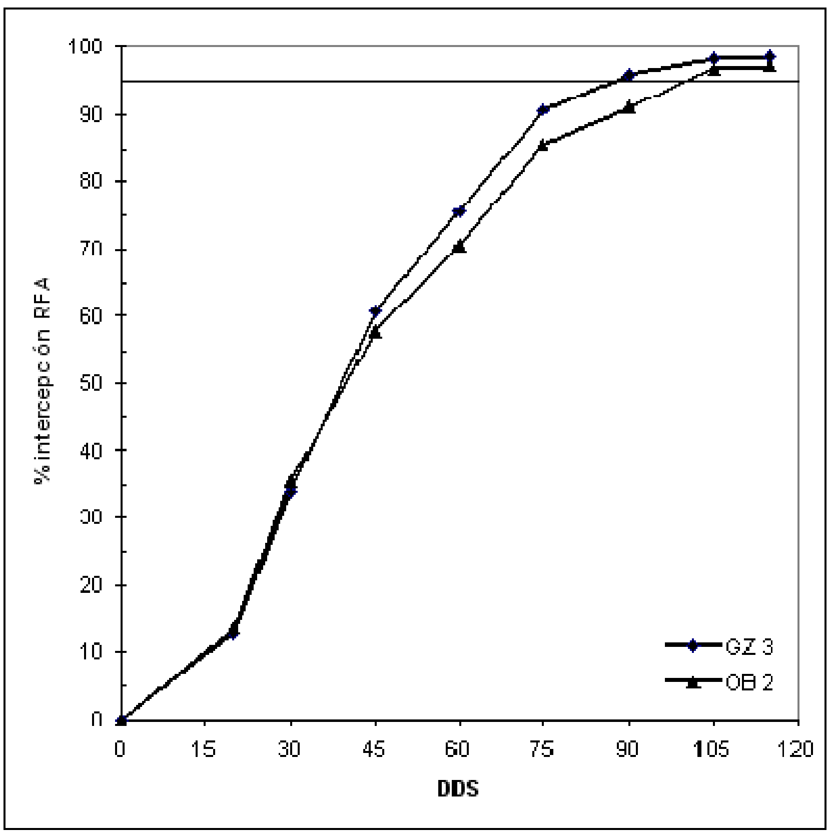

Figure 1. Evolution of % of solar radiation interception of two cotton cultivar in narrow row system (0,75 m) in the Río Dulce irrigation area (Argentine).

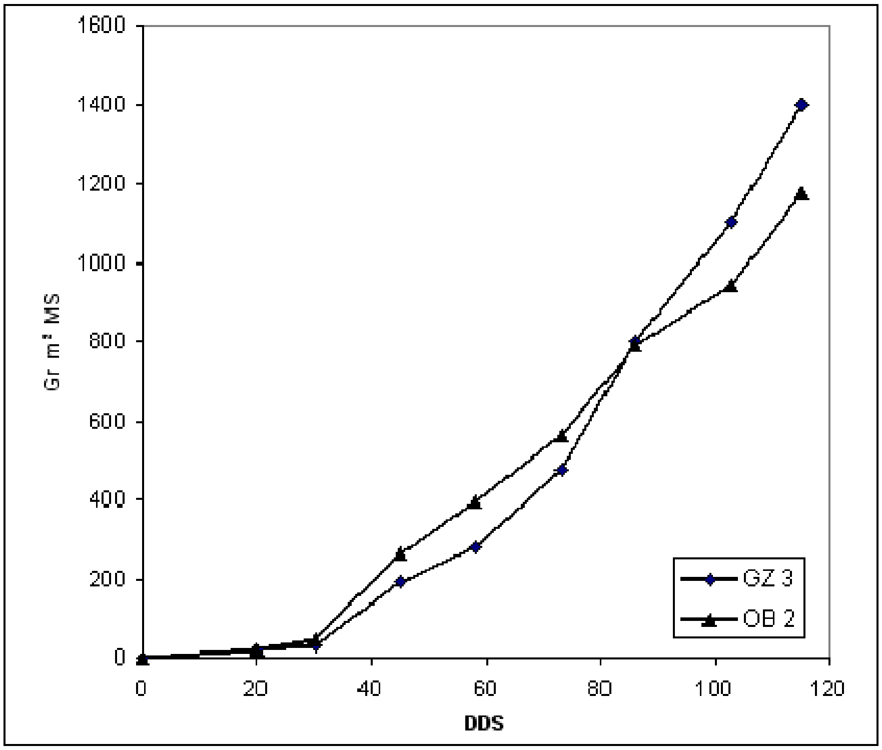

Figure 2. Evolution of the aerial biomass in g m^{-2} in two cotton cultivar in narrow row system (0,75 m) in the Río Dulce irrigation area (Argentine).

Table 1. Quantitative morphologic characteristics of OB2 and GZ3 under in narrow row cotton production system in Argentina.

Cultivars	Height (cm)	Node number	Mean internodes length (cm)	Fruit branch number
Guazuncho 3	77,7 a*	18,0 b	4,3 a	7,9 a
Oroblanco 2	83,9 b	17,5 a	4,8 b	7,7 a
DMS $_{0,05}$	2,20	0,34	0,10	1,24
CV %	1,76	1,19	1,43	9,59

*** Different letters in each column, indicate significant differences (p<=0,05)**

Table 2. Values obtained by GZ3 and OB2 for aerial biomass, harvest index, seedcotton and fiber yields, and % of fiber in narrow row cotton system in Argentina.

Cultivars	Aerial biomass ($kg\ ha^{-1}$)	Seedcotton yield ($kg\ ha^{-1}$)	Harvest index	% of fiber	Fiber yield ($kg\ ha^{-1}$)
Guazuncho 3	12430 b*	5869 b	0,46 a	36,4 a	2136 b
Oroblanco 2	10822 a	5452 a	0,55 b	36,2 a	1974 a
$DMS_{0,05}$	792,29	340,04	0,06	1,68	125
CV %	4,25	3,73	7,86	3,03	5,76

*** Different letters in each column, indicate significant differences ($p<=0,05$)**

Table 3. Values obtained by GZ3 and OB2 for fiber quality in narrow row cotton system in Argentina.

Cultivars	Micronaire index	Maturity index	Length (mm)	Strength ($gr\ tex^{-1}$)	Elongation (%)
Guazuncho 3	4,5 a*	0,90 a	30,3 b	31,8 b	7,1 a
Oroblanco 2	4,4 a	0,89 a	28,5 a	30,3 a	7,3 a
$DMS_{0,05}$	0,18	0,03	0,55	1,12	0,80
CV %	2,53	2,76	1,19	2,28	6,81

*** Different letters in each column, indicate significant differences ($p<=0,05$)**