NARROW ROW COTTON: CAN WE INCREASE YIELD BY ENHANCING ASSIMILATE SUPPLY?

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RESUMO - Narrow-row cotton has become popular in Argentina in the last few years reaching about 90% of the national sowing area. It is mainly cultivated under dryland conditions as a low input crop which is challenging and high risky. This research aimed to investigate whether the increase of assimilate supply can confer yield benefits in narrow row cotton production under field conditions.

Three field experiments were conducted during 2010-11 at the Research Station of INTA Reconquista and at The Vertiente, Avellaneda, both sites located in the North of Santa Fe, Argentina. Row spacing was 0.52 m and plant density was 200.000 plants ha^{-1}. Experiment 1: three levels of nitrogen at pre-flowering under irrigated conditions with base fertilization at sowing; Experiment 2: Two levels of water availability at pre-flowering; Experiment 3: Three levels of solar radiation availability by lower canopy exposure at flowering.

Potential advantages associated with a relatively large vegetative shoot in narrow row cotton with high plant density by the flowering stage may include a canopy ready for the intensive demand for assimilates for rapid and intensive fruit growth, including the high requirements of floral buds. Manipulating water, nitrogen and solar radiation may induce higher seed cotton yields under narrow rows cotton systems being a step forward to understand its potential for subtropical environments.

Palavras-chave*:* Narrow row cotton, assimilate supply

INTRODUÇÃO

Narrow-row cotton refers to a production system based on growing cotton in rows spaced with about 52 cm apart and high density plants. This type of production system has become popular in Argentina in the last few years reaching about 90% of the national sowing area. Reducing distance between rows and increasing plant population, the plant size became smaller and able to be harvested with stripper machines reducing harvesting costs compared with previous traditional crop systems. It is mainly cultivated under dryland conditions as a low input crop which is challenging and high risky. Changing row spacing and plant population has been used to increase yield in many other crops. By changing the spacing between plants, competition for light, water and nutrients is altered, which can change fruit number and retention per plant and the size of the plant (BEDNARZ 2000). Due to the influence of environmental conditions on plant growth and development, specific row spacing and population recommendations for crops may vary. The optimum plant population for any crop is the population that maximizes yield while optimising resource use (WILLEY; HEATH, 1969). Nowadays, Argentinean cotton farmers are mainly using 52 cm as rows spacing and 220.000 plants per hectare. Whether this population is optimal or not to produce high yielding cotton with current Bt varieties is focus of numerous studies.

Many studies have been undertaken of the impact of modifications of canopy configuration to test whether increasing the amount of radiation intercepted improves crop performance. Brown (1971) found increases in the shedding of squares and young bolls in experiments using narrower row spacing and higher plant populations, due to a lower light flux density in the lower part of the canopy. A similar situation develops within the canopy as the crop grows, with newer leaves higher in the canopy shading older leaves.

Boll retention and distribution within a plant play an important role in determining final yield, and are linked to the allocation of assimilate produced during vegetative growth by the plant. If the availability of assimilate is adequate to support the developing bolls, then the bolls will be retained (CONSTABLE, 1991; JENKINS et al., 1990). However, if the demand from growing bolls exceeds the assimilate supply, the retention of bolls will decline as a result of an increase in the number of boll abortions or shedding (GUINN, 1998; MASON, 1922).

Increased early season light capture and growth in cotton before peak flowering and the boll filling stage, produces a larger canopy that can provide more assimilate to reproductive organs and can, in turn, result in higher yields (HEITHOLT et al., 1992). Crops grown under higher solar radiation have a higher photosynthetic capability and assimilate more carbon, than those growing at lower solar radiation (PATTERSON et al., 1977). Environments with lower radiation levels (e.g. cloudy days) can directly affect the production of assimilate, with resulting reductions in both yield and fibre quality (PETTIGREW, 1994)

Most of the time, research has been done comparing different crop configuration, while in this work the idea was to maintain the same configuration and vary the inputs such us water, nitrogen and solar radiation to increase source availability for maximizing cotton yield. This research aimed to investigate whether the increase of assimilate supply can confer yield benefits in narrow row cotton production under field conditions.

METODOLOGIA

Three field experiments were conducted during 2010-11 at the Research Station of INTA Reconquista and at The Vertiente, Avellaneda, both sites located in the North of Santa Fe, Argentina. Nuopal Bt variety was sown in a randomized complete block design with four replications. Row spacing was 0.52 m and plant density was 200.000 plants ha^{-1}. A set of experiments were conducted: Experiment 1: three levels of nitrogen at pre-flowering (T1 100 kg Urea, T2 140 Kg urea, 200 Kg urea and T4 no extra urea) under irrigated conditions with base fertilization at sowing; Experiment 2: Two levels of water availability at pre-flowering (T1 irrigated conditions considering crop requirements, T2 dryland conditions); Experiment 3: Three levels of solar radiation availability by lower canopy exposure at flowering (T1 CE during two weeks, T2 CE during four weeks, T3 control). The lower canopy light exposure was achieved by pushing the plants in the rows immediately adjacent to the 'test' row (the row to be harvested) to a 45 degree inclination and then holding the plants in position using wires tied to steel posts (FUKAI et al., 1991). At the end of the canopy exposure treatment period, the wire was removed and the plants allowed returning to their original canopy structure.

The soil type in the area of the study is a Argiudol acuertico. The average annual rainfall is 1260 mm with a summer dominance. Harvests for total biomass, biomass partitioning, radiation interception and yield, as well as mapping, were done at various developmental stages throughout the season. Meteorological conditions were recorded during the season.

RESULTADOS E DISCUSSÃO

Results from Experiment 1 are shown in Figure 1. Significantly lower total fruit retention and final seed cotton yield was found in T4 with no extra nitrogen at pre-flowering compared with nitrogen treatments. Vegetative dry matter production was increased when nitrogen was applied at pre-flowering, increasing assimilate supply to retain higher number of fruits later in the season. Canopy closure happened earlier reaching 95% of solar interception for the added nitrogen treatments. Increased early season light capture and growth in cotton before peak flowering and the boll filling stage, produces a larger canopy that can provide more assimilate to reproductive organs and can, in turn, result in higher yields (HEITHOLT et al., 1992).

Final total fruit retention was higher for T1, T2 and T3, however, significant fruits abortions were found in all the treatments and this may be due to limitations in solar radiation interception in the lower part of the canopy. This may explain the low yield differences found between nitrogen and no nitrogen treatments. Seed cotton yield was increased about 9-10% with application of nitrogen at pre-flowering.

For Experiment 2, water availability affected the time taken to reach different key crop growth stages. Cut-out and maturity (60% open bolls) occurred earlier in the dryland treatments, while time-to-maturity by the irrigated treatment was significantly delayed. The boll growth period was significantly longer when water availability was higher compared with dryland treatments. The amount of water (rainfall plus irrigation) added in the irrigated treatment was enough to maintain above 60% of plant available soil water content during the whole season preventing any water stress period.

Vegetative dry matter production was higher at early stages of the crop under irrigated conditions, reaching earlier the 95% of solar radiation interception. A longer period to maturity associated with irrigated cotton was translated into a higher number of open bolls and a high boll retention rate by the end of the crop. This may be explained as a reflection of more assimilates being available to meet a higher demand from the growing and developing fruit (BANGE; MILROY 2000, HEARN 1994). However the irrigated cotton produced higher number of nodes and fruiting sites but higher fruits abortions in the lower part of the plant being possibly affected by decreased radiation interception in the lower part of the canopy compared with dryland cotton. The irrigated treatment showed increases (about 17%) of final seed cotton yield (weight of seed and lint) compared with dryland treatment (Figure 2) consistent with Pettigrew (2004).

The pattern of growth and development was different between treatments for Experiment 3. The artificial canopy opening to exposure to higher light showed that both longest periods of exposure (two and four weeks) during flowering, increased vegetative dry matter production, boll dry matter and total dry matter, and fruit retention in second position by 21%, total fruit retention by 18% and final yield, with a much larger number of fruits being retained in the lower part of the plant (Figure 2).

CONCLUSÃO

Summarizing, potential advantages associated with a relatively large vegetative shoot in narrow row cotton with high plant density by the flowering stage may include a canopy ready for the intensive demand for assimilates for rapid and intensive fruit growth, including the high requirements of floral buds. Manipulating water, nitrogen and solar radiation may induce higher seed cotton yields under narrow rows cotton systems being a step forward to understand its potential for subtropical environments.

REFERÊNCIAS BIBLIOGRÁFICAS

BANGE M. P., MILROY S. P. Timing of crop maturity in cotton: Impact of dry matter production and partitioning. **Field Crops Research**, v. 68, p.143-155. 2000.

BEDNARZ C. W., BRIDGES D. C., BROWN, S. M. Analysis of cotton yield stability across population densities. **Agronomy Journal** v. 92, p. 128-135. 2000.

BROWN K. Plant density and yield of cotton in Northern Nigeria. **Cotton Growing Review.** v. 48, p. 255-266. 1971.

CONSTABLE G. A. Mapping the Production and Survival of Fruit on Field-Grown Cotton. **Agronomy Journal** v. 83, p. 374-378. 1991.

FUKAI S., VIZMONTE L., FISCHER K. Control of grain yield by sink capacity and assimilate supply in various rice *(Oryza sativa)* cultivars. **Expl Agric.** v. 27, p.127-135. 1991

GUINN G. Causes of square and boll shedding. In: BELTWIDE COTTON CONFERENCES: p. 1355–1364. 1998.

HEARN, A. B. The principles of cotton water relations and their application in management. In: WORLD COTTON RESEARCH CONFERENCE. p. 66-92. 1994.

HEITHOLT J. J.; PETTIGREW, W. T., MEREDITH, W. R. Light interception and lint yield of narrow-row cotton. **Crop Science** v. 32, p. 728-733 1992.

JENKINS J. N.; MCCARTY, J. C.; PARROTT, W. L. Effectiveness of fruiting sites in cotton - yield. **Crop Science** v. 30, p. 365-369, 1990.

MASON T.G. Growth and abscission in Sea Island cotton. **Annals of Botany** v. 36, p. 457-484, 1922.

PATTERSON, D. T.; BUNCE J. A.; ALBERTE, R. S.; VANVOLKENBURGH, E. Photosynthesis in relation to leaf characteristics of cotton from controlled and field environments. **Plant Physiology**, v. 59, p. 384-387. 1977.

PETTIGREW, W. T. Source-to-sink manipulation effects on cotton lint yield and yield components. **Agronomy Journal** v. 86, p. 731-735, 1994.

PETTIGREW, W. T. Moisture deficit effects on cotton lint yield, yield components, and boll distribution. **Agronomy Journal,** v. 96, p. 377-383, 2004.

WILLEY R.; HEATH S. The quantitative relationship between plant population and crop yield. **Advances in Agronomy** v. 21, p. 281-321, 1969.

Figure 1: Seed cotton yield and fruit weight under 4 different levels of nitrogen at pre-flowering.

Experiment 1. Treatments	Seed cotton yield (Kg. Ha-1)	Fruit weight (g)	% of total fruit retention (maturity)
1. 100 N	3.508 a	4,13 a	46 a
2. 140 N	3.565 a	4,32 a	48 a
3. 200 N	3.438 a	4,28 a	46 a
4. No extra N	3.232 b	4,31 a	39 b

Figure 2: Seed cotton yield and total fruit retention at maturity for Experiments 2 and 3.

Experiment 2. Treatments	Seed cotton yield (Kg. Ha-1)	Experiment 3. Treatments	Seed cotton yield (Kg. Ha-1)
1. Irrigated	3.498 a	1. T1 CE	3.766 a
2. Dryland	2.945 b	2. T2 CE	3.791a
		3. T3 control	3.078 b