Cotton response to three plant population densities in Spain

J. Rossi and E. Braojos
D&PL International (A division of Delta And Pine Land Co.), Monte Carmelo, Sevilla SPAIN
Correspondence author dplspain@vianwe.com

ABSTRACT

A study was carried out in 1999 and 2000 to investigate the effect of three different plant population densities (100,000, 175,000 and 250,000 plants per hectare) over three different cultivars: DP 5111, DP 5690 and DeltaOPAL. The trials were conducted in 1999 and 2000 on a fertile soil in Las Cabezas de San Juan, town 50 km SE Sevilla, in the heart of the largest cotton growing area in Spain. The statistical analysis carried out with the data, showed a good significance for the most of the parameters taken into account. In this study, DeltaOPAL was a full season variety with a higher yield potential, due to a higher number of fruiting branches and bolls per plant. DP 5111 was defined as a short season cultivar with a lower first fruiting branch and earlier maturity (as measured by percent of 1st pick). The three different density levels didn't affect the number of total nodes in the plant, or the seed cotton yield of any of the varieties. However, higher plant densities produce a lower number of fruiting (sympodial) and vegetative (monopodial) branches per plant. The total nodes and the number of bolls per plant also decreased as the density increased. The higher plant densities (175,000 and 250,000 plants per hectare), most used by growers in Spain, affected the earliness of the crop and decreased the seed cotton yield in the first picking. Density did not significantly affect the earliness of DP 5111, however, earliness was significantly reduced at higher plant densities with DP 5690 and DeltaOPAL.

Introduction

Upland Cotton (*Gossypium hirsutum* L.) is grown in South Spain on an average of 90,000 hectares every year, mainly in the Guadalquivir River basin. One hundred percent of the crop is irrigated and machine picked. The growing season is determined by the Mediterranean weather in the area, with rainy periods during spring and autumn, and dry, hot periods during summer. Planting time is from early March to late April, and harvest from late September to late October. A profitable commercial production is often constrained by a short growing season; therefore, earliness is one of the most desired traits for cotton varieties.

The most important disease of the crop is Verticillium wilt (Bejarano-Alcázar *et al*., 1995) which occurs in more than 80% of the fields resulting in yield losses depending on the environmental conditions during the growing season. Cotton is also seriously affected by seedling diseases (Melero, 1986) as a result of the unstable weather during crop stand establishment.

Cotton farmers in Spain try to achieve a desired stand, planting at high densities to overcome possible losses by damping-off, and as an additional management practice to reduce the incidence of Verticillium wilt (El-Zik, 2002). High density is also an approach used to achieve the desired earliness for the crop, since very dense populations create competitive pressure to force plants to become more compact. It had been assumed that these compact plants would have shorter flowering periods and earlier boll maturation, resulting in earlier production (Galanopoulou-Sendouka *et al*., 1980). However, density effects on earliness have been inconsistent. Mohamad *et al*., (1982) found that increasing density delayed maturity, while Smith *et al*. (1979), and Lewis (2001) reported that low plant density delayed maturity.

Likewise, reported effects of plant population on cotton yield have been inconsistent (Jones and Wells, 1997). Apparently, yield is relatively stable across a wide range of population densities (Bednarz *et al*., 2000), but other research has found significant differences in yield due to populations (Bridge *et al*., 1973).

Lint quality parameters were not studied as previous research indicates that plant populations had no consistent effects of fiber properties (Bridge *et al*., 1973; Buxton *et al*., 1977).

This study was conducted to test the effect of different plant populations on the performance of three different cotton varieties in the high input growing conditions of south Spain with the objective of finding useful guidelines for cotton farmers.

Experimental procedure

Tests were conducted during the 1999 and 2000 seasons on a soil of high fertility at Las Cabezas de San Juan, province of Sevilla, SW Spain. Each year the trial consisted of four replications in a randomized complete block design. The planting pattern was the conventional one for spindle picked cotton: 95 cm row spacing.

Experimental plot dimensions were four rows in width by 10 meters in length. The two rows in the middle were hand picked at two different dates for seed cotton yield and earliness (percent of 1st picking). The 1st and 4th rows were used to make the observations for the rest of the parameters: vegetative nodes, fruiting branches, vegetative branches, total nodes, bolls/plant, bolls in fruiting branches and bolls in vegetative branches. The data were obtained one week before the 1st picking from samples of five plants chosen at random.

The three cultivars were selected according to their different fruiting patterns: DP 5111 is a cotton variety bred by Dr. Don Keim located at the D&PL Research Station in Scott, Mississippi (USA). It is considered as a short season cultivar with a bushy plant type. DP 5690 was bred by Dr Larry Burdette at the D&PL Research Station in Maricopa, Arizona (USA). It is a medium-long season variety with cluster fruiting pattern. DeltaOPAL was bred in Goondiwindi (Australia) by Deltapine Australia breeder, Richard Leske, and it is a long season variety with a semi-cluster plant type.

To achieve the desired three final plant densities in 1999, the varieties were planted with a high seeding rate: 30 kg per hectare, and thinned at the four true-leaf stage once the crop stand was secure, thereby leaving the proper number of plants per row meter for any of the treatments. However, in the year 2000, a different method was used. In each one of the plots the seeding rate was different according to the target density. Once the plant stand establishment was accomplished, pieces of row with the desired plant densities were selected for data collecting. This second method attempted to make a distinction among the different populations in the competition for light, right from the beginning of emergence. The light signals are perceived in the plant by a family of photoreceptors: the phytochromes, which modulate growth and development through out the plant's life, including seed germination, seedling de-etiolation, shoot morphology and flowering (Ballaré and Casal, 2000). The phytochrome system controls gibberellin biosynthesis (Morelli and Ruberti, 2002), which is one the hormones involve in plant stature and organ size. The effect of these two different methods used to affect the final plant density will be discussed in the following "Results and Discussion" section.

Planting dates were April 10 in 1999 and April 13 in 2000. Fertilizer at a rate of 72 kg per hectare of nitrogen, 184 kg per hectare of phosphorus and 75 kg per hectare of potassium, was broadcast prior to land preparation. Additional nitrogen was added along the season (175 kg per hectare in 1999 and 190 kg per hectare in 2000). Preplanting herbicides were sprayed: Pendimethalin 33% at 5 liters per hectare and fluometuron 33% at 2 liters per hectare, both years. Aldicarb 10% was applied with the planter at the rate of 7.5 kg per hectare in 1999 and 9 kg per hectare in 2000, as a soil disinfectant. The crop received five furrow irrigations along the growing season each year. Due to the heavy pest pressure, the crop needed nine insecticides sprays in 1999 and 10 in 2000, mainly for *Helicoverpa armigera*. Mepiquat chloride 5% was also applied: 1.4 liters per hectare in 1999 and 0.5 liters per hectare in 2000.

Analysis of variance (ANOVA) was used to determine statistical differences (SAS Institute, 2002). Significantly different means were separated by the Duncan's Multiple Range Test for significance at the 0.05 level of probability.

Results and Discussion

Significant differences were found due to the three levels of plant density for the most of the plant growth parameters studied (Table 1).

Plants grown under low populations have more branches, both monopodial and sympodial, which resulted in a higher number of total nodes and bolls per plant. This data is in agreement with most of the reviewed literature.

There was no effect observed from plant density on the number of vegetative nodes and the node number of the first fruiting branch, which is in agreement with the studies of Bednarz *et al*. (2000) and Galanopoulou-Sendouka *et al*. (1980). However, there are reports demonstrating that the node of the first sympodia is influenced by in-row plant spacing (Lewis, 2001). Kerby *et al*. (1990a) observed the influence of density raising the node number of the first fruiting branch only in one year from a 2-year study. Under narrow-row cropping systems, the high plant densities seem to raise the first fruiting branch, improving the efficiency of stripper machine picking, although the strength of this effect is not consistent (Buxton *et al*., 1977).

However, it has been reported by Galanopoulou-Sendouka *et al*. (1980) and Kerby *et al*. (1990a), that the genotype has a clear influence on node of the first fruiting branch. And, as this current study indicates in Table 2.2, DP 5111 initiated fruiting at a lower node (5.53 vegetative nodes) than did DP 5690 (6.84 vegetative nodes) and DeltaOPAL (7.20 vegetative nodes), confirming the general knowledge that DP 5111 is an early maturing variety.

Several studies have shown that population density is inversely related to total nodes (Buxton *et al*., 1977; Galanopoulou-Sendouka *et al*., 1980; Kerby *et al*., 1990a or Bednarz *et al*., 2000). As it is shown in Table 2.1 that the 100,000 plants per hectare treatment resulted in plants with 20.92 total main-stem nodes while the highest plant density (250,000 plants per hectare) produced plants with 19.85 nodes. As it is shown in Table 1, the interaction variety x density is not significant for main-stem nodes; therefore, with regards to main-stem nodes, the varieties respond to density in a similar manner.

This study does show that plant population significantly effects the number of vegetative and fruiting branches (Table 2.1) in accordance with Buxton *et al.* (1977), Galanopoulou-Sendouka *et al*. (1980), Jones and Wells (1997) and Bednarz *et al*. (2000). Plant density is inversely related to monopodial and sympodial branch number.

Vegetative branches play a significant role in occupying the greater inter-plant space, which exists in low populations. In addition, sympodial branch length (Kerby *et al*., 1990a) and nodes per monopodial branch have been shown to increase with decreasing plant density (Baxton *et al*., 1977).

Results on bolls/plant, bolls in fruiting branches and bolls in vegetative branches clearly indicate the ability of the cotton plant to compensate for variations in stand density, as a result of its indeterminant growth habit. Lower populations produce plants with significantly more bolls (Table 2.1). This data is in agreement with several reported by Maas (1997), Jones and Wells (1997) and Bednarz *et al.* (2000).

Seed cotton yield and earliness are the most interesting parameters from a practical point of view. One of the objectives of this work is to provide cotton growers some guidelines to at least maintain, or preferably increase, yields while managing for earliness under Spain's Mediterranean climatic conditions.

The relationship between plant population and yield is controversial in cotton. It seems that final yield is relatively stable across a wide range of population densities (Bednarz *et al*., 2000). Bridge *et al.* (1973) found the highest yields from plant populations ranging from 70,000 to 121,000 plants per hectare, while higher or lower densities resulted in reduced yield; Smith *et al.* (1979) concluded the same results.

Kerby *et al.* (1990a) found a yield response from different genotypes when exposed to different levels of plant populations. Indeterminate cultivars, such as Acala SJ2, were strongly influenced by the environment (Including plant density) resulting in lower yields at higher plant densities. The more determinate cultivars, however, varied much less across plant populations.

In this current study, a significant yield response to varying plant densities did not occur. In Table 2.1, there appears to be a trend toward higher seed cotton yields as the plant population increases; however, this trend is not significant. The interaction variety x density clearly indicates that the tested genotypes responded similar to the effects of plant density with respect to yield (Tables 1 and 4), in agreement with Smith *et al.* (1979). However, the data does show that higher densities have more fruiting forms than lower densities. If the number of bolls per hectare is calculated from the number of bolls per plant and the number of plants per hectare, the results in Table 3 show a greater number of harvestable bolls at the higher densities. Galanopoulou-Sendouka *et al*. (1980) achieved similar results concluding that the higher number of fruits in the higher densities does not produce a proportional yield increase.

Although boll measurements were not taken during this current study, the lack of yield relative to boll number may be explained by boll weight. Several studies have concluded that boll size is inversely related to population density (Bridge *et al*., 1973; Baker, S.H., 1976; Buxton *et al*., 1979; Galanopoulou-Sendouka *et al*., 1980; Mohamad *et al*., 1982; Jones and Wells, 1997). Furthermore, as Kerby and Buxton (1981) found, the leaves of cotton plants grown at higher populations have lower available carbohydrate levels, which could have an impact on boll development. High plant density also resulted in more dry matter accumulation in leaves and stems relative to fruit (Kerby *et al*., 1990b).

Like yield, the effect of plant populations over the crop earliness is not clearly established. Although some researchers concluded that increasing plant density, earliness increases (Smith *et al*., 1979; Galanopoulou-Sendouka *et al*., 1980; Jones and Wells, 1997), this current study supports the idea that thick stands delay maturity (See Earliness as a measurement of the percent of first pick in Table 2.1). These results are in agreement with those of Mohamad *et al.* (1982), Kerby *et al.* (1990a), Maas (1997) and Bednarz *et al.* (1998).

At high densities, the rate at which fruiting positions are produced along sympodial branches is slowed since the time intervals (plastochrons) between appearances of fruiting positions are longer (Kerby and Buxton, 1981).

A varietal response to plant population was also observed of earliness. In Table 4, the earliness of DP 5111 (as measured by the percentage of 1^{st} pick) was not significantly affected by plant density. However, the maturity of DP 5690, and to a greater extent DeltaOPAL, was clearly delayed maturity at the higher plant densities. Kerby *et al*. (1990a) showed exactly the same results, concluding that increasing plant density delayed maturity of the more indeterminate genotypes, but had no effect on the more determinate ones.

As previously mentioned in "Materials and Methods", the final plant density in every plot was established by one of two methods. In 1999, plots were thinned when plants were at the four true-leaf stage, while in 2000; row pieces were selected with the desired plant density. The reason for this change in 2000 was to avoid the light competition among plants during the time between emergence and thinning. The light signals are perceived in the plant by a family of photoreceptors: the phytochromes, which modulate growth and development through out the plant's life, including seed germination, seedling de-etiolation, shoot morphology and flowering (Ballaré and Casal, 2000). A phytochrome-mediated change in the orientation of whole shoots and individual leaves enhance light capture. In plants like *Lolium multiflorum*, the tillers adopt a more erectophile position in response to the light reflected by green leaves from neighbor plants, placing leaf lamina at higher, better illuminated strata of the canopy (Casal *et al.* 1990).

In the 1999 trial, the number of vegetative nodes may have been influenced by the competition for light among seedlings during the period between emergence and thinning. As shown in Table 5, the average number of vegetative nodes in 1999 was significantly higher than in 2000, which may indicate a response by plants to capture a more efficient light for photosynthesis.

The effect of the two methods to get the achieved plant density over the three cultivars is shown in Table 6. For all the varieties, the number of vegetative nodes is higher in 1999 than in 2000, although without significant differences. However, the strength of the cultivars response is in accordance to their own maturity type, being DP 5111 (short season variety) less sensitive than DeltaOPAL (mid-full season variety).

To eliminate the possible influence of different temperature regimes for both years, 1999 and 2000, over the number of vegetative nodes, a graph with the average temperature for the months of April and May in both years is included (Figure 1). The effect of day temperatures over the floral initiation was studied by Mauney (1966), finding that higher temperatures result in higher nodal position for the first fruiting branch. Apparently nodal position of the first sympodia is determined between emergence and the appearance of the first true leaf (Gipson, 1986). Studies by Gipson (1974) demonstrated that night temperatures above 20 ^{0}C resulted in significantly higher nodal positions. As it is shown in the graph, the temperatures in the critical period for every year are quite similar each other (always below 20 ^{0}C). In 2000 they are even a little higher than in 1999. Therefore, we can conclude that the difference in vegetative nodes found in our experiment is only due to the effect of thinning in 1999.

Summary and Conclusions

The 3 different levels of plant densities did not significantly affect the final seed cotton yield of the three varieties in this study. Nor did the three cultivars differ significantly on the impact of density on seed cotton productivity. Plant density did not impact the number of vegetative nodes, although at lower plant populations the number of vegetative branches produced increased.

As the density increased, the plants had lower number of fruiting branches, lower number of total nodes and a lower number of bolls per plant. However, the earliness of the crop, as measured by the percent of first pick, was reduced by a higher plant density in the overall analysis. The earliness of DP 5111 is less sensitive to different levels of plant density, whereas DP 5690 and DeltaOPAL showed a greater impact over this important character in the short growing season areas like Spain.

DeltaOPAL showed a higher yield potential, as a result of a higher number of total nodes, more fruiting branches and bolls/plant.

DP 5111 had a lower first fruiting branch (less number of vegetative nodes) and a higher percent of first pick, like any typical short season variety. This cultivar is also less sensitive to the light competition produced by high density stands, as it was shown in the comparison between the two methods to establish the final plant density in 1999 and 2000.

Acknowledgements

The authors wish to thank Marco Barrera for his assistance during field data collecting, Janet Burgess and Dr. Ana Aguado for their assistance with statistical analysis. Manuel Fernández, farm manager, for his support during 1999 and 2000 cotton growing seasons. Dr. Kater Hake for his contribution to the design of the experiments. Stephanie J. Hake for her aid in the redaction of the paper, and Dr. Thomas Kerby for his appreciable advice and technical expertise.

References

- Baker, S.H. (1976). Response of cotton to row patterns and plant population. *Agronomy Journal*, **68**: 85-88.
- Ballaré, C.L. and Casal, J.J. (2000). Light signals perceived by crop and weed plants. *Field Crop Research,* **67**: 149- 160.
- Bednarz, C.W., Baker, S.H., Brown, S.M. and Bridges, D. (1998). Effects of plant population on growth and development of cotton in South Georgia. 1998. Beltwide Cotton Conferences Proceedings. National Cotton Council: 1450 (Abstract).
- Bednarz, C.W., Bridges, D.C. and Brown, S.M. (2000). Analysis of cotton yield stability across population densities. *Agronomy Journal*, **92**: 128-135.
- Bejarano-Alcázar, J., Melero-Vara, J.M., Blanco-López, M.A. and Jiménez-Díaz, R.M. (1995). Influence of inoculum density of defoliating and nondefoliating pathotypes of *Verticillium dahliae* on epidemics of Verticillium wilt of cotton in Southern Spain. *Phytopathology*, **12**: 1474-1481.
- Bridge, R.R., Meredith, W.R. and Chism, J.F. (1973). Influence of planting method and plant population on cotton (*Gossypium hirsutum* L.). *Agronomy Journal*, **65**: 104-109.
- Buxton, D.R., Briggs, R.E., Patterson, L.L. and Watkins, S.D. (1977). Canopy characteristics of narrow-row cotton as influenced by plant density. *Agronomy Journal*, **69**: 929-933.
- Casal, J.J., Sánchez, R.A. and Gibson, D. (1990). The significance of changes in the red/far red ratio, associated with the neighbour plants or twilight, for tillering in *Lolium multiflorum* Lam. *New Phytology*, **116**: 565-572.
- El-Zik, K.M. (2002). Effect of Verticillium and Fusarium wilts on cotton yield and quality. 2002

Beltwide Cotton Conferences Proceedings. National Cotton Council.

- Galanopoulou-Sendouka, A.G., Sficas, N.A., Gagianas, A.A. and Gerakis, P.A. (1980). Effect of population density, planting date, and genotype on plant growth and development of cotton. *Agronomy Journal*, **72**: 347-353.
- Gipson, J.R. (1986). Temperature effects on growth, development, and fiber properties. Cotton Physiology. The Cotton Foundation Reference Book Series. Number One: 47-56.
- Gipson, J.R. (1974). Effect of temperature and methyl parathion on vegetative development and fruiting of the cotton plant. *Agronomy Journal,* **66**: 337-341.
- Jones, M.A. and Wells, R. (1997). Dry matter allocation and fruiting patterns of cotton grown at two divergent plant populations. *Crop Science*, **37**: 797-802.
- Kerby, T.A., Cassman, K.G. and Keeley, M. (1990a). Genotypes and plant densities for narrow-row cotton systems. I. Height, nodes, earliness, and location of yield. *Crop Science*, **30**: 644-649.
- Kerby, T.A., Cassman, K.G. and Keeley, M. (1990b). Genotypes and plant densities for narrow-row cotton systems. II. Leaf area and dry-matter partitioning. *Crop Science*, **30**: 649-653.
- Lewis, H. (2001). Plant population levels and earliness in American upland cotton. 2001 Beltwide Cotton Conferences Proceedings. National Cotton Council: 461-464.
- Maas, S.J. (1997). Competition among equally-spaced cotton plants grown at four plant population densities. 1997 Beltwide Cotton Conference Proceedings. National Cotton Council: 1485-1487.
- Maddonni, G.A., Otegui, M.E., Andrieu, B., Chelle, M. and Casal, J.J. (2002). Maize leaves turn away from neighbors. *Plant Physiology,* **130**: 1181-1189.
- Mauney, J.R. (1966). Floral initiation of upland cotton *Gossypium hirsutum* L. in response to temperatures. *Journal of Experimental Botany,* **17**: 452-459.
- Mohamad, K.B., Sappenfield, W.P. and Poehlman, J.M. (1982). Cotton cultivar response to plant populations in a short-season, narrow-row cultural system. *Agronomy Journal,* **74**: 619-625.
- Morelli, G. and Ruberti, I. (2002). Light shade in the photocontrol of *Arabidopsis* growth. *Trends in Plant Science (http://plants.trends.com)*, **7**: 399-404.
- Melero, J.M. (1986). Enfermedades del algodonero causadas por hongos de suelo. Proceedings 2nd Symposium Nacional de Agroquímicos. Consejería de Agricultura y Pesca. Junta de Andalucía: 7-15.
- Mohamad, K.B., Sappenfield, W.P. and Poehlman, J.M. (1982). Cotton cultivar response to plant populations in a short-season, narrow-row cultural system. *Agronomy Journal*, **74**: 619-625.
- SAS Institute, (2002). JMP, the statistical discovery software. Version 5. SAS Institute Inc. BLDG L. 100 SAS Campus DR. Cary, NC.
- Smith, W.C., Waddle, B.A. and Ramery, H.H. Jr. (1979). Plant spacings with irrigated cotton. *Agronomy Journal*, **71**: 858-860.

Table 1. *ANOVA mean squares. Statistical analysis combining 1999 and 2000 years.*

Source	Degrees of Freedom	Veg. Nodes	Total nodes	Fruiting branches	Veg. branches	Bolls/plant	Bolls Fr. Branches	Bolls veg. branches	Seed cotton yield (kg/ha)	Earliness (%1st picking)
Year	1	22.12*	5.78	50.52*	1.81*	0.38	25.94*	32.56*	15581746.98*	185.64*
Replication (Year)	6	0.83	2.31	1.50	0.74	12.02*	7.42*	0.76	6787185.03*	13.11
Variety	2	18.10*	100.87*	33.65*	4.62*	18.99*	7.56*	2.59*	2650964.97	514.02*
Density	2	0.20	8.90*	10.61*	15.10*	204.96*	47.31*	57.18*	94178.27	59.14*
Year x Variety	2	0.81	0.11	0.34	0.20	0.98	2.65	0.41	2458422.75	13.23
Year x Density	2	0.43	6.49	10.27*	0.25	3.25	9.19	5.22*	1677249.30	7.58
Variety x Density	4	0.78	5.38	3.41	0.49	3.62	2.81	0.21	1622392.02	27.83*
Variety x Density x Year	4	0.41	2.15	1.22	0.36	3.58	2.07	0.50	1343698.75	24.92
Variety x Density x Year x Replication	47	0.41	2.75	2.81	0.79	3.48	2.19	0.67	1054838.71	9.39
Coef. of variation (%)		9.74	8.08	11.99	28.95	18.19	17.52	45.29	16.07	3.33

*: Significant at 5% level of probability

Table 2. *Duncan's Multiple Range Test (Alpha = 0.05)*

Table 2.1. *Levels of plant density.*

Density (plants/Ha)	Veg. nodes	Total nodes	Fruiting branches	Veg. branches	Bolls/plant	Bolls fruiting branches	Bolls vegetative branches	Seed Cotton yield (kg/ha)	Earliness (%1st picking)
100000	6.48	20.92 a	14.44 a	3.10 a	13.44 a	9.89 a	3.55 a	6342	93.85 a
175000	6.45	20.78	14.33 a	2.21 b	9.57 b	8.33 b	1.23 b	6369	92.15 a
250000	6.69	19.85 b	13.17 b	1.52 c	7.65 c	7.03 c	0.60 c	6469	90.30 b

Table 2.2. *Varieties.*

Variety	Veg. nodes	Total nodes	Fruiting branches	Veg. branches	Bolls/plant	Bolls fruiting branches	Bolls vegetative branches	Seed Cotton yield (kg/ha)	Earliness (%1st picking)
DP 5111	5.53 a	18.12 a	12.59 a	1.90 a	9.56 a	7.99 a	1.57 a	6553	97.12 a
DP 5690	6.84 b	21.14 b	14.30 b	2.20 a	9.95 a	8.25 ab	1.70 ab	6009	91.60 b
DeltaOPAL	7.20 b	22.21 c	15.01 b	2.74 b	11.21 b	9.05 b	2.16 b	6621	87.85 c

Table 3. *The effect of plant density on the number of bolls/plant and number of harvestable bolls/ha.*

Density (plants/ha)	Bolls/plant	Harvestable bolls/ha
100000	13.44 a	1,344,000
175000	9.57 b	1,674,750
250000	7.65 c	1,912,500

Table 4. *The effect of plant density on the earliness of cotton cultivars.*

Variety	Density level	Seed cotton yield (kg/ha)	Earliness (% 1st picking)
DP 5111	100000	6605.6	96.61 a
	175000	6023.8	97.85 a
	250000	7023.5	96.87 a
DP 5690	100000	5966.3	93.88 a
	175000	6433.8	92.13 a
	250000	5626.9	88.81 b
Delta OPAL	100000	6453.8	91.06 a
	175000	6648.8	86.48 b
	250000	6760.6	86.03 b
Prob > F		0.0626	0.0307

Table 5. *The average number of vegetative nodes and fruiting branches during 1999 and 2000.*

Year	Vegetative nodes	Fruiting branches
1999	7.08 a	13,14 a
2000	5.98 b	14,85 b

Table 6. The effect of plant density on vegetative nodes during 1999 and 2000.

Variety	Year	Density level	Vegetative nodes	Mean vegetative nodes by year
DP 5111	1999	100000	5,9	5,9
		175000	6,1	
		250000	5,8	
	2000	100000	4,9	5,1
		175000	5,4	
		250000	5,1	
DP 5690	1999	100000	6,9	7,4
		175000	7,7	
		250000	7,6	
	2000	100000	6,5	6,3
		175000	6,1	
		250000	6,3	
Delta OPAL	1999	100000	7,9	8
		175000	7,6	
		250000	8,5	
	2000	100000	6,8	6,4
		175000	6	
		250000	6,6	
Prob > F			0.41	0,81

Figure 1. *Daily average temperatures (°C) between planting and plant establishment.*