Influence of Irrigation and Plant Density on Cotton Yield in Southern Italy

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ABSTRACT

The effects of irrigation timing and plant density on the main morphological and agronomic characters of cotton were investigated over five years from 1987 to 1991 in Southern Italy. Five irrigation levels were combined with four plant densities (6, 9, 12 and 15 plants per m^2). Times and volumes of irrigation were determined by thermopluviometric patterns and the phenological plant phase. The highest seedcotton yields wee obtained with high plant densities and irrigation at each phenological stage. These results confirm the importance of optimum water management in southern Italy. Irrigation increased the open bolls per plant markedly while the boll weight number per plant decreased in correlation with plant density.

Introduction

The Ministry of Food, Agricultural and Forestry Resources started a research program on the "Possibilities of developing cotton production in southern and insular Italy" during the five-year period (1987-91) to obtain technical and economic data regarding the crop potentials. Many agronomic issues were studied, including fertilization, weed control, plant density, sowing time with and without mulching, defoliation, growth regulators and irrigation. Special emphasis was given within the project both to the irrigation technique that is essential for crop enhancement under the typical conditions of limited water supply in southern Italy and to all the agronomic problems related to water. The objective was to define the irrigation timing and water volumes to ensure optimal water supply at critical crop stages to maximize irrigation efficiency. Special attention was given to the choice of the optimal plant density as influenced by the variation in water supply.

Materials and Methods

Field experiments were conducted during five growing seasons (1987-91) in San Severo (Foggia), in the South of Italy (41° 21' N, 15° 33' E, 87 m a.s.l.) on a silty clay soil typical of the Mediterranean region, where cotton growing was quite widespread in the past. In the first two years, eight irrigation regimes were tested choosing times and water volumes according to the meteorological patterns and the growth stages. The design was a complete randomized block with four replications and plots of 20 m^2. In the following three years were reduced to six, based on the results of the two previous year's irrigation treatments. The cultivar used throughout was 'GSA 75'.

Irrigation regimes were obtained supplying water at the following stages:

1987 - 88	1989 - 91
S	S
SA	SA
SI	SI
SC	
SAI	SAI
SIC	
SAC	SAC
SAIC	SAIC

S = sowing; **A =** growth stage; **I** =start of flowering; **C** = bolls setting.

Starting from year three, a split plot design was used with four replications of the six irrigation treatments in the main plots and four plant densities (6 - 9 - 12 and 15 plants per m^2) in the subplots. At each watering the crop received 50% of the maximum evapotranspiration determined by the following formula:

$$ETM = \sum_{1}^{n} (E \bullet Kp \bullet Kc)$$

ETM = cumulative maximum evapotranspiration;
n = time interval between two successive watering;
E = daily evaporation rate from 'class A' pan;
Kp = conversion factor from E to the potential evapotranspiration (ETP) equal to 0.80;
Kc = crop coefficient varying with the crop growth stage.

Annual seed cotton yield, number of bolls per plant, plant height, bolls' weight, lint percentage were subjected to the analysis of variance and the means were compared using the Student Newman Keuls test.

Results

The results of experiments showed a beneficial effect of both irrigation, carried out from sowing to start of flowering, choosing times and water volumes varying

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according to the meteorological patterns and the growth stages, and plant densities on the morphological and reproductive characters. During the five growing seasons, the response of seed cotton yield to irrigation and plant densities varied as influenced by the prevailing weather conditions. The climate was quite unfavourable in the five-year period of the test because of an abnormal pattern of temperatures and very long drought periods (Fig. 1). In particular the five-year period was characterized by quite cool and dry springs and temperatures above the plurennial mean in the period of bolls setting.

Irrigation regimes were found to have a significant effect on seedcotton yield that increased progressively from the treatment in which irrigation was only applied at sowing (S). In general the highest increase of seedcotton yield was observed when irrigation was applied at the start of flowering (I).

Irrigation at the growth stage (A) seems essential to enhance yield. This is the case only when irrigation is applied at the start of flowering, as indicated by the results of both SAI treatments that showed the highest value of 3.40 t ha^{-1} in the two-year period 1987-88 and SAI, SAC, SAIC treatments in which the highest yields were obtained with values ranging between 2.34 and 3.15 t ha^{-1} in the three-year period 1989-91 (Fig. 2). As to irrigation timing the best yield results were obtained with seasonal irrigation volume ranging from 1.500 to 2.300 m^3 ha^{-1} (Table 1).

The earliness in ripening (assessed as percentage of the product obtained at the first picking) resulted to be affected by the number and time of water applications: it decreased as their number increased especially adopting late watering (Fig. 3). Some influence of the tested irrigation treatments is also observed on the morphologic characters. In particular plant height was affected by watering applied at the growth stage and at the start of flowering where the maximum values ranged between 65 and 81 cm.

Irrigation favoured a sharp increase in the number of bolls per plant with variations from 5 to 7 in the most irrigated treatment in the two-year period 1987-88 and from about 3 to 6 in the three-year period 1989-91 (Fig. 4). In this case also the positive effect of watering applied at the growth stage and at the flowering was evident. There is no significant influence of irrigation on boll weight which is influence more by years with values of 4.8 g in 1990 and 7.1 g in 1987 (Fig. 5).

The fiber characteristics were not affected by different irrigation regimes showing on average satisfactory values; the lint percentage was in average of 35.6 while some difference was found in less irrigated treatments that showed lower strength and higher micronaire values.

the number of plants per unit area is another agronomic factor requiring optimal combination with the irrigation regime. The experiments in the last three years was concerned with the combination of 4 plant densities (6 - 9 - 12 - 15 p/m^2) with different irrigation regimes. The analysis of seed cotton yields has shown an increase as the plant density increases. In particular, averaged over three years, the yield was 1.8 t ha^{-1} with a density of 6 p/m^2 and increased to 2.0, 2.3 and 2.6 t ha^{-1} respectively, with 9, 12 and 15 plants m^{-2} (Fig. 6). The interaction between plant density and irrigation regimes was quite poor although some influence was observed on earliness that was favoured as the density increased.

Among the morphologic characters, the plant height at harvest did not show any significant response to plant density although values tend to decrease as plant density increases (60.9, 61.4, 59.7, 59.0 cm respectively with densities of 6, 9, 12, 15 plants/m^2). Plant density also affected the number of boll per plant and the boll weight, showing higher values in the crop with the lowest density but this does not seem to compensate for the low number of plants in relation to production. The number of bolls per plant was 5.5 in the treatment 6 p/m^2 and decreased to 4.1 at the maximum density (Fig. 7). A similar trend was observed in the boll weight where the values decreased from 5.3 g at lowest plant density to 4.8 at the highest density. Neither lint percentage nor fiber quality were affected by plant density.

Conclusions

The results of the experiments showed:

- the positive effects on yield of irrigation carried out from sowing to start of flowering, choosing times and water volumes that varied according to the meteorological pattern and the growth stages;
- the beneficial effects of irrigation at start of flowering and during flower formation-;
- a seasonal irrigation volume ranging from 1.500 and 2.300 m^3ha^{-1} gave the best yield response;
- the need to avoid irrigation after fruit setting so that crop maturity is not delayed;
- the positive effect of higher plant densities;
- the limited influence of the experimental treatments on lint quality.

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Table 1. Seasonal irrigation volumes.

Irrigation Tmt.	$m^3\ ha^{-1}$				
	1987	1988	1989	1990	1991
S	500	500	230	300	250
SA	1200	970	530	663	850
SI	1280	1130	1150	1111	1390
SC	1300	1250			
SAI	1500	1450	1300	1610	1690
SIC	1900	1680			
SAC	1950	1800	1600	1304	1500
SAIC	2700	2400	2250	2252	2340

Figure 1. Meteorological trends.

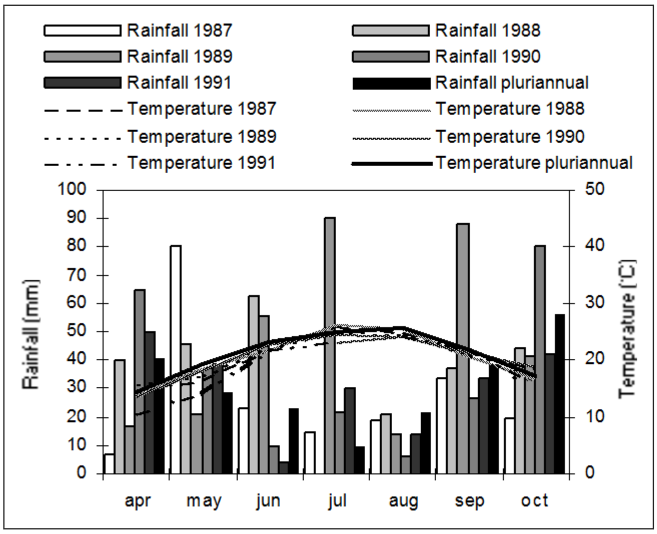

Figure 2. Influence of irrigation timing on seedcotton yield.

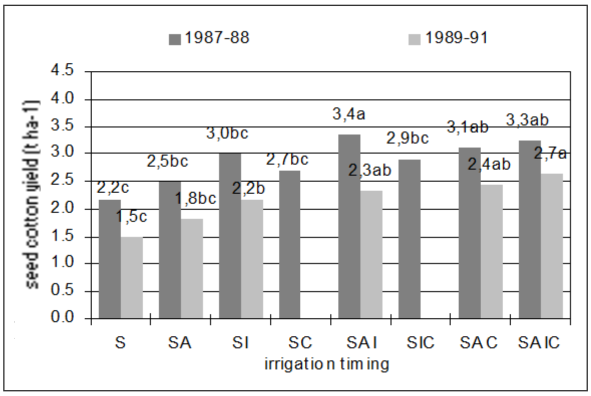

Figure 3. Influence of irrigation timing on earliness.

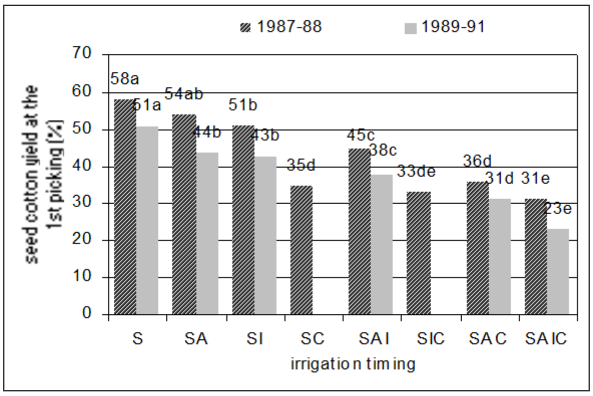

Figure 4. Influence of irrigation timing on bolls per plant.

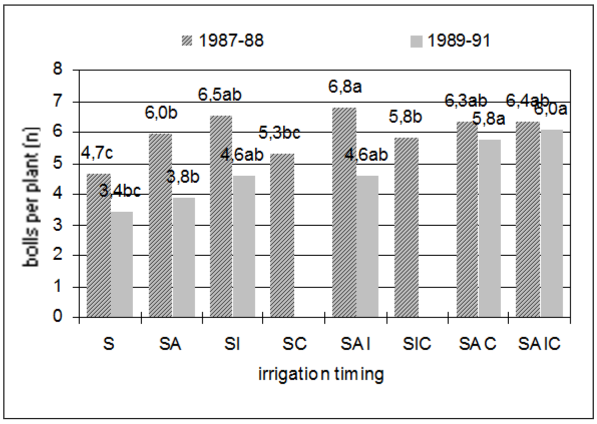

Figure 5. Influence of irrigation timing on boll weight.

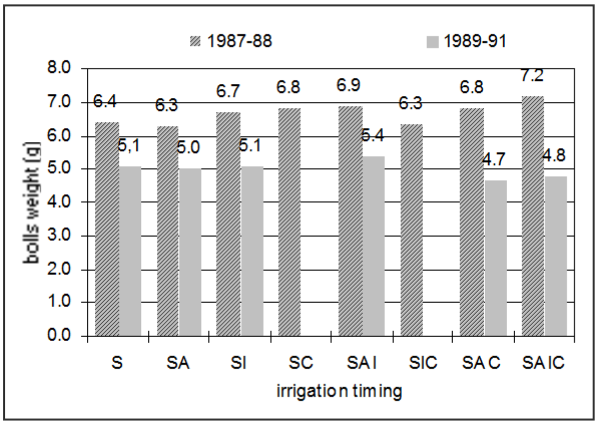

Figure 6. Influence of plant density on seedcotton yield.

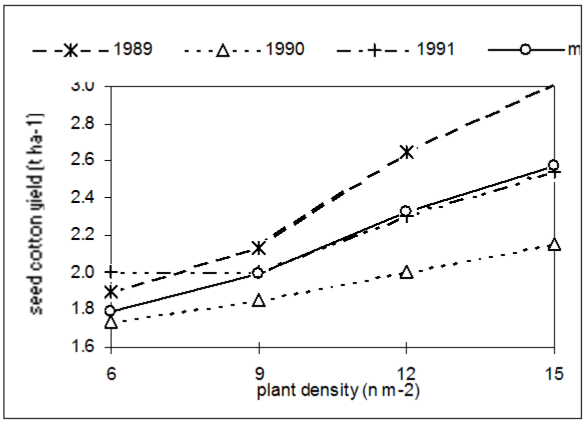

Figure 7. Influence of plant density on bolls per plant