PROGRESS OF CERCOSPORA LEAF SPOT IN COFFEE UNDER DIFFERENT IRRIGATION MANAGEMENT SYSTEMS AND PLANTING DENSITIES

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ABSTRACT: Irrigation and density are practices that change the microclimate of the crop and affect the incidence of light, temperature and relative humidity and, thus, the intensity of diseases in coffee. Therefore, quantifying the influence of these practices on disease progress is useful in making decisions regarding their appropriate management. This study evaluated the effect of different planting densities and irrigation management practices on the incidence and severity of Cercospora leaf spot on adult coffee plants, and irrigation and planting density practices were related to progress of the disease and plant leaf development. A randomized block experimental design was used with four replications in a split-plot arrangement. The treatments consisted of four planting densities located in the plots (conventional and dense): 2500 (4.0 x 1.0 m), 3333 (3.0 x 1.0 m), 5000 (2.0 x 1.0 m) and 10,000 (2.0 x 0.5 m) plants.ha^{-1}, and four irrigation management practices (split-plots), which were: irrigation when soil water tension reached values near 20kPa; irrigation when soil water tension reached values near 60 kPa; irrigation management using the climatic water balance (calculated by the software Irriplus); and a control without irrigation. Each row in the split-plot consisted of 10 plants, with the six center plants being considered as useful. It was found that irrigation management influences the incidence of Cercospora leaf spot and leaf formation; in non-irrigated plants the incidence of Cercospora leaf spot was 30% greater than in the irrigated managements. The foliage had values close to 1000 as the area under the disease progress curve. In regression analysis of the area under the severity and incidence progress curve, the quadratic model gave the best fit, with the following equations: $y=0.000004x^2-0.0137x+192.05$ ($R^2=0.6901$) and y=0.000014x2-0.4048x+5943.7 ($R^2=0.6086$), respectively. The minimum value of the area under the severity progress curve was obtained when using a density of approximately 7500 plants per hectare. The maximum value was obtained when using the density of 1712.5 plants per hectare. For the area under the incidence progress curve, similar results were obtained. High planting density systems of 10,000 plants/ha and 5,000 plants/ha reduced the incidence of Cercospora leaf spot by 35% and 31.5%, respectively. Planting density did not affect leaf development.

Index terms: *Cercospora coffeicola*, Epidemiology, Plant Pathology, *Coffea arabica.*

PROGRESSO DA CERCOSPORIOSE DO CAFEEIRO SOB DIFERENTES MANEJOS DE IRRIGAÇÃO E DENSIDADES DE PLANTIO

RESUMO: *A irrigação assim como o adensamento são práticas que alteram o microclima da cultura, as quais interferem na luminosidade, na temperatura e na umidade relativa do ar e, por consequência, na intensidade de doenças no cafeeiro. Por isso, quantificar a influência dessas práticas no progresso das doenças torna-se útil na tomada de decisão sobre o seu manejo adequado. Avaliou-se, no presente trabalho, o efeito de diferentes densidades de plantio e manejos de irrigação na incidência e na severidade da cercosporiose em cafeeiros adultos e relacionaram-se manejos de irrigação e densidades de plantio ao progresso da doença e enfolhamento da planta. O delineamento experimental foi em blocos ao acaso, com quatro repetições, em esquema de parcelas subdivididas. Os tratamentos foram constituídos por quatro densidades de plantio localizadas nas parcelas: 2.500 (4,0 x 1,0m), 3.333 (3,0 x 1,0m), 5.000 (2,0 x 1,0m) e 10.000 (2,0 x 0,5m) plantas.ha*$^{-1}$ *e quatro manejos de irrigação (subparcelas), sendo: irrigação quando a tensão da água no solo atingiu valores próximos a 20kPa; irrigação quando a tensão da água no solo atingiu valores próximos a 60kPa; : irrigação com a utilização de manejo do balanço hídrico climatológico (calculado por meio do software Irriplus) e uma testemunha não irrigada. Cada linha da subparcela foi constituída por 10 plantas, sendo consideradas como plantas úteis as seis centrais. Verificou-se que os manejos de irrigação influenciaram a incidência da cercosporiose e o enfolhamento, sendo que, em plantas não irrigadas a incidência da cercosporiose foi 30% maior, que os manejos irrigados. Quanto ao enfolhamento verificou-se que os tratamentos 20kPA e 60 kPA foram 9% e 5% maior comparado ao tratamento não irrigado. O aumento mais expressivo no enfolhamento foi obtido quando empregado o manejo do balanço hídrico com um valor 13% maior que a testemunha. Na análise de regressão da área abaixo da curva do progresso da severidade e incidência, o modelo quadrático obteve o melhor ajuste, tendo as equações* $y=0,000004x^2-0,0137x+192,05$ ($R^2=0,6901$) *e y=0,000014x2-0,4048x+5943,7* ($R^2=0,6086$)*, respectivamente. O valor de mínima para área abaixo da curva do progresso da severidade foi obtido quando utilizada uma densidade de 7500 plantas por hectare aproximadamente. O valor de máxima foi obtido quando empregada a densidade de 1712,5 plantas por hectare. Para a área abaixo da curva do progresso da incidência foram obtidos resultados semelhantes. Os sistemas de plantios adensados, 10.000 plantas/ha e 5.000 plantas/ha, reduziram a incidência da cercosporiose em 35% e 31,5%, respectivamente. As densidades de plantio não interferiram no enfolhamento.*

Termos para indexação: *Cercospora coffeicola, Epidemiologia, Fitopatologia, Coffea arabica.*

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1 INTRODUCTION

Irrigated agriculture is expanding in promising regions, limited by low annual precipitation or poorly distributed rainfall. Even in regions climatically suitable for the cultivation of coffee, such as the South of Minas Gerais, the supplementary irrigation, due to the effect of prolonged droughts in critical periods of water demand (FARIA; REZENDE, 1997). The coffee tree, in order to vegetate and fruitful needs moisture available in the soil for the period from September/October to April/May, seasons that coincide with the flowering until the filling of beans (SANTINATO et al., 1988). Three phenological stages of coffee tree are critical concerning hidric need: fruit development stage (October to December) – severe hidric deficit delays fruit growth, resulting in low screens, and reduces productivity; graining stage (January to March) – hidric deficit affects fruits' graining, increases empty locule and reduces productivity; maturation stage (April to June) – hidric deficit does not affect already formed fruits ripening or year production, however, affects the budding and fruit formation the following year (CAMARGO, 1985; FARIA; REZENDE, 1997).

With the need to improve yields and to obtain economic returns faster in coffee, there is used the practice of high density planting, based on a larger number of plants per hectare or stems for better utilization of the area (CARVALHO; CHALFOUN, 1998). Both irrigation and densification are practices that alter the culture's microweather, which interferes in lighting, temperature, air relative humidity and, consequently, affects the diseases intensity (MIRANDA, 2006; TALAMINI et al., 2001, 2003).

Blotch, caused by the fungus *Cercospora coffeicola* Berk & Cooke, is one of the oldest coffee tree diseases. The disease is even more important since it is a problems from the seedling in the greenhouse all the way to the field. In greenhouses the disease causes defoliation, which affects the growth of the seedlings, making them rickety and not adequate for planting. In crops implanted in low fertility terrains or with unbalanced fertilization, the disease causes empty locule beans and premature fall of affected beans. The wounds are also a possible entry spot for other fungi that lower the beverage quality (MATOS et al., 2006).

According to Carvalho, Cunha and Chalfoun (2005), the disease causes severe damages, which reflects in losses from 15% to 30% in coffee productivity. To know the epidemiology of the disease and weather influence, conduct proper irrigation management, correctly choosing planting densities and understanding favorable interactions to disease progress allow to know its maximum intensity throughout the year, the periods in which it tends to grow or decrease and progress stabilization periods of the disease.

Weather conditions (temperature, humidity and insolation) and factors connected to plant nutrition (hidric deficit, sandy or compacted soils and nutritional unbalance) have direct or indirect effect over blotch occurrence (CARVALHO; CHALFOUN, 1998). Infection of *C. coffeicola* is more intense under full sun exposure and with nutritional deficiency. As for densely shaded coffee trees, incidence of blotch is lower than in coffee crops that are not subjected to intense shading (CUSTÓDIO et al., 2010; POZZA et al., 2001). Santos, Souza and Pozza (2004) found evidences in association between hidric deficiency and blotch progress in coffee trees irrigated by dripping where they observed that the higher values of blotch incidence was in non-irrigated parcels, while in irrigated parcels the incidence on leaves and fruits was higher when smaller irrigation blades were applied.

The objective of the present study was to evaluate the effects of different planting densities and irrigation managements in incidence and severity of blotch in adult coffee trees and relate the disease progress with plant's leafing.

2 MATERIALS AND METHODS

The work was conducted in a research area of the Lavras Federal University (Universidade Federal de Lavras, em Lavras, MG). the area is located at 910m of altitude, in the coordinates 21°14' South latitude and 45°00' West longitude. The region presents Cwa type weather, according to the Koppen rating, with average temperatures, rainfall and relative humidity of 19,4°C, 1.529,7mm and 76,2%, respectively (BRASIL, 1992).

The crop planting was performed using healthy coffee tree seedlings, cultivar Rubi MG-1192 (*Coffea arabica* L.), sensitive to blotch. The soil was analyzed for their physicochemical and water characteristics for the installation of field culture.

From the fifth year after planting, fertilization was made by fertirrigation (injecting pump), divided into four parcels (October-January), the four production systems. The controls received conventional fertilizer without irrigation. Micronutrients were supplied via foliar fertilization, according to the levels observed in the nutritional analysis.

The experimental design was a randomized block with four replications and the treatments arranged in a split plot. The four planting densities were found in the plots and the three techniques of irrigation management and irrigated controls were not distributed at random subplots, totaling 16 treatments. Each row of subplots consisted of 10 plants, useful plants being considered as the six central plants.

Treatments had three irrigation management techniques: not irrigated control (T1); irrigations during the entire year when ground water tension reached values close to 20kPA (T2); irrigations during the entire year when ground water tension reached 60kPA (T3) and irrigation by climatological hidric balance management using software Irriplus, with fixed irrigation shifts three times a week (T4). These treatments were studied effectively in four planting densities (conventional and densed): (i) 2.500 plants/ha (4,0 x 1,0m), (ii) 3.333 plants/ ha (3,0 x 1,0m), (iii) 5.000 plantas/ha (2,0 x 1,0m) and (iv) 10.000 plants/ha (2,0 x 0,5m).

Irrigation system had a central control unit (pumping system, sand and screen filter, fertilizer injector, manometers and connections), PVC main tube line, PN 80, PVC derivation lines, PN 40, sidelines with flexible polyethylene tube, PN 40, drippers and valves. The system was periodically assessed for water distribution uniformity. Irrigation for each treatment in each density was controlled by valves, referring to the four repetitions for each treatment.

Ground humidity was indirectly monitored by digital tensiometers installed at depths of 0,10; 0,25; 0,40; and 0,60m. irrigation of each subplot occurred when water tension reading at 0,25m indicated irrigation tension related to that treatment. The correspondence between ground water tension and humidity was obtained by specific ground humidity curves, determined in laboratory for the different considered depths. The tensiometers were placed in the plants row approximately 0,10m away from the base of the stem in two of the four repetitions, representative in the experimental area. Irrigation blades were calculated considering the readings received by tensiometers, in the four installation depths. As for the climatological hydric balance management, the necessary weather data were monitored daily, using an automatic weather station µMetos□, installed in the experimental area. Irrigations were performed in fixed shifts of two and three days a week. The Kc values were adapted to the different production systems, according to the recommendations by Santinato and Fernandes (2002).

After that, the Kc values were altered taking into consideration the shaded area percentage, according to trimester evaluations on plant's crown projection diameter and standardizing for every density with a single value, aiming the framework pruning and cleavage operations performed on the crops.

The diseases' evaluations were performed every two weeks in all irrigation treatments and in the four production systems. The analyzed variable was the incidence and severity of blotch on coffee tree, in a total of 16 assessments. Six leaves per plant were analyzed, in the third or fourth pair of leaves from plagiotropic branches randomly marked in the medium third of the plant, placed on the North side. The useful parcel was of six plants and samples were not destroying, being assessed 36 leaves per parcel. The blotch incidence was determined based on the quantification of leaves with presence of lesions compared to the total number per parcel. The severity or percentage of lesion area was determined using diagram scales for blotch (FERNANDES et al., 1991).

With the objective to verify the disease effect in culture leafing, assessments were performed with average breaks of 30 days, in a total of 8 assessments. The plagiotropic branches, whose leafing were assessed, were marked with ribbons on the third pair of leaves. For each assessment, the number of pairs of leaves was counted from the ribbons. The data were transformed, graphically represented and compared to the incidence and severity of disease.

The incidence and severity data of blotch on coffee leaves, as well as the leafing data, obtained during the evaluation period were transformed in area below the progress curve, according to the equation proposed by Shaner and Finney (1977).

$$\text{AACPD(E)} = \sum_{i=1}^{n-1} [(X_i + X_{i+1})/2][(t_{i+1} + t_i)]$$

In which: AACPD(E) = area below disease or leafing progress curve; X = disease intensity (leafing); t = time and n = number of assessments in time.

With the AACPD and AACPE levels, variance statistic analyses were performed and the average grouping test (SCOTT-KNOTT, 1974), at 5% de probability. Also, there were regression analyses of the area below the severity progress curve and the area below the incidence progress curve for the different planting densities.

3 RESULTS AND DISCUSSION

The results concerning the area below the severity progress curve (AACPS) and incidence (AACPI) of blotch on coffee tree did not demonstrate significant effect ($P<0.05$) of the interaction planting density versus irrigation management. Thus, such factors were considered independent in the analysis of observed data.

The variance analysis results showed significant difference ($P>0,05$) on the effect of coffee crop systems studied over the area below the incidence and severity progress curves of blotch on coffee trees (Figure 1). Blotch severity was of 36,2% and 33,9% lower on densed crop systems of 10.000 and 5.000 plants/ha, respectively, when compared to traditional system.

The results confirm that, in densed planting systems, shading of a plant over another lowers blotch occurrence.

The minimum densing ratings associated to the lower area below the incidence/severity progress curve is of approximately 7400 plants/ha. The lowering of blotch incidence by shading has been emphatized by Custódio et al. (2010), Nataraj and Subramanian (1975) and Santos et al. (2007). According to several authors (CARVALHO; CHALFOUN, 1998; TALAMINI et al., 2003), the main causes for aggravated blotch intensity are hidric deficit associated to nutritional deficience or unbalance. Full sun coffee would be more sensitive to blotch due to the photoactive pigment cercosporin, produced by some isolates of *C. coffeicola* and considered a toxin (DAUB; EHRENSHAFT, 2000).

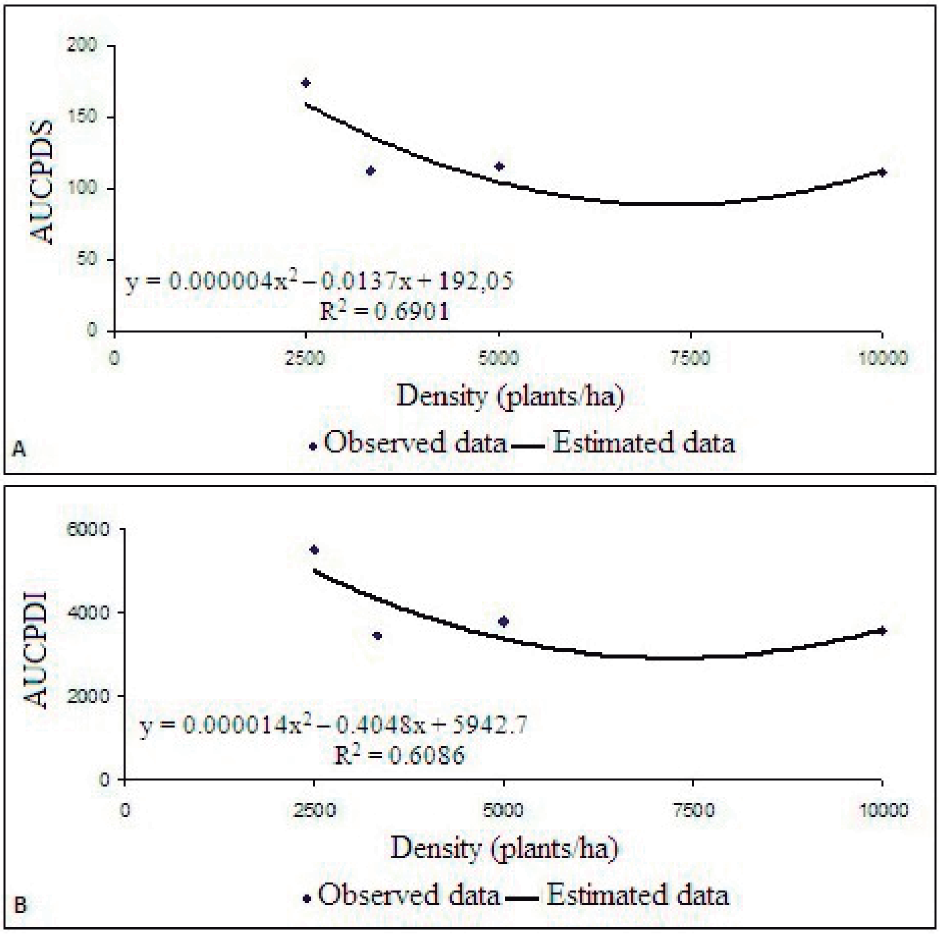

FIGURE 1 - Area below the disease progress curve, in different crop densities: (A) area below the severity progress curve for blotch (AACPSC) and (B) area below the incidence progress curve for blotch (AACPIC) on coffee trees, in different planting densities.

In densed system, in which the soil can remain wet longer, coffee tree would absorb water and nutrients for a longer period, easing hidric stress and nutritional conditions favorable to blotch fungus. In densed systems, incidence and severity kept low throughout the assessments after reaching their maximum values in March and April (Figures 2 and 3) with incidences close to 30%. Non-densed crops showed the highest values of blotch incidence during most of the evaluated period.

Besides shading, the higher water and minerals availability in densed system, suggested by Pavan, Chaves and Androcioli Filho (1994), might have limited the blotch occurrence, since the nutritional unbalance or deficiency on coffee plants favors the disease incidence (FERNANDEZ-BORRERO; MESTRE; DUQUE, 1966). Blotch needs insolation excess and higher temperatures so that the fungus' spores may germinate, occurring at 30°C and also for its growth, at 24°C (ZAMBOLIM et al., 1997).

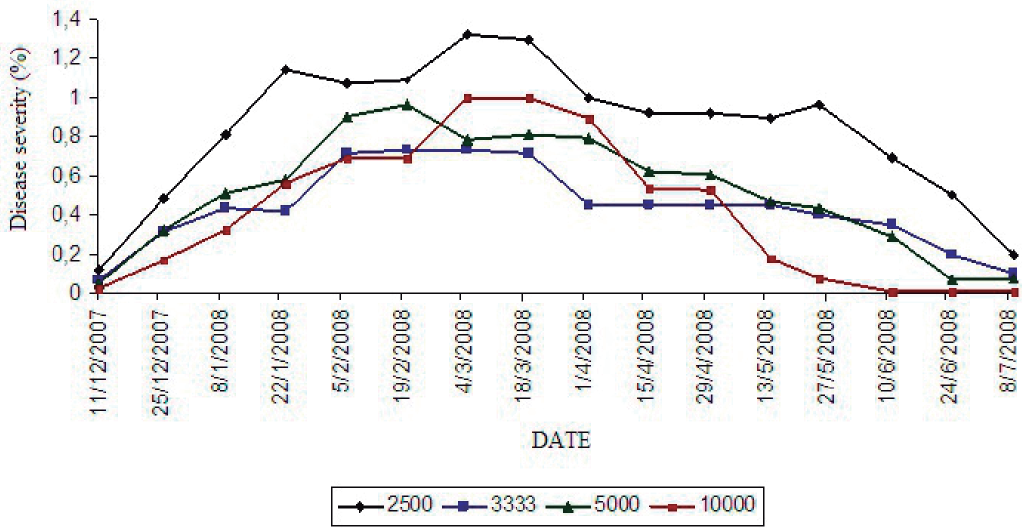

FIGURE 2 - Blotch severity progress curve in different crop densities, in the period from December 2007 to July 2008.

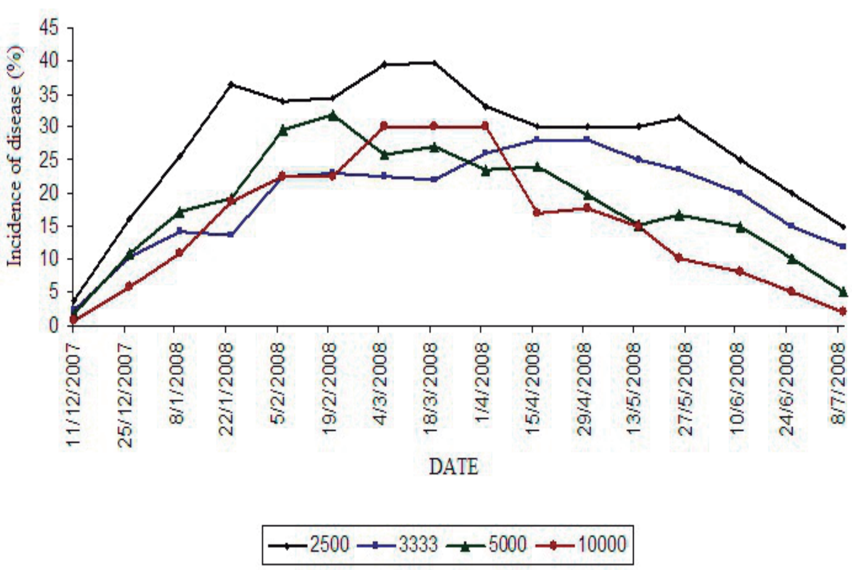

FIGURE 3 - Blotch incidence progress curve in different crop densities, from December 2007 to July 2008.

The results related to the area below the severity and incidence progress curves for blotch on coffee trees showed that there was significant difference (P<0,05) for irrigation managements, when compared to irrigated coffee crops. That could be explained by the difficulty of nutrients absorption by the plant due to hydric deficit (Figures 4 and 5). Irrigated crops had average reduction of the area below the severity and incidence progress curve of 39% and 34%, respectively, when compared to non-irrigated crops.

Blotch incidence and severity irrigated by different managements or non-irrigated remained high between January and May (Figures 6 and 7). Maximum incidence was reached by non-irrigated coffee trees, with levels close to 30% (Figure 7). Santos et al. (2008), when working with the progress of the disease on organic and conventional systems, verified that the maximum incidence occurred in July. The irrigated crops showed the lowest blotch incidence values during most of the evaluated period.

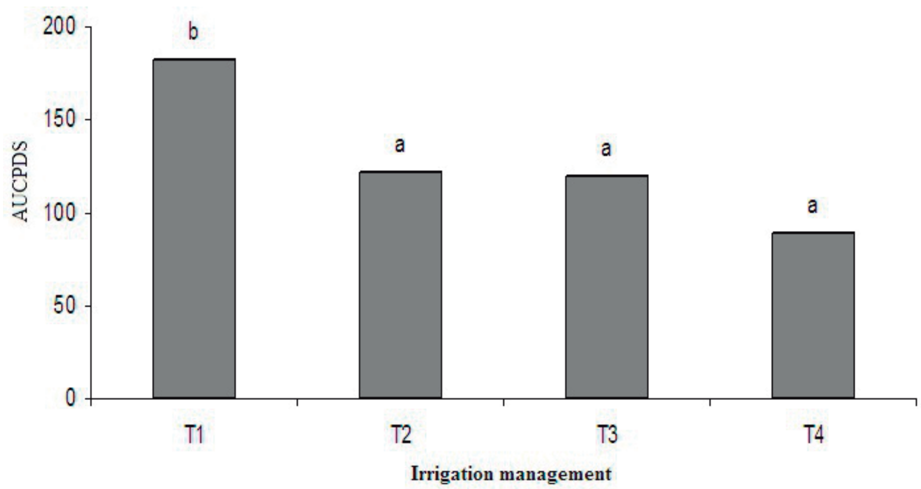

FIGURE 4 - Area below the blotch severity progress curve (AACPSC) on coffee crops subjected to different irrigation managements: (T1) non-irrigated plants, (T2) and (T3) irrigated when ground water tension reached values of 20kPA and 60kPA, respectively, and (T4) irrigated using weather hidric balance management (Calculated by Irriplus software).

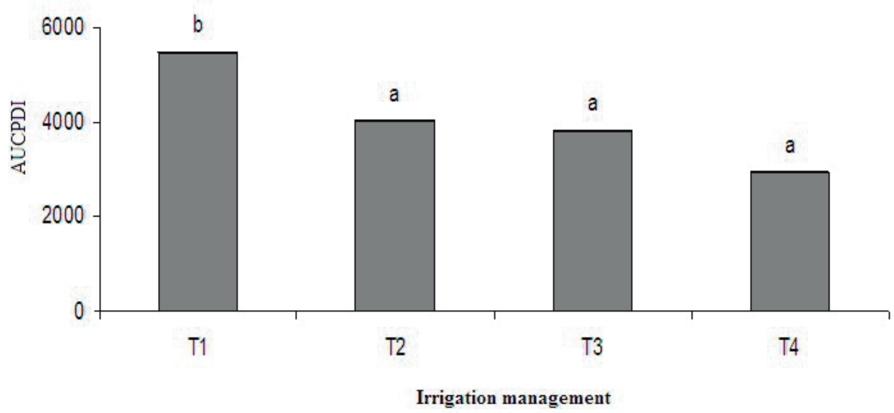

FIGURE 5 - Area below the blotch incidence progress curve (AACPIC) on coffee crops subjected to different irrigation managements: (T1) non-irrigated plants, (T2) and (T3) irrigated when ground water tension reached values of 20kPA and 60kPA, respectively, and (T4) irrigated using weather hidric balance management (Calculated by Irriplus software).

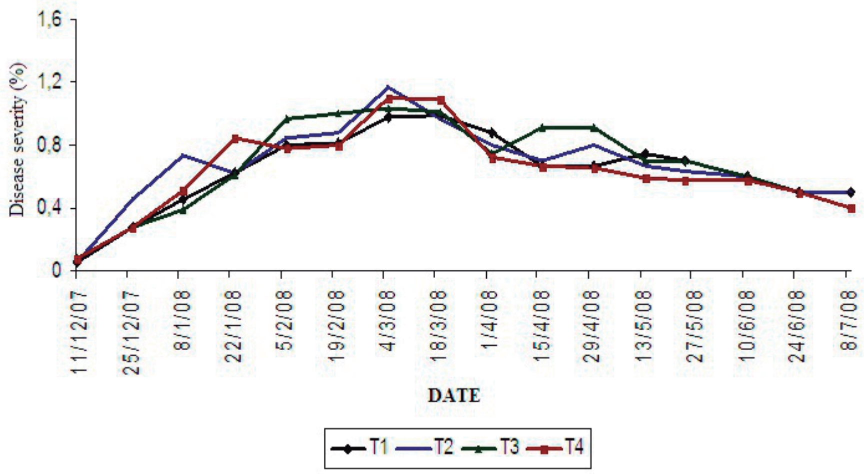

FIGURE 6 - Severity progress curve of blotch on coffee crops subjected to different irrigation managements: (T1) non-irrigated plants, (T2) and (T3) irrigated when ground water tension reached values of 20kPA and 60kPA, respectively, and (T4) irrigated using weather hidric balance management (Calculated by Irriplus software).

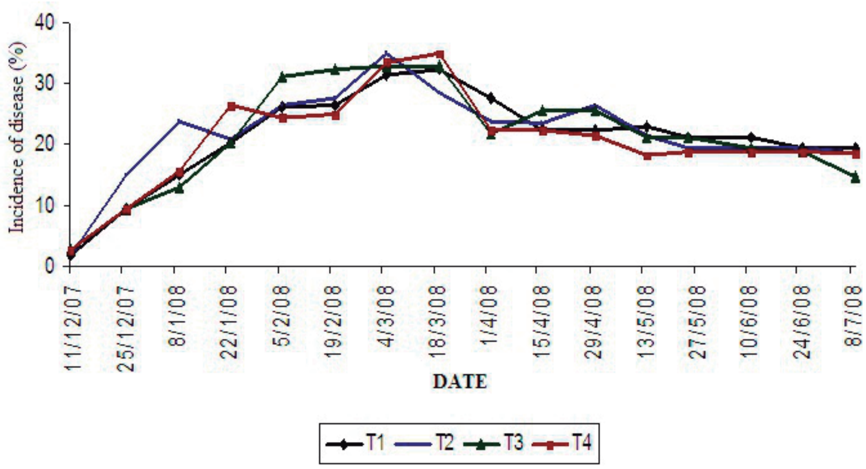

FIGURE 7 - Incidence progress curve of blotch on coffee crops subjected to different irrigation managements(T1) non-irrigated plants, (T2) and (T3) irrigated when ground water tension reached values of 20kPA and 60kPA, respectively, and (T4) irrigated using weather hidric balance management (Calculated by Irriplus software).

According to Coelho et al. (2009),irrigation fulfills the plants' water needs, as well as it improves the nutrition related aspects. Leaf increasing propitiated by irrigated system changes the microweather on the air part of plants, for it keeps humidity and, therefore, reduces the inoculation potential of blotch. Santos (2002), in an experiment relating irrigation blades levels and blotch incidence, reported that the higher levels of the disease were observed for non-irrigated parcels, indicating a positive influence in the water availability for the plant in disease incidence reduction.

Before the observed results, it is expected that densed systems make water available for the coffee trees a longer period due to the lower ground incident radiation and lower evaporation, as well as the natural capacity of plants to intercept rain water, thus showing more infiltration, which lowers superficial flow and increases ground water retention.

According to the observed weather data, the highest blotch levels were observed when the higher radiation (W/m2) levels were observed and the lowest relative humidity levels (Figure 8).

Santos et al. (2008) reported that the larger volume and better rainfall distribution favor the pathogen, propitiating humidity for conidia germination and contribute for inoculum dispersion. Carvalho, Cunha and Chalfoun (2005) also reported that the disease is favored by high relative humidity, mild temperature, insolation excess and hidric stress.

Even though crop densities have not influenced leafing, irrigation managements interfered as much as in leafing as in blotch incidence (Figure 9). The area below the leafing progress curve was higher for irrigated coffee crops, which could be due to higher nutrient absorption by the plants under such conditions. Less leafing was registered by non-irrigated plants. Coffee trees that received irrigation when ground water tension reached 60kPA and 20kPA had increases of 5% and 9% in leafing, respectively. The highest coffee tree leafing was observed when irrigation was performed using the hydric balance management (calculated by software Irriplus) with a 15% increase. The area below the disease progress curve was higher for non-irrigated crops, thus the authors suggest that water unavailability can compromise the nutrient catchment by the roots, therefore making it more sensitive.

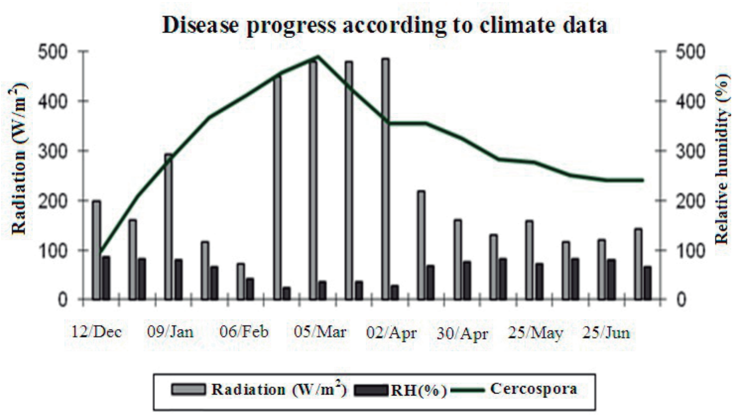

FIGURE 8 - Relation between blotch incidence progress curve and weather data radiation (W/m^2) and relative humidity (%). Source: Lavras Federal University weather station (Estação meteorológica da Universidade Federal de Lavras - 21º14'30'' S and 45º00'10'' W).

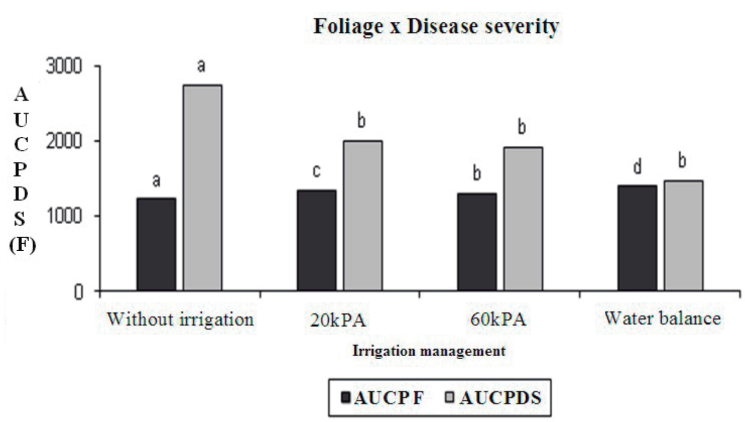

FIGURE 9 - Leafing and blotch severity over irrigation managements. AACPD – area below the disease progres curve. AACPSC - area below the blotch severity progress curve.

4 CONCLUSIONS

Densed planting system with 7500 plants/ ha reached minimum levels for the area below the blotch severity and incidence progress curves. Blotch incidence and severity were also lower for the systems of 10.000 plants/ha and 5.00 plants/ ha with reduction of 35%; 31,5% and 36,2%; 33,9% respectively, compared to the 2.500 plants/ ha system.

Crop densities did not interfere in leafing.

Irrigation management interfered on the area below the leafing progress curve with an increase of 13% when managed based on hidric balance was used.

The lowest values for the area below the severity and incidence progress curves for blotch were obtained when plants were irrigated by the weather hydric balance management.

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