Wet Bulb and Effective Area of Absorption of Nutrients in Coffee: A Review Article

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Abstract: The coffee production is a prominent activity on the national scene and even international and in this context, irrigation contributes to the maintenance of that highlight and increased production. Localized irrigation system has been used in coffee production to maintain the productivity of coffee plant, due to its timely application of water, bringing a savings to the producer, which is associated with these systems the fertigation technique. The various studies show the importance of the wet track and its relationship with the root development of the coffee plant, bringing with him important aspects for the management of the coffee tree. Within these aspects of irrigation management is advantageous location in relation to other systems for providing water in the root zone of the coffee tree, providing little variation in soil moisture during a period, moreover, through the technique of fertigation supplies nutrients necessary for coffee located, promoting greater efficiency in the absorption and utilization of nutrients by plants.

Key words: Localized Irrigation • Fertigation • Wet Area of Soil • Root System

INTRODUCTION

The productivity of coffee production in recent years has been increasing gradually, due to managements as: fertilization, pruning, weed control, renewal of crops with varieties with greater productive potential and use more pronounced of technologies associated with the irrigation [1].

The irrigation water is a new input to the Brazilian coffee, available in virtually every agricultural properties. Its rational use could provide a leap in productivity in small, medium and large coffee-growing holdings, by its own action, by providing the nutrients in the soil and to conduct necessary fertilizers and pesticides to crops.

The Conilon coffee has been normally irrigated with pressurized systems of type sprinkling and dripping. Among the existing irrigation systems are conventional irrigation, sprinkler fixed, drip and center pivot [2].

In the case of irrigation sprinkler wet the entire project area, therefore, the percentage of wet area (PM) is 100%, therefore (PM/100) = 1. Localized irrigation already comprises the application of water in just a fraction of the acreage, high-frequency and low-volume, keeping the soil in the root zone of plants close to field capacity. The area of wet soil exposed to the atmosphere is well reduced and, consequently, is less water loss by direct evaporation from the soil. Water applied by these systems penetrates the soil and if it redistributes forming a wet bulb, whose shape and size depend on the applied flow, the type of transmitter, the duration of irrigation and soil type [3].

Other factors influencing the wet bulb dimensions are: structure and texture of the soil, irrigation system, the transmitter height from the ground, initial moisture of the soil and the presence of concretions and gravel [4-6]. The overestimate of the percentage of wet soil reduces the efficiency of the system charge from the oversizing hydraulic structure to the waste of water, energy and fertilizers; while under-estimating may result in risks to culture stress and promote the bad distribution of root system [7].
Reliable information about the dimensions of the bulb in contact with soil under drip irrigation helps determine the optimal flow transmitters and spacing to reduce the costs of system equipment and offer better conditions of water in the soil to the more efficient use of water and fertilizers [8].

The bulb or damp soil volume is the distribution of water in drip wet volume; it is also an indispensable tool in determining how and when to irrigate [9]. There is a need for a robust approach, yet easily implemented, to calculate and show the default damping from drip irrigation systems to assist in the management of the system [10]. Due to specificity of soils, all adjusted tables are not always suitable for soils of Brazil, making essential studies that characterize [9].

In addition to the study of the characteristics of wet bulb formation, another important aspect for the management of irrigation is the root development of the coffee tree, since this factor is directly related to the calculation of the actual irrigation of culture. Relationship brings some questions, such as how deep effective root of the deployed today in the coffee crops in production, the calculation of the actual irrigation necessary has been met for coffee in order to provide a wet bulb formation in root zone effective culture.

Soares et al. [11] evaluated the influence of percentage of wet area (PAM) soil on production and distribution of root system of the coffee tree in Patrocínio-MG found that increasing the PAM provided better distribution of root system, as the distance from the stem. In the irrigated treatments, the root system had better distribution in the lateral direction. In the treatment with PAM equal to 30% wet track was 1.2 m and the effective depth of root system was of 0.60 m, which was done the water balance and had a concentration of 90% of the roots in the ground portion equivalent to the wet track. In the treatment with PAM equal to 50%, in which the wet track was of 1.8 m and the effective depth 60 cm was 80%, of the roots were found on the ground portion equivalent to the wet tracks, showing that the best development conditions promoted irrigation of root system in the horizontal direction.

Most work with the Rena and Guimarães [12], Partelli et al.[13] e Silva and Martins[14], show that much of the root system of the coffee plant is in layer of 0.00-0.20 m, whereas the majority of producers use depths of 0.25 to 0.35 m for the management of their irrigation in coffee, to conclude that for several times the farmer you're wasting water, since effective roots of plants are in more superficial layers of the soil, besides using a longer irrigation, whereas as depth increases, also increases linearly real irrigation required and total and the irrigation time.

**Influence of Soil Type on the Wet Bulb:** The knowledge of the particle size distribution of solid particles of the soil is essential for various applications, such as in the analysis of quality, study on compaction and water movement in the soil, the availability of water, aeration, soil conductivity to air, to water and heat [15,16]. The soil texture second Scheinost et al.[17], is the primary factor among several that affect the retention of water in the soil, because it determines the contact area between water and solid particles, determining that the accommodation of the particles and the distribution of pores. Klein et al. [18] also report that the main factors that influence on retention and availability of water to plants are the texture and soil structure. The wet bulb is formed from a punctual source of ground water that propagates three-dimensionally through front of wetting [6]. Already Kandelous et al. [19] studied the distribution of water content between two transmitters, with overlapping, in a subsurface drip irrigation system, the authors concluded that the system can be described by a two-dimensional model just before the wet bulb overlap occurs and from then on would require a three-dimensional model. Second Subbaiah [10] found that the flow of water under drip irrigation is more complex, since the water is applied from issuers and each transmitter, the water spreads out in all directions. Such behavior is in sharp contrast with the geometry and dynamics of volume of wet soil under sprinkling irrigation when the total area of the surface of the soil is wet and the vertical distribution of water content in the soil is essentially constant [20]. The knowledge of the dimensions of the wet bulb has importance for the determination of depth and maximum width in planning of irrigation, thus preventing water loss by leaching and exaggerated overlay the emitters. The agronomic point of view, the dimensions of the bulb are useful to determine the volume of wet soil for irrigation, where are concentrated plant roots. In addition, the knowledge of these dimensions is also useful in calculations of water slide to be applied and the amount of nutrient in the wet volume, being fundamental to the program of fertigation [21-22]. In clay soils, due to the lower rate of infiltration, it turns the bulb formation with greater horizontal dimension, explained by greater influence of capillarity on gravity. In soils with stratified layers, there are layers with different porosities, affecting the flow and water retention and, consequently, the wet bulb. This implies that, when the front of wetting reaches...
layers of different textures, these acts as a barrier, especially in soils that exhibit textural gradient in the soil profile. For different flows and emitter for same time, minor irrigation flows will tend to form wet bulbs deeper, less superficial radius; already for the same flow rate higher the issuers irrigation time, the greater the surface radius [23]. Taking into consideration the average wet volume for different combinations of flow and while, Maia [21] noted that the average volume was higher than in the Argisols, being followed by Cambisols and Neossolo Quatzarêntico, which showed approximately 87% Argisol volume. After these, the latosol appears Luvisolo and Neossolo Flúvico, with 81, 77 and 40% Argisol volume. In Luvisolo Háplico in addition to spacing between transmitters, the effective depth and width of the wet soil volume and water content at field capacity are more important than just the volume of wet soil. An increase in the total amount of water in the soil contributes more to an increase in the wet depth than an increase in diameter wet.

In addition, incorrect irrigation practices can cause serious and permanent damage to the environment, since the increased flow of transmitters above the recommended causes the water which flows out take down not only the fine particles of soil, but also nutrients that, in some cases, can cause soil contamination [24]. The experimental investigations show that in fine texture horizontal and vertical extension of the wetting front moves with velocity approximately equal. But in coarse textured soils, vertical speed component of front of wetting is greater than the horizontal component, which causes the percolating is deeper in such soils under water application point [25]. Phogat et al. [26] report that dampened volume changes also depend on both the flow and soil properties. From the analysis of the different numerical experiments, it is concluded that, for the same depth of drip irrigation and soil, spacing the vertical component of the wet zone is deeper to a slower discharge rate than for a faster. This is in line with the conclusions of Bresler et al. [27] model without considering the extraction of roots and water evaporation. Also they noted that there was a brief overlap of wet bulbs in soil of fine texture and deep percolation appears to be smaller in fine textured soil than in thick texture. Deep percolation increases with increase in irrigation application depth [28]. The distribution of the water and the shape of the volume of wet soil can be predicted by physical laws of capillary water movement in the soil for a punctual as linear [29]. It is necessary to know how that water distribution is affected by soil water-physical. Thus, it is possible to scale the irrigation system so wet a sufficient volume of soil to ensure that the application of water by plants is attended and that this volume of soil is inserted inside the radicular system of culture [30]. The storage of water to be considered in studies of water balance depends on the depth of exploration of the root system in soil. As the culture of the coffee tree explores different depths of soil in terms of stage of development, physiological characteristics and attributes of the soil, the water capacity available (CAD) is always subject to a continuous variation over the years and the seasons [31]. The more intense drying on the line of culture up to 1.6 m was verified by Serafim et al. [32] which indicated the presence of drying bulb caused by the plant. According to those authors relevant information to be drawn is that the roots present to 1.6 m are active and remove water from the soil. Thus, although the culture does not have water readily available in layers closer to the surface during the drought, the greater volume of soil explored by that contributes to reduce the water deficit. How deep is operated by culture is directly proportional to the water available and considering the field observations in which the roots of conventional crops exploit a depth of up to 0.8 m [33] the presence of roots up to 1.7 m in crops studied, provides approximately twice more water available to plants. In the same way that soil attributes influence occurs in wet bulb, the root system also suffers consequence due to soil management, being difficult to establish, in isolation, the effect of these attributes on the growth of plants.

**Wet Bulb and Fertigation:** One of the major bottlenecks in the irrigated coffee production is related to the supply of nutrients via irrigation water technique called fertigation. Localized irrigation is the most suitable for fertigation because it allows keep in limited area available to the roots, soil moisture and nutrient concentration optimal for the development of culture, met with the same distribution system [34, 35], satisfying their needs promptly, according to their stage of development [36]. Compared to the conventional system of fertilization, fertigation allows you to increase productivity and improve the quality of the fruit of the coffee tree, reduces costs with labor on fertilization and increases efficiency in soil management [37-40]. The fertigation on coffee production has been discussed on the basis of works related to irrigation [37, 38, 41], for liquid fertilizing [42] and the fertigation [43-46]. For the coffee plant cultivated in non-irrigated land, the main producing regions established after years of research, the doses and
installments of N and most appropriate to the period of K₂O formation of crop. However, for the coffee plant fertigation such information is not yet defined. For fertigation drip coffee in the formative phase in dense planting may reduce by 30% the amount of N e K₂O recommended for cultivation in upland [47], already Guimarães et al. [48] working in the region of Minas Gerais with Arabica coffee noted that using the fertigation, can reduce the doses of fertilizer recommended for 70% of the recommendation basic. The drip irrigation offers important advantages to meet the standards of water and nutrient management contemporary efficiency, since it allows the accurate control of water supplied in small quantities directly to the root zone. Frequent irrigation helps maintain favorable water conditions near field capacity to root development in the volume of soil partially wet [49]. Moreover, combining the application fees and the plant through the wet volume ensures the efficient absorption of water and nutrient absorption, reducing losses due to deep percolation of water and agrochemicals [50]. Another advantage of the drip irrigation system corresponds to greater efficiency in the application of fertilizers when compared to manual or mechanized methods of application for coverage [51]. According to Antunes et al. [51], when the irrigation technique is combined with the application of fertilizers, there is a 35% increase in productivity of roots in relation to water use only. Evaluating the effect of drip fertigation on spatial distribution of root system of the coffee tree, Barreto et al. [52] observed that the coffee plant irrigated and fertilized conventionally different conditions for root development occurred, varying according to the tax treatments. For the plants irrigated by tubgotejadores with emitters spaced every 0.50 m, root depth was less effective (Average of 0.63 m) than observed for the plants irrigated by emitters positioned every 0.80 m (Average of 0.70 m). In nutritional management for fertigation was observed less inequality in effective root depth among the treatments, as well as in an average increase of 51.1% of density of roots. There was a tendency of root volume maintenance in the region near the emitters, while more distant points of the development of the wet bulb, root growth was 77%. Irrigation of plants by tubgotejadores buried the 0.10 m depth provided greater root development in response to the fertigation. Results obtained by Motta et al. [53] with Catuaí coffee in non-irrigated, fertilized conventionally, found a wide variation in horizontally and vertically in the soil chemical properties and distribution of roots. The thin roots have contributed to higher proportion in the total length of roots, as well as most of the roots concentrate under the canopy and 0.2 m depth. Confirmed-if the restriction of the root development in the range of fertilization. Drip irrigation on the root development is limited to the volume of wet ground by issuers, with root length density decreasing with depth [54-56], hence the importance of the study of the formation of the wet bulb into the soil, which second Nafchi et al. [24] very little attention is given to estimate soil water distribution using drip irrigation in real conditions in the field, according to Souza and Folegatti [49] unfortunately, important factors for this estimate, both in design and management are often forgotten and current practices in Brazil and elsewhere are often based on empirical information or data collected indiscriminately from the professional literature. Some studies have shown that the depletion of water in the soil is closely related to the depth of rooting [57, 58]. Other studies have highlighted the leading role of main root systems on the uptake of water in the soil [59]. Generally, the default extraction of soil moisture from the root zone, is that the water is initially extracted from the surface layer, with the extraction zone progressing downward through the profile. Whenever the ground water near the surface is supplied by precipitation or irrigation, extraction front returns the surface and subsequently moves down again. Then, the water will be taken from deeper and deeper layers. Roots in topsoil play the dominant role in water harvesting, when soil moisture is not restricted [60]. Despite the widespread use of fertigation through drip irrigation, information about the simultaneous movement of water and dissolved solids are scarce [49, 61]. The fertigation monitoring should be done to evaluate the management itself, based on impacts caused in the soil that might influence the development of plants, which must involve the monitoring of the application of fertilizers observing the concentration of the solution injected, concentration of the final solution in the output of the transmitters, distribution uniformity along the area, distribution of nutrients in the soil profile and the interaction between irrigation and fertilizer system trapped [62-64], those factors that will result in increased productivity and in reducing negative impacts of irrigation, when well-planned [65].

**CONCLUSION**

Given that the various studies show the importance of the wet track and its relationship with the root development of the coffee plant, bringing with him important aspects for the management of the coffee tree.
Within these aspects of irrigation management is advantageous location in relation to other systems for providing water in the root zone of the coffee tree, providing little variation in soil moisture during a period. In addition, through the technique of fertigation supplies nutrients necessary for coffee located, promotes greater efficiency in absorption and utilization of nutrients by plants, as several papers report that the NPK nutrients are concentrated near the emitter water irrigation systems and may conclude, near the area of nutrient absorption of coffee. Despite the importance of the aspects mentioned, some soil factors (density, structure and soil texture), should be observed in the formation of the bulb/wet track, but also the management of irrigation (flow rate and spacing of emitters) due to the behavior of nutrients in the soil and the influence on the development of the root system, for the irrigation system can contribute to positive development were coffee. On the studies mentioned concludes the importance of studying the field, with respect to these factors and the wet bulb/track ratio and root system development mainly in Brazil, where still and found to have been superficial in the literature.

REFERENCES


