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DISTRIBUTION OF NUTRIENTS IN PROFILE OF A LATOSOL SUBSURFACE DRIP VIA FERTIGATED

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ABSTRACT

It is important to follow the dynamics and distribution of nutrients in the soil profile in crops with fertigation. This practice allows you to establish or adjust the appropriate application of fertilizers and management of irrigation water, and it can prevent environmental damage such as soil salinization and contamination of ground water and surface water sources. Starting from the hypothesis that the increase in water depth extends the distribution of nutrients in the soil solution, is aimed in this work to study the dynamics and distribution of nutrients P, K, Mg and Ca in the profile of an Latosol fertilized via drip subsurface cultivated with sugarcane. The experiment was carried out in the experimental area belonging to the Federal Institute Goiano - Campus Rio Verde, GO. The experimental design was a randomized block design with four replications. The factors analyzed were three levels of fluid replacement (0, 50 and 100% of field capacity). Soil samples were collected after fertigation installment of finish using a ring with dimensions of 0.05 x 0.05 cm in diameter. Sampling proceeded depth by depth in equidistant grid points of 0.05 x 0.05 m on a profile of 0.40 x 0.40 cm samples totaling 96 in all treatments. The increase in water depth increased amplitude distribution of nutrients in the soil profile thereby increasing the availability of nutrients to the root uptake.

Keywords: Sugarcane, localized irrigation, nutrient bulb.

DISTRIBUIÇÃO DOS NUTRIENTES NO PERFIL DE UM LATOSSOLO FERTIRRIGADO VIA GOTEJAMENTO SUBSUPERFICIAL

RESUMO

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Em cultivos com fertirrigação, é importante realizar o acompanhamento da dinâmica e distribuição dos nutrientes no perfil do solo. Esta prática permite estabelecer ou ajustar a aplicação adequada dos fertilizantes e o manejo da água de irrigação, além de poder prevenir danos ambientais, como a salinização dos solos e a contaminação do lençol subterrâneo e fontes de água superficiais. Partindo-se da hipótese de que o aumento da lâmina de água amplia a distribuição dos nutrientes na solução do solo, objetivou-se nesse trabalho estudar a dinâmica e distribuição dos nutrientes P, K, Mg e Ca no perfil de um Latossolo fertirrigado via gotejamento subsuperficial cultivado com cana-de-açúcar. O experimento foi implantado em área experimental pertencente ao Instituto Federal Goiano - Campus Rio Verde, GO. O delineamento experimental utilizado foi de blocos ao acaso, com quatro repetições. Os fatores analisados foram três níveis de reposição hídrica (0, 50 e 100% da capacidade de campo). Foram coletadas amostras de solo após o término do parcelamento da fertirrigação utilizando um anel com dimensões de 0,05 m de altura x 0,05 m de diâmetro. Procedeu a amostragem por grids de camada a camada em pontos equidistantes de 0,05 x 0,05 m num perfil de 0,40 x 0,40 m totalizando 96 amostras em todos os tratamentos. O aumento da lâmina de irrigação aumentou a amplitude de distribuição dos nutrientes no perfil do solo, aumentando assim a disponibilidade de nutrientes para a absorção radicular.

Palavras-chave: Cana-de-açúcar**,** irrigação localizada, bulbo de nutriente.

INTRODUCTION

Irrigation located mainly the subsurface drip allows a water application efficiency and nutrients in the soil, but requires an adequate management especially when working with subsurface irrigation.

Wet bulb geometry information is important for the design and management of drip irrigation, mainly to estimate the volume of wet soil, emitter flow and water application time (MAIA et al., 2010).

In fertigation doses recommended for culture can be fractionated according to nutritional needs. The technique optimizes the use of inputs so that the absorption efficiency is increased, moreover there is a reduction of labor, cost of agricultural machinery operation and flexibility in the application (MELO et al., 2009).

According Barros et al. (2010) well as determining the shape of the wet bulb in crops with fertigation, it is important to follow up the dynamics and distribution of nutrients in the soil profile. This practice allows you to set or adjust the appropriate application of fertilizers and the management of irrigation water, and can prevent environmental damage such as soil salinization and contamination of ground water and surface water sources.

In insufficient water applications, the salts can focus on the more superficial depths of the soil occurring a smaller root system development coming to explore a smaller volume of soil, and therefore carries a lower productivity. However when applying excessive blade, these nutrients are provided in a depth of soil where there is no presence of roots, promoting nutrient leaching that can reach ground water causing environmental contamination (DONAGEMMA et al., 2008). The authors also show that there are few studies in tropical soils that show the nutrient efficiency in the lamina fraction applied and installment strategies fertigation as a means to increase productivity without causing loading of nutrients to groundwater.

In Brazil, has been disseminating a rising tide of drip irrigation system users is the application of fertilizers through fertigation. However information about the movement dynamics of these nutrients dissolved in the irrigation water are scarce. It is known that, in drip irrigation, water distribution is concentrated around the emitter, resulting in the accumulation of salts at the end of wet soil bulb (SOUZA et al., 2009).

Research work carried out by Laurindo et al. (2010) has shown that irrigation depths applied by drip irrigation does not interfere with the distribution of K^+ applied by fertigation and Ca and Mg in the soil in depth, but smaller water depths promote greater concentration of P in the most superficial depth of soil, and larger blades P to carry the deeper depths. Papadopoulos (2001) it states that the absorption efficiency of N, P and K may undergo variations of the order of up to 85%, 35% and 90% for localized irrigation.

Thus, starting from the hypothesis that the increased hidric replacement expands the distribution of nutrients in the soil solution, the aim of this work was to study the dynamics and distribution of nutrients P, K, Mg and Ca in one fertigated via Latosol profile subsurface drip cultivated with sugarcane.

MATERIALS AND METHODS

The experiment was conducted in the experimental area of the Federal Institute Goiano - Campus Rio Verde, GO, located at latitude 17°48'28" S and longitude 50°53'57" W, with an average altitude of 720 m gently rolling relief (6% slope). The climate was classified as Köppen as Aw (tropical) with precipitation in the months from October to May, and drought in the months from June to September. The annual average temperature ranges from 20 to 35 °C and precipitations range 1500-1800 mm per year. The soil was classified as dystrophic Red Latosol of medium texture (EMBRAPA, 2013). Table 1 shows the physical-hydrical characteristics and chemical soil characteristics observed before the implementation of the experiment.

Table 1. Physical-hydrical characteristics and chemical soil of the experimental area, in the depth of 0-0.20 and 0.20-0.40 m deep.

Physical-hydrical characteristics								
Depth	Grain size (g kg $^{-1}$)			θ_{CC}	θ_{PMP}	Ds	PT	Textural
(m)	Sand	Silt	Clay	--- % ---		g cm^{-3}	cm^3 cm^{-3}	Classification
0–0.20	458.30	150.20	391.50	51.83	30.50	1.27	0.55	Clayey
0.20–0.40	374.90	158.30	466.80	55.00	31.33	1.28	0.51	Clayey

Chemical characteristics											
Depth	pH	O.M.	P	K	Ca	Mg	Al	H+Al	S	CTC	V
(m)	em H_20	g kg^{-1}	mg dm^{-3}	---------------------- mmol dm^{-3} ----------------------							(%)
0–0.20	6.20	63.42	7.06	2.04	20.40	16.80	0.00	57.75	41.80	99.55	41.99
0.20–0.40	6.60	44.47	2.65	4.09	14.40	13.20	0.00	44.55	31.69	76.24	41.57

θ_{CC}, field capacity (10 kPa); θ_{PMP}, permanent wilting point (1500 kPa); Ds, bulk density; PT, porosity total; pH in distilled water. P and K, Mehlich^{-1} extractor. O.M. - organic matter. V - base saturation.

The experimental design was a randomized block design with four replications. The factors analyzed were three levels of water replacement (0, 50 and 100% of field capacity).

The initial soil preparation consisted of prior harrowing in order to eliminate existing vegetation, distribution of lime, at a dosage of 2.0 t ha^{-1}, based on the results of soil analysis, aiming to increase the saturation bases, as recommended by Sousa & Lobato, 2004.

In sequence, the soil was grooved to 30 centimeters deep and fertilized for planting sugarcane. For the construction of the planting furrows, using subsoil and subsequent removal of soil, which was performed manually by forming the planting bed.

The planting of sugarcane occurred in March 2011 experimental plots were established, consisting of three dual-line grooves (planting "W" or planting in "Pineapple") with spacing of 0.40 m in rows in row double, 1.40 m between double rows and 8 meters long, totaling 43.2 m^2 of total area. It was planted variety RB 85-5453.

The irrigation was conducted based on digital punch tensiometry with sensitivity of 0.1 kPa, and the tensiometric rods installed in depths of 0.20 and 0.40 m deep.

The drip pipe was buried at 0.20 m depth from the soil surface, in the middle of the double line.

The whole experimental area was chemically corrected as a result of soil analysis according to recommendations Sousa & Lobato (2004), with application of 100 kg ha^{-1} of nitrogen (ureia), 120 kg ha^{-1} P_2O_5 (superphosphate) and 80 kg ha^{-1} K_2O (potassium chloride). The phosphorus fertilization was done at planting. Nitrogen fertilizer was applied totally via irrigation water (fertigation) in installments monthly through the development of culture, a total of ten applications, while potassium fertilizer was partly held in the planting furrow, representing 30% of the total and the rest applied through irrigation water, and only in the treatment with 0% water replacement, the application of nitrogen and potassium was carried out in installments to haul.

Table 2. Percentage of fertigation in installments during the cultivation.

	Application												
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	Total
Month	J		J		A		S	O	N	D	J	F	
						---------- % ----------							
Potassium*	2	4	6	8					10				100
						---------- % ----------							
Nitrogen						10					-	-	100

* It was used white potassium chloride.

The applications were performed at concentrations equal to all parcels in order to provide an equal amount of nutrients. The N and K irrigation occurred simultaneously without the application of different blades. For injection of fertilizers in the irrigation system we opted for a gun that Venturi secionava fertilizers after dissolved in a box reservoir with a capacity of 350 L.

For the implementation of irrigation water via fertilizers, was primarily only water applied to the hydraulic balance of the irrigation system, and allow more uniform distribution of fertilizers, then it was made fertigation and the finish was applied in water to flush the system irrigation.

Soil samples were collected after installment of the end fertigation using a ring with dimensions of 0.05 x 0.05 m in diameter. Before sampling the soil was moistened in order to smooth the sample to facilitate preventing the collapse of same once it has carried out sampling grids depth by depth in equidistant points of 0.05 x 0.05 m a profile (0.4 x 0.4 m correspondestes respectively the depth from the surface away from the location drip point) Figure 1.

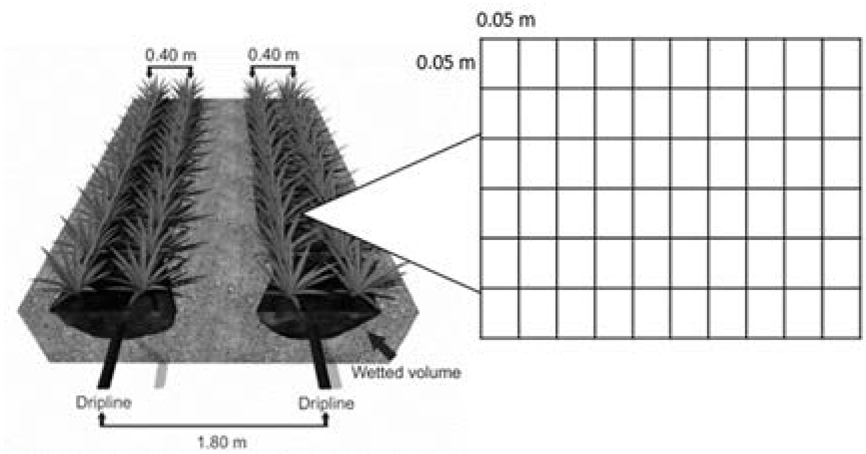


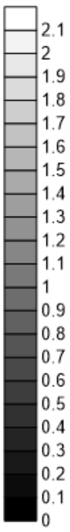
Figure 1. Sampling scheme for determining the nutrients from the emitter during the soil profile.

Were sent to the laboratory to determine the availability of nutrients (Ca, Mg, P and K) and subsequent assessment of biological behavior of nutrients applied installments via irrigation water for crop development. Graphs of the distribution of nutrients were developed in the soil profile using the Surfer 9.0 software (SOFTWARE GOLDEN, 2010).

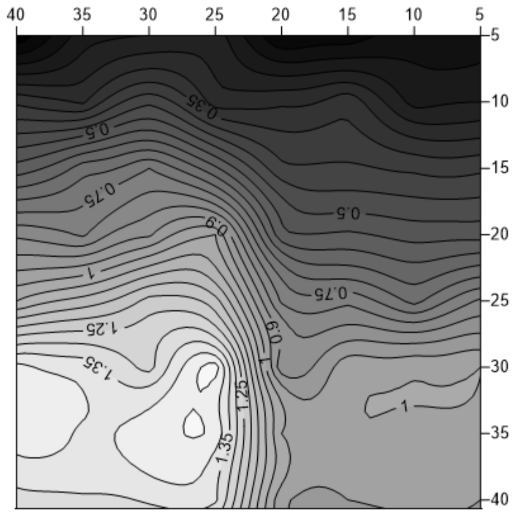
RESULTS AND DISCUSSION

Calcium (Ca) and magnesium (Mg) were added via limestone in the soil before the soil preparation and planting of sugarcane. It is observed in Figure 2A and 3A that the treatment which received no water replacement (rainfed), both Ca and Mg tended to focus more heterogeneous in the soil profile, located mainly below 20 cm deep. Already in the treatments that received throughout the cultivation 50% (Figure 2B and 3B) and 100% (Figure 2C and 3C) of water replacement (WR), both Ca and Mg tended to be concentrated in regions closer to the roots. The Ca and Mg concentrations tended to be highest at 0% WR, but when irrigated these values tended to be highest at 50% WR and comparison to 100% WR. This fact is related to greater absorption of these nutrients due to the greater availability of water for irrigation.

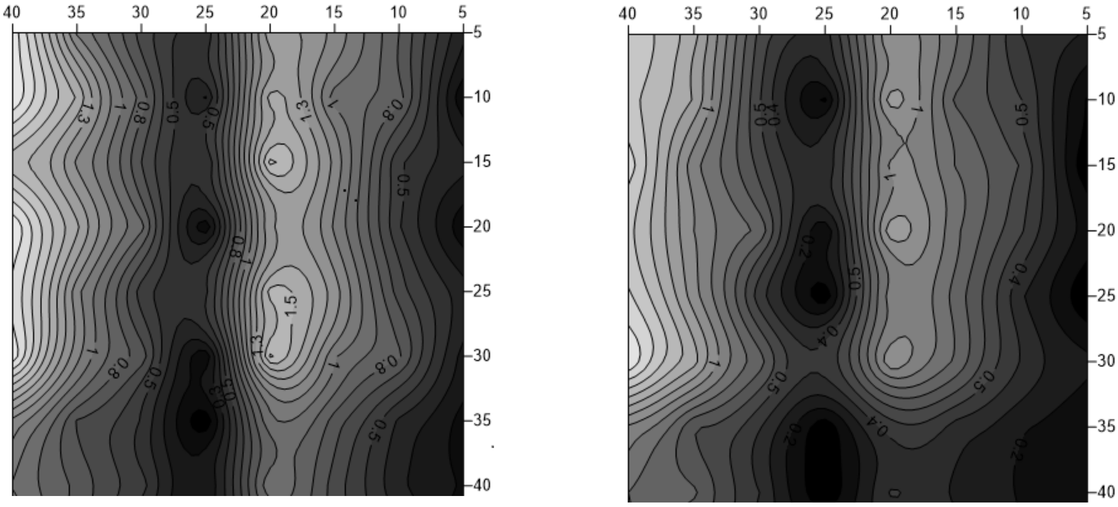
The Ca and Mg nutrients in rainfed conditions, are more retained in the soil when applied by fertigation, they have to drive through the accelerated soil profile, which in part may explain the efficiency gains with this system (VITTI et al., 1994). Results found by Laurindo et al. (2010) in area Acrisol epieutrófico, show that Ca and Mg in the depth 0.00 to 0.20 m showed the same trends, there was an increase in the levels of these two elements until 0.50 m away.



Scale: Ca (0-2.1 mg dm^{-3})

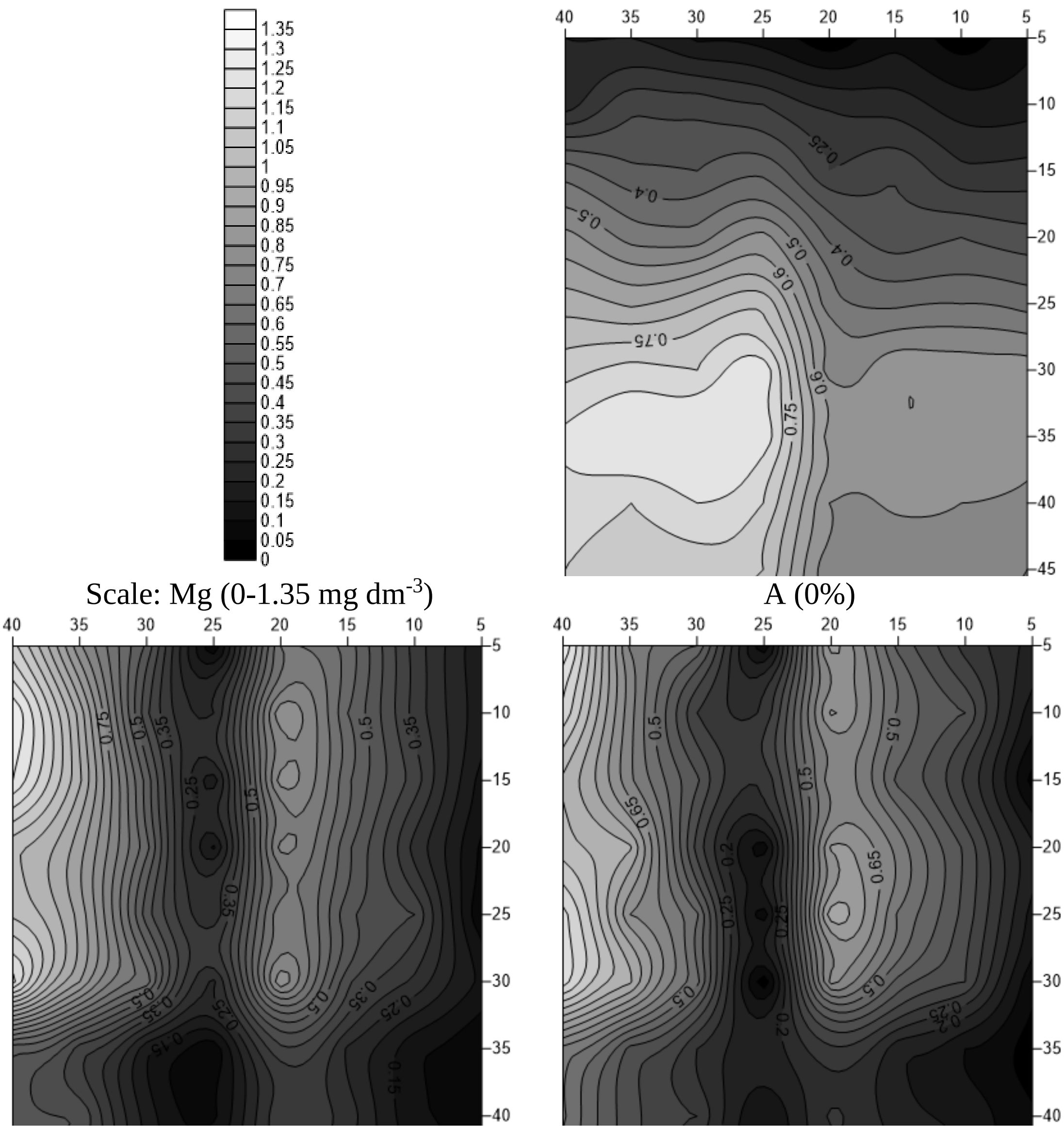


A (0%)



B (50%) C (100%)

Figure 2. Distribution of Ca in Latosol profile on water replacements 0% (A), 50% (B) and 100% (C) of field capacity.



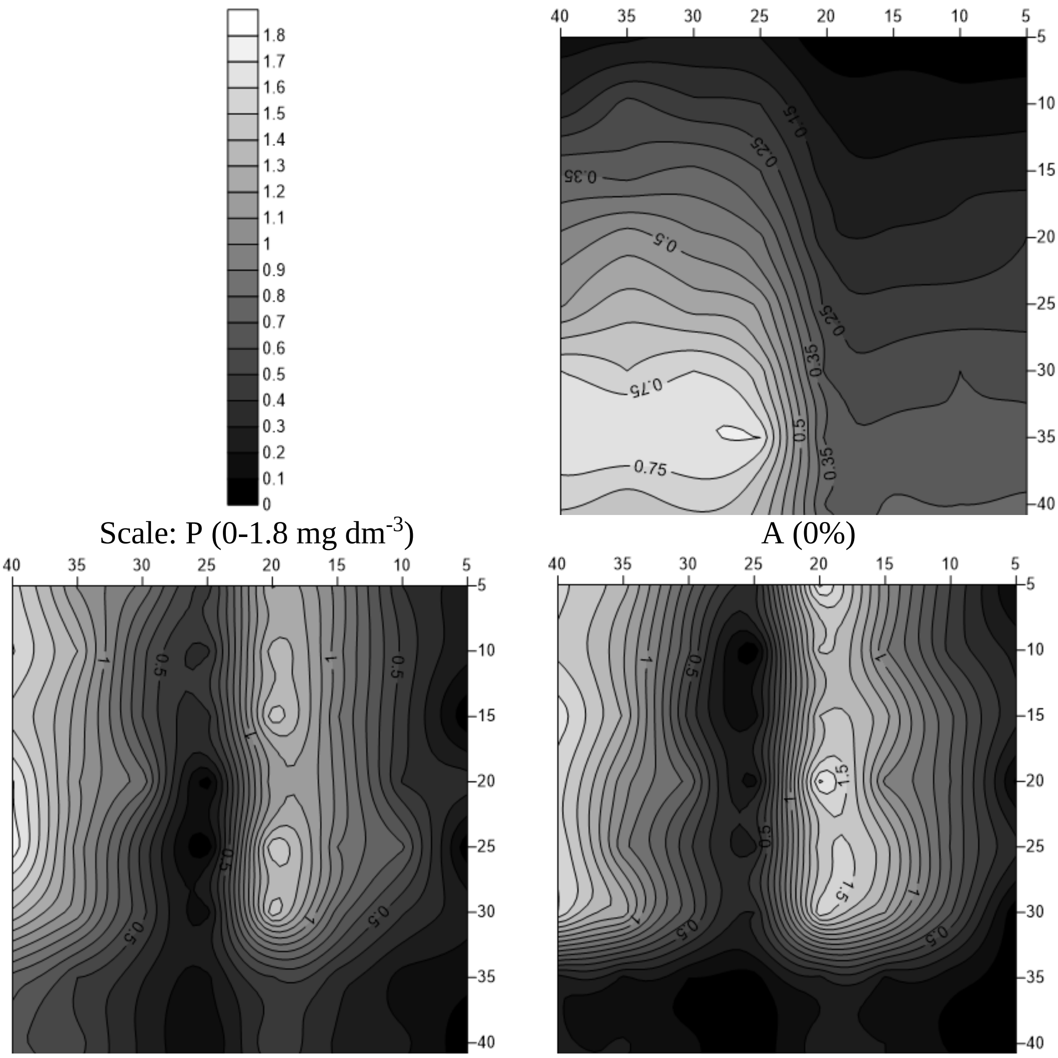
Scale: Mg (0-1.35 mg dm^{-3}) A (0%)

B (50%) C (100%)

Figure 3. Distribution of Mg in Latosol profile on water replacements 0% (A), 50% (B) and 100% (C) of field capacity.

The phosphorus (P) was added via planting in soil in the furrow. It is observed that the treatment with 0% WR the concentration of P is somewhat distributed in the soil profile, moreover, tended to concentrate in a small region corresponding to the location that was added in the furrow (Figure 4A). According Zanini et al. (2007) phosphorus has mobility its limitations when applied in solid form, as in fertigation conditions motion can reach 0.20 m in depth so as along the surface.

With irrigation we observed that P was transported to the regions with the highest concentration of roots, thus enabling their increased absorption, although there is a greater focus on treatment with 100% WR (Figure 4C) compared to 50% WR (Figure 4B), but with irrigation concentration P is superior to dry. These results corroborate Fernandes et al. (2011) who observed that fertigation favors its movement P along the profile, making the adsorption sites more rapidly becomes saturated. For Foratto et al. (2007) the frequencies of 1; 3; 5 and 7 days employed to carry out irrigation and fertigation did not result in different moisture distributions of pH and phosphorus levels in the wet bulb. According Vivancos (1996); Zanini et al. (2002) P application through drip can increase five times the movement of this nutrient in the soil compared with conventional implementation, and use of phosphoric acid provides greater mobility in soil than P triple superphosphate.



Scale: P (0-1.8 mg dm^{-3})

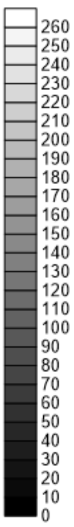
A (0%)

B (50%)

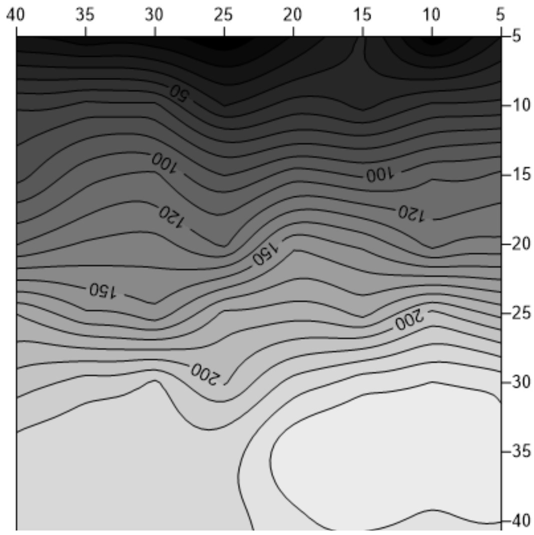
C (100%)

Figure 4. Distribution of P in Latosol profile on water replacements 0% (A), 50% (B) and 100% (C) of field capacity.

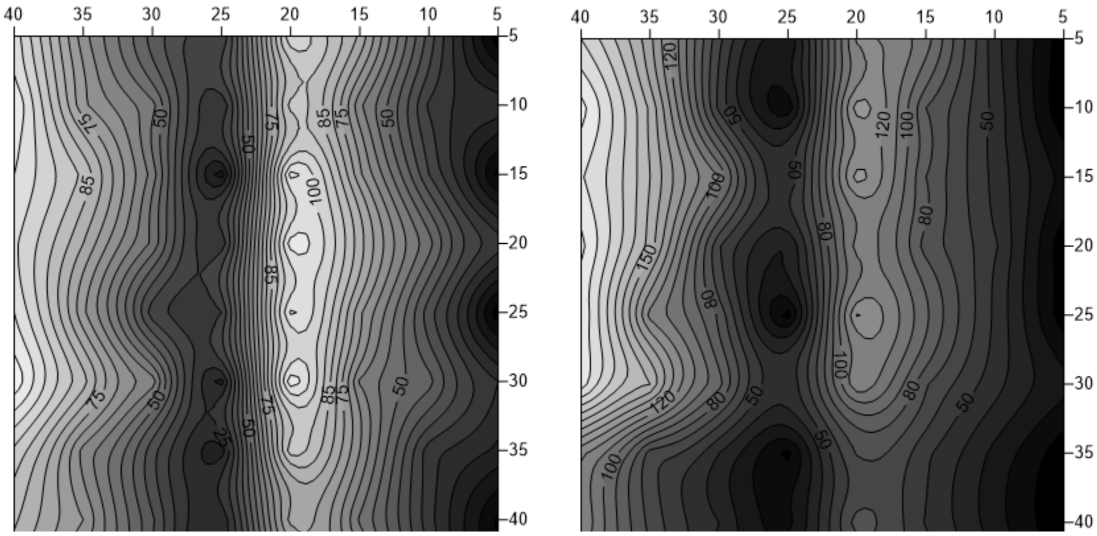
Potassium (K) was added to the soil through irrigation water (fertigation) installments during the cultivation of sugarcane. It is observed that the treatment of 0% WR the concentration of K is evenly distributed in the soil profile, with higher concentrations below 20 cm (Figure 5A). Already with irrigation it was observed that the highest amount of K is concentrated in the region near the area of higher concentration of sugarcane roots, but their concentrations are lower (Figure 5B and 5C). This fact can be explained by the higher leaching rate this nutrient depending on their dynamics in the soil. For Santoro (2011), moisture content in the soil, or water availability is essential for the dynamics of potassium and nitrogen in the soil, their availability and as a function of mass flow and diffusion. It is noted that influence, in this study, where the dry area K is higher concentrations only in the subsurface depth of soil, whether applied via fertigation, due to its ground mobility mechanism, but in areas where there daily applications of water through localized irrigation, the distribution has become more evenly over the soil profile following the flow of the watering bulb at the area of application by drip, and absorption by the roots of plants, affecting a three-dimensional redistribution of nutrient following the flow front of the wetting (ZANINI, 1991), and not only to the deeper soil depths, as occurred in the dry area. However, to Lopes et al. (2010); Barros (2010) the salts moving more slowly towards the front wetting, or the water flow in the soil. Thus, we can say that fertigation promotes greater availability of K near the root, and for all its dynamic, not losing your total concentration depending on the water flow in the soil. For Laurindo et al. (2010) the K in the soil, when the irrigation with this element is made drip radially decrease with increasing horizontal distance of the application point in the direction orthogonal to the row of plants to a depth of 0.60 m.



Scale: K (0-260 mg dm^{-3})



A (0%)



B (50%) C (100%)

Figure 5. Distribution of K in Latosol profile on water replacements 0% (A), 50% (B) and 100% (C) of field capacity.

The uniform distribution of nutrients through the drip line, and with higher concentrations near the area of root absorption refers to fractional application of nutrients through fertigation, allowing their presence almost stable throughout the growing season, high rainfall will not have much impact on the growth of plants, readily available nutrients to plants in the area pressentes absorption, lower leaching losses, especially nitrogen, and gaseous or runoff.

In general, if comparing it to dry, the slides 50% and 100% were active in the mobility of nutrients according to the mobility of solutes in the soil, and the occurrence of absorption by the roots, and ways of applications, all of these factors may or not justify the different concentrations in the sampled soil strips, and pH change.

But it is noteworthy that the drip irrigation systems depend on physical-hydrical soil properties with respect to horizontal distribution of water, so it shows great variability, but there is usually the formation of a wet bulb near the area of the roots, facilitating absorption of nutrients by the plant, and the bulb size is affected by the managing irrigation, soil type and characteristic of the hydraulic system.

CONCLUSION

The increased water replacement provided greater amplitude distribution of nutrients in the soil profile thereby increasing the availability of nutrients to the root uptake.

The dynamics of the distribution of phosphorus shows quite homogeneous understood the bulb area, even though it was deposited in the furrow.

Potassium despite its dynamics in the soil profile, the split application has enabled adequate maintenance on the effective depth of the root system to the full development of independent culture water replacement applied.

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