

NITRATE LEACHING IN TWO NUTRITIONAL AND WATER MANAGEMENT SYSTEMS OF AVOCADO IN MICHOACAN

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Nitrogen fertilizing is a process consuming 45% of the fertilizer applied in orchards. The application of nitrogen fertilizing in July and October coincides with the rainfall season; therefore, nitrogen losses are increased, causing environmental pollution and low efficiency of fertilizer use. The aim of this work was to evaluate two nutritional and water management systems and their effect on inorganic nitrogen outside avocado roots. The experiment was made in Tancitaro, Mich., from January 2001 to December 2006 in a twelve-year-old Hass orchard, planted at a distance of 10 x 10 meters. Treatments were fertigation and hose irrigation. In the pressurized treatment, irrigation was carried out every 8 days with 200-500 L of water, depending on the month; while hose irrigation was conducted for 5-12 minutes every 18-21 days.

In both treatments, fertilizing had an annual average of 220 kg N ha⁻¹, maintaining as established P and K. Suction tubes were installed for monitoring the NO₃ concentration at 30, 60 and 90 cm deep in soil. Results indicated that each year pressurized irrigation management yields 25 to 35 ppm of N-NO₃ and hose irrigation reaches 80 to 100 ppm of N-NO₃.

LIXIVIACION DE NITRATOS EN DOS SISTEMAS DE MANEJO NUTRICIONAL Y DE AGUA EN AGUACATE DE MICHOACAN

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La fertilización nitrogenada es una práctica que consume el 45% del fertilizante aplicado en huertas. La aplicación de fertilizante nitrogenado en julio y octubre, coincide con la época de lluvias por lo que las pérdidas de nitrógeno también se incrementan contribuyendo a la contaminación del ambiente y baja eficiencia de uso de fertilizante. El objetivo de este trabajo fue evaluar dos sistemas de manejo nutricional y de agua con respecto a la pérdida de nitrógeno inorgánico fuera de la zona radicular del aguacate. El trabajo se estableció en Tancitaro, Mich., desde enero de 2001 a diciembre de 2006 en una huerta con el cultivar Hass de 12 años de edad y un marco de plantación 10 x 10 m. Los tratamientos fueron fertirriego y riego con manguera. En el tratamiento presurizado se regó con intervalos de ocho días de 200 a 500 L de agua, dependiendo del mes y en el riego por manguera, se regó un tiempo de cinco a doce minutos cada 18 a 21 días. En ambos tratamientos, la fertilización fue en promedio de 220 kg de N ha⁻¹, manteniendo fijos el P y el K. Se colocaron tubos de succión para monitorear la concentración de NO₃ en tres profundidades 30, 60 y 90 cm. Se tomó la lectura de 90 cm como nitratos lixiviados. Los resultados indicaron que en promedio

anualmente, el manejo con riego presurizado produce de 25 a 35 ppm de N-NO₃, mientras que el riego por manguera registra de 80 hasta 100 ppm de N-NO₃.

Introduction

Avocado crop of Michoacán state is the main agricultural industry in terms of its social and economic impact. No one agricultural industry provides work for so many people (1,000,000 employees/year) like avocado industry does, besides generates the most amounts of income profits to the state (US \$500 millions/year). Due to volcanic nature of soil where this crop is grown, soils are highly permeable reaching infiltration rates until 200 mm hour⁻¹ with steady state between 50-90 mm hour⁻¹ (Tapia et al 2006b). This property along sandy loam soil texture, provides an adequate medium to root growth and tree development due drainage is a first condition required for this crop (Benanchio 1982). However, along with fast water infiltration, also water reaches highly soil depths faraway the root system layer. Most of the root density (90%) is found in the first 60 cm of soil depth (Tapia et al 2006a).

Water seepage contains nutrients, basic cationic and eventually agrochemical, pesticides and organic pollutions. Agree with Alcalá et al (2002), the soils of this mexican region bear high water detachment in deep soil layers. This effects could be a pollution source of the numerous springs and mountain little creeks in the avocado stripe of Michoacan. In the case of the nitrate, upper concentrations above of 10 ppm de NO₃ in potable water, could origins troubleshooting in human disease (Killpack and Bucholz 1994). Nitrate pollution is one of the main factors of aquifer and surface streams pollution of high environment impact due to agricultural practices (Groeneveld et al 2001).

The avocado stripe of Michoacán, has more than 45,000 ha under irrigation, this zone has experimented a summit in the pressurized water systems equipment with a covered area of 25,000 ha. Other 20,000 ha is irrigated with plastic tubes filling a micro-watershed located in each tree. The use of water in each water management can have a difference of 2,000 liters of water. This situation can lead to leak pollution and eventually affecting springs and aquifers. The aim of this work was to evaluate nitrate leakage in two water management systems, located micro-sprinkle irrigation (LR) and plastic tube irrigation (control) in an avocado orchard of Michoacan.

Material and Methods

The experiment was carried out in a commercial orchard ten years old, from Autumn of 2002 to spring of 2006, located in Choritiro ranch municipality of Tancitaro, Mich. Orchard is planted to 10 meters of tree separation and 10 meters of rows separation, tree variety was "Hass". Soil is classified as Vitric hapludand (Alcalá et al 2002), locally named as "Topure". This soil is derivated from volcanic ashes and has pH= 5.9, electric conductivity < 1.0 mS/cm, field capacity= 30.1%

and wilting point= 18.6%. Irrigation water properties are salts free ($89 \mu\text{S cm}^{-1}$ y $\text{pH}= 7.0$). Experimental treatments were two. Control (T), received irrigation through a plastic tube filling a micro-watershed in the bottom of the stem but without wetting the stem. Control received the prevalent fertilization practice that consists of fertilization with 17-17-17 ($\text{N-P}_2\text{O}_5\text{-K}_2\text{O}$), applied in the beginning of rainfall season (4.5 kg per tree), at end of the rainfall season (5.5 kg/tree) and on march (3 kg per tree). Control irrigation was performed every three weeks with a 10 to 20 minutes of water time depending of the year season. Alternative treatment (LR), was 70 liters per hour located micro-sprinkler irrigation with weekly operation of eight hours maximum and nutrition applied through water system agree with suggested nutrition program (Tapia et al 2003). In both treatments were installed five soil solution suction tubes to sampling soil water and the analysis of nitrate pH, and salinity. Three tubes were in 30, 60 and 90 cm depth meanwhile other two tubes were to two and three meters away the stem of the tree. Irrigation program per month is showed in Table 1. Each treatment was evaluated in two trees taking each tree and each date as a replication (Jasso et al 2001). Experimental design was completely randomized. Data evaluation was nitrate concentration (NO_3), in each sample tube measured in situ with Horiba @ ionometer analyzer.

Cuadro 1. Programa de riego mensual en aguacate con dos métodos de riego en Tancítaro, Mich.

Table 1. Irrigation Schedule of avocado in two water methods in Tancitaro, Mich.

¹Fuente: Tapia et al (2006b)

Mes	Tratamiento de riego		ETP ¹ (litros/árbol)
	Control (T) (litros)	Riego localizado (RL) (litros)	
Enero	1,800	1,120	5
Febrero	1,400	1,400	5
Marzo	2,880	1,960	9
Abril	2,400	2,240	5
Mayo	1,400	1,120	3
Total	9,880	7,840	22

Results and Discussion

The analysis of variance performed to the nitrate concentration data in the different soil depths, revealed that in the first layer no significant difference in the soil nitrate concentrations of the soil solution was detected. This indicated that both treatments held the same amounts of available nitrate in soil solution throughout twelve months of the year. Nevertheless, in 60 and 90 soil depths, evaluated solution nitrate concentrations, were different in both treatments, this probe that one treatment held upper concentration in the deepest layer, which can be a pollution source of nitrate to the aquifers and sub-surface streams of the avocado stripe of Michoacán.

Cuadro 2. Análisis de la varianza de concentración de NO₃ en solución del suelo en tres profundidades de suelo de la zona radicular de aguacate en Michoacán.

Table 2. Analysis of variance of soil solution NO₃ concentration in three soil depths of the avocado root zone

Profundidad del suelo (cm)	Cuadrado medio tratamiento	Efecto de tratamientos				
		G.L.	Cuadrado medio error	G.L. error	Fc	Pr>F
30	321160.5	1	146312.8	59	2.2	0.14
60	621936.0	1	94496.3	59	6.6 *	0.013
90	2090880	1	69100.9	59	30.2 **	0.0001

* = Significancia (p<0.05), ** = Significancia (p<0.05), NS = No hay significancia (p>0.05).

The average values of the N-NO₃ concentrations in the soil solution of the three soil depths of the root zone, are showed in Table 3. The values of concentration for each depth are higher than the earlier layer. Control registered values between 80 and 97 ppm of N-NO₃, meanwhile LR just reached between 36 and 86 ppm. In both treatments is noted that exists a huge difference in the performance of the found values along the soil depth. Control was a consistent behaviour in the three soil depths with values nearby to 97 ppm of N-NO₃. In LR the relationship between soil depth and N-NO₃ concentration is inverse cause increasing depth soil the N-NO₃ concentration was decreasing. Top layer was 73.7 ppm of N-NO₃ and bottom layer was just 36.1 ppm. These registered amounts indicate that annually Control leakages almost three times more N-NO₃ than LR, outside the avocado root system. Soil texture of this kind of soils, enhance N-NO₃ losses as argued by Powell and Gaines (1994), but is evident that best water management practices can reduce this fact as was detected in this work with a reduction in 33% of the N-NO₃ seepages faraway the avocado root system.

Cuadro 3. Concentración media de N-NO₃ en la solución del suelo en tres profundidades de la zona radicular del aguacate en dos tratamientos de manejo de agua en Michoacán

Table3. N-NO₃ average concentration in three depths of soil solution avocado root area in two water management systems of Michoacán.

Tratamiento	Profundidad del suelo (cm)		
	30	60	90
Riego localizado (RL)	73.7 a	47.7 b	36.1 b
Riego con manguera	97.2 a	80.4 a	96.1 a
DMS (Tukey 5%)	31.8	25.5	21.8

Nota: cantidades con la misma letra iguales

Figure 1 displayed the nitrate concentrations in the soil solution in three sample soil depths of the avocado root system. Throughout year control shape clearly three peak of maximum concentration of N-NO₃ in soil solution. These peaks have coincidence with the events of fertilization (until 90% of the producers with plastic tube irrigation, fertilizes at this time), first peak on March, middle peak in the beginning of the rainfall season, and last peak on the end of the rainfall. The trouble of leakage is enhanced with strong rainfall due soil humidity reaches a point which soil can not hold water as it was noticed by Killpack and Bucholz (1993). Added to this situation avocado evapotranspirative diminishing in rainfall season (Tapia et al 2006b), consume just a third part of the available water, rest of the water drains to deeper layers. Unfortunately, crop fertilization take place on plenty rainfall season and the heavy rains and limited soil water retention (200 mm), caused nitrate leakage reaching highest peaks on July and October months (Figure 2).

Maximum N-NO₃ concentrations are found in upper soil layer, but quickly are reduced on next month which shows that crop intakes just a fraction and rest of the nutrient increase the seepages of the deepest layer (90 cm). This fact indicates the high infiltration rates of these soils and the elevated control N-NO₃ losses (92.2 ppm) higher than LR (32.4 ppm).

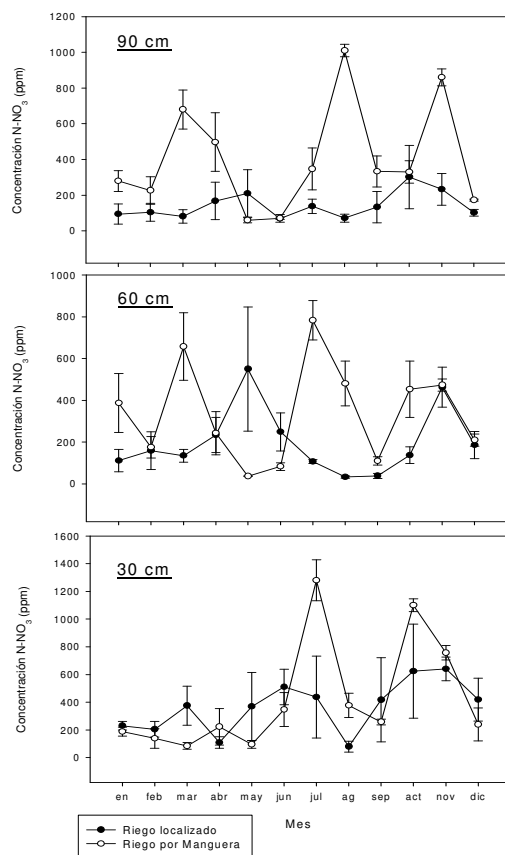


Figura 1. Concentración de N-NO₃ en tres profundidades de suelo en dos sistemas de manejo de agua en aguacate de Michoacán. 2001-2006.
 Figure 1. Concentration of N-NO₃ in three soil depths of two water management systems in avocado of Michoacan. 2001-2006

In the Figure 3 is showed the concentration of N-NO₃ in the surface lateral advance of the soil at 2 and 3 meters of distance away the stem of the tree. It is observed in both cases that along increasing the distance from stem, Control reduces the N-NO₃ concentrations until be lowest amounts at three meters of distance. This effect is due to the fertilization is made in wide stripes around the tree and when the distance from stem is bigger, fertilizer concentrations trends to reducing until being almost none. Meanwhile, LR could have a higher N-NO₃ concentration, in the distance from stem tree, due the micro-sprinkler has a 6.5 of wet diameter and although the applied fertilizer amounts are smalls, the frequency of application is high throughout year and the N-NO₃ concentrations are higher with 361 ppm against control with just 104 ppm in upper soil layer. In LR the amount of applied water is limited, although in upper layer the N-NO₃ concentration is higher, water percolation and nitrate leakage is lower. The N-NO₃ soil availability is desirable because the avocado root system has intake roots mainly in upper soil layer, some of them leaving out the soil, growing between soil surface organic matter. This fact allows the tree enhance its nutrition

and is agree with Steven et al (1988), whose recommended limited nutrition management to reduce N-NO₃ leakage, without affect yield and nutrition and reducing costs with best management practices of low environmental impact.

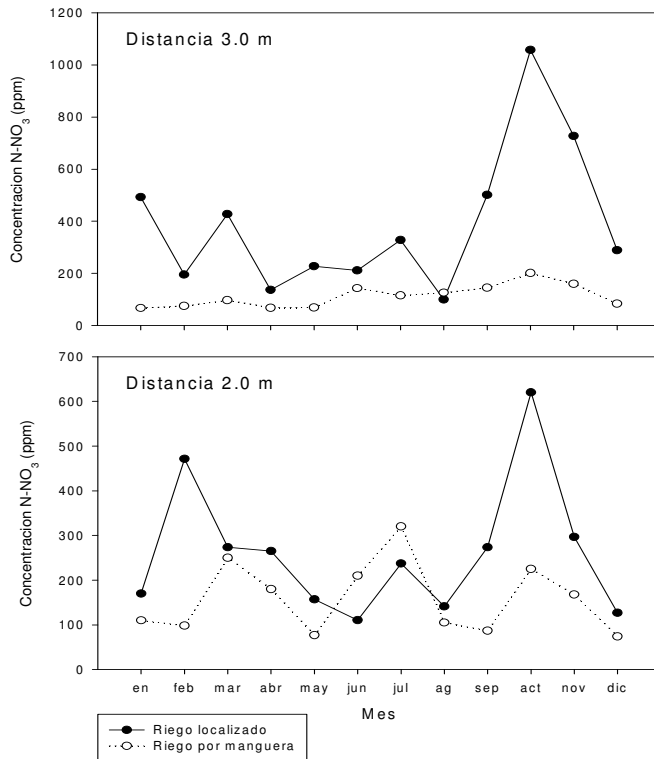


Figura 2. Concentración de N-NO₃ en la profundidad 0-30 cm en las distancias dos y tres metros a partir del tronco en solución del suelo en aguacate de Michoacán.

Figure 2. Concentration of soil solution avocado of Michoacan N-NO₃ at 30 cm depth in one and two meters of distance from stem.

Conclusions

1. In upper soil layer the amount of N-NO₃ is similar in both treatments, during most part of the year, although small differences in some months were detected, due the amount of fertilizer applied.
2. The difference in deeper soil layers N-NO₃ concentration, revealed that control could leakage 180 % more nitrate (96 ppm of N-NO₃) than micro-sprinkler irrigation (36 ppm of N-NO₃).
3. In five study years, months of higher leakage in Control were March, August and November with 650, 1000 and 900 ppm of N-NO₃, concurring with the fertilizer application months.
4. Micro-sprinkler irrigation bears higher N-NO₃ availability in surface lateral distance with annual average N-NO₃ of 361 ppm against control with just 104 ppm in the 3.0 m distance.

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