Study soil analysis in Alamo, Temapache and Veracruz, to generate doses of fertilization in orange

Análisis edafológico en Álamo Temapache, Veracruz, para generar dosis de fertilización en naranja

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RESUMEN

A nivel mundial los cítricos son el principal frutal cultivado, en México la producción de naranja es de gran importancia económica, los principales municipios productores del estado de Veracruz se encuentran Álamo, Papantla, Martínez de la Torre, Tihuatlán, Chicontepec y Temapache. Estas zonas, mantienen un rendimiento promedio bajo en comparación con otros países productores y un factor que puede mejorar los rendimientos es la óptima fertilización la cual tiene que ser respaldada con análisis de suelos para poder definir una dosis. Se realizaron 646 muestreos de suelo a una profundidad de 30 cm, en el municipio de Temapache, Veracruz, mediante un muestreo aleatorio simple, el tamaño de la muestra se adaptó a las condiciones de cada comunidad. Los análisis fueron enviados a dos laboratorios. Se evaluaron el pH, materia orgánica, nitrógeno, fósforo, potasio. Los resultados se analizaron con estadística no paramétrica mediante un análisis de frecuencias para lo que se plantearon diez rangos, se utilizó R stadistic package versión 64 3.2.0. El pH en más del 70% de los suelos fue alcalino, la concentración de materia orgánica solo en el 34.44% se encontró en condiciones adecuadas, los macroelementos se encuentran en condiciones óptimas a excepción del nitrógeno el cual se presentó en niveles bajos.

Palabras clave: nitrógeno; fósforo; potasio; dosis de fertilización.

ABSTRACT

Worldwide Citrus is the main fruit grown in Mexico orange production is of great economic importance, the main producing municipalities orange state of Veracruz are Alamo, Papantla, Martinez de la Torre, Tihuatlán, Chicontepec and Temapache. These areas, maintain a low average yield compared with other producing countries and a factor that can improve performance is optimal fertilization which has to be backed up with soil analysis to define a dose. 646 soil samples at a depth of 30 cm, in the municipality of Temapache, Veracruz, by random sampling, sample size was adapted to the conditions of each community were made. Analyses were sent to two laboratories. pH, organic matter, nitrogen, phosphorous and potassium were evaluated. The results were analyzed with nonparametric statistical analysis using frequencies for what ten ranges were raised, all with R software. The pH by more than 70% of the soil was alkaline, the concentration of organic matter in only 34.44% was found under suitable conditions, the macroelements are in good condition except nitrogen which was presented at low levels.

Keywords: Nitrogen; Phosphorus; Potassium; Fertilization doses.

1. Introduction

Globally citrus fruits are the main cultivated fruit, with an area that exceeds 8.3 million hectares, above crops such as bananas, apple trees or vine, world production of citrus by 2015 was 123.8 million tons, corresponding 58% to oranges, 23% to mandarins, 12% to lemons and 7% to grapefruit (FAOSTAT, 2015). In Mexico the production of orange is of great economic importance, only in 2014 produced $ 6,727,474.63. Veracruz harvests more than 50% of the national orange surface (SIACON-SAGARPA, 2015). Among the main orange producing communities in the state of Veracruz are Álamo, Papantla, Martinez de la Torre, Tihuatlán, Chicontepec and Temapache.

The latter is mainly engaged in citrus production with a total of 50,718.75 ha, of which 43,371.50 ha are grown with orange. (SIAP-SAGARPA, 2015). However, according to data from SIACON-SAGARPA (2015), orange yield per hectare in Veracruz has remained the same for the last 30 years, unlike other producing countries such as the USA, which double yields, compared with Mexico (FAOSTAT, 2015). One of the main reasons why production in Veracruz per unit area is low is due to the poor management of plant nutrition (Maldonado *et al.*, 2008). According to Curti *et al.* (2000), there are no experimental results that make it possible to specify the fertilizer doses and times of application, which consider the nutritional status and demand of the crop and the nutrient soil supply, which leads to the use of general fertilization doses that do not they consider the specific needs of the crop or the soil characteristics (Alpízar *et al.*, 2006).

In order to improve plant nutrition, methodologies have been proposed to estimate the fertilizer dose, considering crop demand, soil supply and fertilizer efficiency. When the amount of nutrients supplied by the soil is lower than that demanded by the crop to reach a specific yield, fertilizer must be applied (Etchevers, 1987; Szucs, 1997). This methodology, called restitution, takes into account the amount of nutrients extracted by the plants to produce the fruit, foliage, stems and roots, which are values of importance to determine the amount of nutrients removed from the soil reserves and therefore both the amount of fertilizer to be supplied according to the quantity of fruit produced. Based on the above, the aim of this study was to generate fertilization doses and an analysis of the levels of pH and organic matter in the soil, for the orange tree cultivation in the Álamo Temapache Veracruz production area, through the soil analysis of the soil and its interpretation.

2. Materials and methods
Location
The project was developed in different communities in the municipality of Álamo Temapache, Veracruz in the spring-summer 2013 cycle, as part of the project entitled "Promotion of innovation to improve citrus yield in the Huasteca Region of Veracruz and Hidalgo" Linked to Universidad Autónoma Chapingo and the Directorate of Agricultural Development of the Municipality of Álamo.
Evaluated variables
The following municipalities were sampled: Adalberto Tejeda, Álamo tortuga, Ampliación reforma, Buena vista, Buenos aires, Chapopote, Citlaltepec, Hermenegildo Galeana, Ilusión, Inde-pendencia, La camelia, La esperanza, La espe-ranza, La mata, La providencia, La reforma, Las cañas, Limonar, Llano grande, Loma larga, Lucio blanco, Macario Cortez, Monte chiquito, Ojival Santa María, Otatal, Paso del perro, Rancho nuevo, Raudal nuevo, Raya oscura, Rodríguez clara, Tamatoco, Toaco, Tumbadero, Tumbadero del águila y Vara alta. Each of the producers who trained five ZIGZAG samples at 30 cm^{-1} depths in each farm was previously trained. The samples were mixed to generate a compound and take a kg^{-1} that was sent to laboratories Nutre Plantas and CEDEFRUT located in Texcoco de Mora state of Mexico and Tlapacoyan Veracruz, respectively.

The variables that were evaluated were: pH which was measured with a potentiometer in a 1: 2 soil-water ratio; organic matter (Walkley and Black, 1934); Nitrogen by kjeldahl method (Hesse, 1971); phosphorus by the method of Olsen (1954); potassium by the method of Bray and Kurtz (1945).
### Analysis of the data
Sampling was simple randomized and the sample size was defined based on the conditions of each community (n = 10 to 30). The results obtained from each soil sampling were represented by an analysis of the distribution of frequencies and in this way to know the number of times a random variable was presented, a value of 10 ranks was taken to classify the results, R software (version 64 3.2.0). In order to elaborate a nutritional diagnosis, Etchevers (1987) proposed the following formula to generate a fertilization dose: Fertilizer dose = f (nutrient demand per crop (A) - availability of nutrients in the soil (B)/fertilizer efficiency (C)). The nutritional demand to calculate the fertilization dose was proposed by Maldonado *et al.* (2008), where they mention that for each ton of fruit produced, 1.86 kg^{-1} of N are extracted y 0.17 kg^{-1} of P; 2.25 kg^{-1}K.

3. Results and discussion
pH
The pH fluctuated in the different samples analyzed, in communities such as the Ojital Santa Maria values of 4.64 were obtained in contrast to the Tamatoco, which was found to be pH 8.36. The frequency analysis performed on this variable showed that 70.12% of the total soil is between 7.03 -7.43 (Figure 1A), based on the official Mexican norm NOM-021-RECNAT-2000, which establishes the specifications of fertility, salinity, soil classify-cation, are in a moderately alkaline classification, with this same reference we found that 1.54% of total poplar soils are acidic, 8.51% are moderately acidic, 19.65% neutral, 70.12% moderately alkaline and 0.15% to alkaline soils.
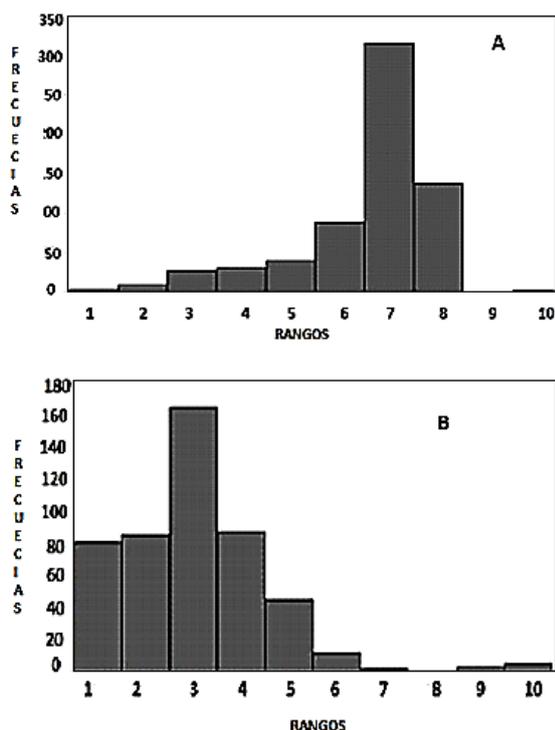
Figure 1. Frequencies of pH and organic matter (mg kg-1) in ten ranges, pH (1 = 4.635-5.035, 2 = 5.035-5.435, 3 = 5.435-5.835, 4 = 5.835-6.235, 5 = 6.235-6.635, 6 = 6.635-7.035, 7 = 7.035-7.435, 8 = 7.435-7.835, 9 = 7.835-8.235, 10 = 8.235-8.635), organic matter (1 = 0.245-1.145, 2 = 1145-2.45, 3 = 2.045-2.945, 4 = 2.945-3.845, 5 = 3.845-4.745, 6 = 4.745-5.645, 7 = 5.45-6.546, 8 = 6.545-7.445, 9 = 7.445-8.345, 10 = 8.345-9.245).

On the one hand, these results contrast with those obtained by Bautista *et al*. (1998) in their study for the classification of soils for productive purposes in Córdova, Veracruz, where they found that the pH was 80% acid and 20% neutral in the twenty-five soil samples made to nine communities. On the other hand, Cheng *et al*. (2016) in conducting a study to evaluate the quality of soils for orange production in China, found a wide variation in pH ranging from 3.75 to 8.23, with acidest soils. Citrus fruits develop well in a pH range from 4 to 9, however the optimal pH is between 5.5-7 (Molina, 2000). It is probable that the results are due to the fertilization applied in the zone, Liebig *et al*. (2002) mention that the application of fertilizers contributes to the decrease or increase of pH in the soil, this effect depending on the damping capacity of the same.

Organic material
Organic matter (OM) is an active fraction of the soil its importance is vital in the productivity and sustainability of agricultural systems (Carter, 2002). The results obtained for this variable presented a wide fluctuation, values in communities such as "La Mata" and "Camelia" obtained values of 0.25% and in "Otatal" and "Vara Alta" values above 8%. The frequency analysis performed with 10 classes found that the range with the highest number of samples is 2.045-2. 945%, with a total of 34.44% of the samples corresponding to soils with an average MO content (Figure 1B). Based on what was proposed by NOM-021-RECNAT-2000, 5.63% were very poor soils, 6.26% poor soils, 15.44% moderately poor soils, 20.04% soils, 23.59% moderately rich soils, 17.32% rich soils and 11.69% soils rich in OM. Cheng *et al*. (2016) found that most of the orange crop is grown under conditions of low organic matter with contents ranging from 5.46 to 12.7 g kg^{-1} as in the case of Álamo Temapache, Veracruz. The wide variability in the results is supported by SAGARPA (2012) in a study of delimitation and integration of a National Network of Agro-technological Observatories (OATs), supported by ninety samples by producing areas of Veracruz, found that the average content of organic matter reaches more than 3% considered as medium, but with wide variability and very rich sites that exceed 5% and very poor sites with 0.7%. Contains low amounts of organic matter, so increasing the percentage of organic matter by incorporating organic residues would help improve physical-mechanical conditions (Zhang *et al*., 2002). The results can be attributed to the management given to the soil for the production of orange, Álvarez (2001) and Lavado (2006), mention that the level of organic matter is dependent on the climate, soil and its management (tillage, rotations, fertilization) and the intensification of agricultural activity produces deterioration in OM levels.

Nitrogen phosphorus and potassium
The statistical frequency analysis indicated that 38.69% of the samples were found in a range of 2.095-12.095 mg kg^{-1} and 46,36% in 12.095-22.095 mg kg^{-1} (Figure 2A).
These results indicate that 74.30% of the soils present low nitrogen content (NOM-021-RECNAT-2000; Hardy *et al*., 2012).
Cruz *et al*. (2015) when assessing soil nitrogen dynamics in "La Mancha" Veracruz, found low element levels in all soil samples, with values ranging from 0.17 to 0.39 mg kg^{-1}. These results may be due to the fact that nitrogen is a vital element in agricultural production and because the large amount required is the element that is found to be lesser in most soils (Echeverría and Sainz Rozas, 2005). Likewise, the levels of organic matter are low, which directly influences the nitrogen content of the soil (Echeverría and Sainz, 2007).

Phosphorus deficiencies limit crop production and is one of the major global problems in soil fertility (Rashid *et al.*, 2005). Phosphorus was an element that behaved similarly in most samples, the statistical range raised 0.445-19.445 mg kg^{-1} was the one that obtained 96.9% of the values (Figure 1B) and according to Hardy *et al.* (2012) and NOM-021-RECNAT-2000 correspond to soils with a mean element content. These results may be due to phosphorus soil precipitation or fertilization with elements such as iron or calcium (Khiari *et al.*, 2005). The potassium evaluated in the samples presented little fluctuation, the range that obtained the highest number of values was 60-203 mg kg^{-1} which represents 71.82% of the total of the samples, based on the NOM-021- RECNAT-2000, potassium levels are high. These results coincide with those found by Geissert and Ibañez (2008) in their studies to evaluate the edaphic quality and nutrient availability in agricultural soils of the central zone of Veracruz, where the seven samples evaluated had potassium values that fluctuated between the 50.74, 136.85, 163.8, 218.96, 222.87, 238.51-492 mg kg^{-1} indicating that more than 70% of the samples are under optimum potassium conditions. The results can be attributed to that in a large part of the soils, a high concentration of potassium can be observed in the first 30 cm^{-1} (Brito and Rolim, 2005). However, citrus fruits remove a large amount of potassium, mainly fruits, is an element that is required in greater quantity after nitrogen (Molina, 2000), so it is necessary to take it into account in fertilization.

Dose of fertilization

The nutritional requirement of the crop was calculated by considering the extraction per ton of fruit harvested, with an expected yield of 20 t • ha^{-1}, the plant's investment in organ generation and maintenance, and the efficiency of fertilizers, so that, under the concept of restitution, an optimum fertilization of N, P2O5, K2O kg • ha^{-1} was defined (Table 1).
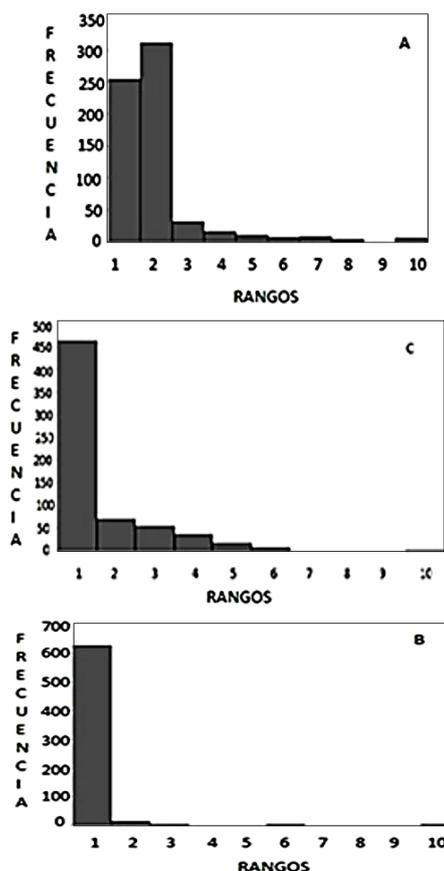
Figure 2. Frequencies of Nitrogen (mg.kg^{-1}) (A), Phosphorus (mg.kg^{-1}) (B) and Potassium (mg.kg^{-1}) (C) in ten ranges, nitrogen (1 = 2.095-12.095, 2 = 12.095-22.095, 3 = 22.095 -32.095, 4 = 32.095-42.095, 5 = 42.095-52.095, 6 = 52.095-62.095, 7 = 62.095-72.095, 8 = 72.095-82.095, 9 = 82.095-92.095, 10 = 92.095 -102.095) phosphorus (1 = 0.445-19.445, 2 = 19.445-38.445, 3 = 38.445-57.445, 4 = 57.445-76.445, 5 = 76.445-95.445, 6 = 95.445-114.445, 7 = 114.445-133.445, 8 = 133.445 -152.445, 9 = 152.445-171.445, 10 = 173.445-190.445), potassium (1 = 60-203, 2 = 203-346, 3 = 346-389, 4 = 489-632, 5 = 632-775, 6 = 775-918, 7 = 918-1061, 8 = 1061-1204, 9 = 1204-1347, 10 = 1347-1490).

Table 1

Doses of fertilization by rank to produce 20 tons of fruit per hectare

Nitrogen		Rank	Match mg kg^{-1}	Dose	Rank	Match mg kg^{-1}	Dose	Rank	Potassium mg kg^{-1}	Dose
Rank	Dose	Rank	mg kg^{-1}	Dose	Rank	mg kg^{-1}	Dose	Rank	mg kg^{-1}	Dose
2.095	47.4528	2	12.095-22.095	0	1	0.445-19.445	0	1	60-203	0
3.095	41.6928	3	22.095 -32.095	0	2	19.445-38.445	0	2	203-346	0
4.095	35.9328	4	32.095-42.095	0	3	38.445-57.445	0	3	346-389	0
5.095	30.1728	5	42.095-52.095	0	4	57.445-76.445	0	4	489-632	0
6.095	24.4128	6	52.095-62.095	0	5	76.445-95.445	0	5	632-775	0
7.095	18.6528	7	62.095-72.095	0	6	95.445-114.445	0	6	775-918	0
8.095	12.8928	8	72.095-82.095	0	7	114.445-133.445	0	7	918-1061	0
9.095	7.1328	9	82.095-92.095	0	8	133.445-152.445	0	8	1061-1204	0
10.095	1.3728	10	92.095-102.095	0	9	152.445-171.445	0	9	1204-1347	0
11.095	0				10	173.445-190.445	0	10	1347-1490	0

** Apparent density = 1.2, Fertilization efficiency: nitrogen 60%, phosphorus 20% and potassium 60%.

It can be observed that in general, the fertilization dose is only circled by nitrogen. Maldonado *et al.* (2008), found that the substitution method can help find the best fertilizer dose, which reduces economic losses and pollution. In their study in 'Persian' lemon, they observed that the regional fertilization recommendation was 828 grams per nitrogen plant per tree; when applying the restitution method, the fertilization dose found was less than half (828 g to 310 g per tree of N), and a significant increase in yield was obtained, implying a better efficiency of fruit produced by applied nitrogen.

Alva *et al.* (2006) significantly improved the efficiency of N utilization in 'Hamlin' orange, since it only used 2.2 - 2.3 kg of N to produce a Mg of fruit, through an efficient use of irrigation and the management of the fertilizer. Koo *et al.* (1984) found that 4.4 kg of N were required to produce 1 Mg of fruit. Maldonado (1999) found a ton of Mexican lime fruit containing 1.8 kg of N.

The pH evaluated in the samples indicated that the majority are alkaline, the fertilization should be with superfostofato, anhydrous ammonia, or ammonium sulphate, monoammonium phosphate and diammonium phosphate, which have a higher acidity index than ammonium nitrate, anhydrous ammonia and urea (FAO, 1992).

Conclusions

The pH levels in the soils are mostly alkaline, results that are influenced by the type of fertilizers that are applied in the zone, reason why to lower to the optimum level is a necessary task. Organic matter in general is found in stable soil conditions, only 5.63% are very poor soils, 6.26% are poor soils and 15.44% are moderately poor soils. The levels of potassium and phosphorus fertilizers are in optimal conditions so the recommended doses did not include fertilization of these elements, although the nitrogen in the soils is low, therefore the recommended doses for the rank one which fluctuated from the 4 to 2 kg ha^{-1} of nitrogen.

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