RESEARCH / INVESTIGACIÓN

Effect of sulphuric acid on roses crop (Rosa sp.)

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Abstract: The chemical effects of sulfuric acid produced by a sulfuric acid-generating machine include lowering the pH of the water to increase the bioavailability of nutrients in the soil and then be easily absorbed by the plant. This research determined the effect of sulphuric acid produced by the SAG machine on the productivity of the cultivation of roses (*Rosa sp.*) in the OK Roses S.A. floricultural farm, in Cotopaxi, Ecuador. The research method was descriptive, quantitative, and it had a quasi-experimental design. Primary data collection was obtained from the productivity field records and laboratory analyses of water, soil, and foliage. The results showed that the generation of sulphuric acid produced by the SAG machine lowers the pH and bicarbonates in the water. This process allowed the elements bioavailability from soil to plant like Mg and S and microelements like Fe, Mn, Cu, and Zn. The productivity index stem-plant^{-1} month^{-1} increased by 16.16% over two years.

Key words: roses crop, *Rosa sp*, sulphuric acid.

Introduction

Roses are the best known and sold flowers in the world. According to some researches, Lamz[1], Navarro[2], García[3], and Food and Agriculture Organization of the United Nations[4] salt stress causes physiological and biochemical changes in the metabolism of rose cultivation, conditioning its productivity. For Gardi[5] and Xu[6] the quality parameters required by the international market for fresh rose have contributed to the accelerated deterioration of the soil-water-plant-environment system, mainly due to the high residuality of acidifying agrochemicals applied to this monoculture; causing compaction, destruction of aggregates, and disappearance of macropores from the first 30 cm of the soil. According to Martínez[7], this limits the ionic availability of nutrients, which limits the agronomic efficiency, productivity growth, and profitability of the crop. In the opinion of Sánchez[8], soil degradation is also linked to irrigation with sodium bicarbonate groundwater.

Investigations conducted in Morocco by Bourakhouadar[9] in alkaline waters and saline/sodium soils concluded that the use of irrigation water treated with a SAG machine (sulphuric acid-generating) produced rapid desalination, and decreased sodium. This improves soil permeability and aggregation, facilitating the leaching of salts. The water that initially had an alkaline pH of 8.4, by SAG machine intervention was reduced to 6.0. The HCO_{3^-} bicarbonates decreased from 3.5meq L^{-1} to 0.95meq L^{-1}. In the same way, Ahmad[10] said the barley lots with SAG treated water, and zero tillage increased 19% (Kg/acre) in the yield. Technical records at the OK Roses S.A. flower farm indicated the water of irrigation is alkaline because that exceeds 200 ppm of bicarbonates and pH over 8 points. This condition limits the ionic availability of nutrients and decreases the productivity of stems for export. In this context, this research focused on analyzing the quality of irrigation water with the intervention of the SAG machine, determining the influence of the sulphuric acid produced by the SAG machine on the bioavailability of soil nutrients, and finally, evaluating the productivity of Rosa Freedom cv and Rosa Vendela cv.

Methods

The floricultural farm is located in the inter-Andean region of Ecuador, Cotopaxi, Latacunga at 2910 meters above sea level. The soil is clay loam. The daily total irrigation sheet is 469.47 m^3. The absolute maximum average temperature is 20.3°C. The precipitation annual average is 396.6 mm. The population was represented by the cultivation of *Rosa sp.* Freedom and Vendela cultivars under the greenhouse with an initial productivity index of 0.76 stem-plant^{-1} month^{-1} for the Freedom cv, and 0.89 stem-plant^{-1} month^{-1} for the Vendela cv. The total production area was 56200m^2. Data for Freedom cv were obtained in block one of 7602m^2, and data for Vendela cv were obtained from block six of 4671 m^2.

The SAG machine is based on the principle of co-production of sulphuric acid and hydrogen with proportions that are friendly to water, soil, and air. This technology neutralizes waters saturated with mineral-salts, also saline or sodium soils. Buhidar[11] explains the physical-chemical process begins with the introduction of alkaline water through a pressurized line that maintains the constant internal pressure into the machine. Then elemental sulfur with a purity of 99.9% is incorporated and burned in a combustion chamber at a temperature above 205 °C. One-tenth of the oxygen-rich water supply is introduced under pressure forward two "venturi." This process creates a vacuum. The elemental sulfur (S) ignites in the combustion chamber and melts. The molten sulfur is oxidized to create sulfur dioxide (SO^2), which spreads down the pipe to mix with water, and it forms sulfurous acid with pH 2 in (Equation I), then sulphuric acid with pH 6.5 in (Equation II).

(I)

$$SO_2 + H_2O \longrightarrow H_2SO_3 + \frac{1}{2}\,O_2$$

(II)

$$2SO_2 + 2H_2O + O_2 \longrightarrow 2H_2SO_4$$

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The hydration values (Equation II) for the production of sulphuric acid are defined as 64.06 g/mol + 18.015 g/mol + 31.998 g/mol = 98.078 g/mol.

The SAG machine was installed on the flower farm in May 2016. Data was collected and analyzed at two-time points. The first period was from May 2014 to January 2016. The second period was from May 2016 to April 2018.

Laboratory analyses of water, soil, and foliage were performed. The inferential statistic was applied to the obtained data from inductive reasoning. The approach was quantitative, and the design quasi-experimental. Analysis of Variance (ADEVA) was used with Fisher's mean test (α=0.05) to determine the stem-plant^{-1}month^{-1} productivity index of the two cultivars.

The analysis focused on the following variables:

Variables analyzed in water were Hydrogen potential (pH) and bicarbonates (HCO_3). Variables analyzed in the soil were pH, C.E., N, P, K, Ca, Mg, S, Na, B, Mn, Cu, Zn, and Fe. Variables analyzed in the foliage were N, P, K, Ca, Mg, S, Na, B, Mn, Cu, Zn, and Fe. Variables analyzed in the productivity were Productivity Index (P.I.) about stem-plant^{-1} month^{-1} and stem-length (S.L.) for export.

Results and Discussion

Effects on water

The water pH decreased from 8.28 to an average of 6.47 on the scale, complying with the technical requirements for fertigation processes in rose cultivation. Bicarbonates dropped from 319 ppm to an average of 64.77 ppm (Figure 1). According to Aza[12], bicarbonates above 200 ppm hinder the absorption of microelements, as well as the capture of macroelements like Ca and Mg. These two parameters in the water directly influenced the ionic availability of nutrients in the soil.

Bourakhouadar[9] concluded that irrigation with SAG-treated water produced rapid desalination, and sodium decreased. This improved permeability and soil aggregation, which in turn facilitated the leaching of salts. The water initially had an alkaline pH of 8.4, but by the intervention of the SAG machine, it was reduced to 6.0. The E.C. suffered a slight increase from 0.56 to 0.64 dS m^{-1}. The HCO3-bicarbonates initially from 3.5 meq L^{-1} decreased to 0.95 meq L^{-1}.

Effects on soil

The results indicated that the pH of the root zone (water bulb) at 20 cm from the ground, decreased by 0.24 and 0.25 in blocks one and six in Freedom and Vendela cultivars, respectively. This meant 1.6 times more acid, according to Scott[13]. In a free soil like it is the case of this farm, "a CE 0.5 mS cm^{-1} represents an energy consumption of 67.5%, and a CE 1.0 mS cm^{-1} represents an energy consumption of 80.6%"[14]. It decreases in C.E. could indicate a lower energy expenditure of the plant with the installation of the SAG machine, and directly influence productivity rates.

Soil and foliar analyses revealed the nutritional availability that the soil is providing as assimilable to the plant. After the intervention of the SAG machine, the bioavailability of macro and micronutrients were directly reflected in the plant tissue (Table 1).

Effects on plant

The data indicated the concentrations of Mg and S became "Normal" in the plant, which is 0.36% and 0.25% by Freedom cv, and 0.37% and 0.27% by Vendela cv, respectively. In the same way, micronutrients like Fe, Mn, and Cu presented "Normal" concentrations in the Vendela cv, that is, 146.33 mg kg^{-1}, 147.33 mg kg^{-1}, and 7.84 mg kg^{-1}, respectively. These data indicated that the implementation of the SAG machine improves the nutritional balance of the plant, which can be verified in the productivity of the crop.

The results obtained by the Analysis of Variance ADEVA, with the Fisher's mean test (α=0.05) for the productivity index stem-plant^{-1} month^{-1} of Freedom and Vendela cultivars, indicated that the factors "SAG Machine" and "Cultivar" are statistically significant; however, it was not significant for the "Machine: cultivar" interaction.

The analysis for the factor "SAG Machine" (Figure 2) indicated that the mean productivity index stem plant^{-1} month^{-1} for both cultivars Freedom and Vendela, reached 0.99, that is, 16.16% more than 0.83 stem-plant^{-1} month^{-1} before establishing the SAG machine. So the SAG machine had a positive effect on the productivity index stem-plant-1 month-1 in the cultivation of *Rosa sp.* According to Aza[12] the best productivity index of the Freedom cv in Ecuadorian flower farms is 1.0 stem-plant^{-1} month^{-1} with more demanding quality parameters like bud size, vase life, size, and foliage color.

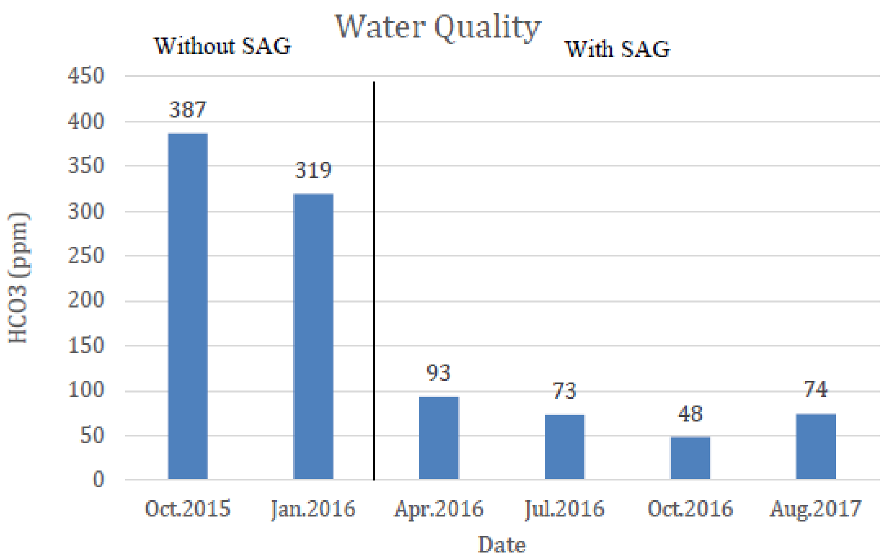

Figura 1. Bicarbonates present in the water before and after of the SAG machine intervention. Note: Taken from water analyses by AGQ Labs & Technological Services (2015-2017)

			Soil				Plant				Absorption rate by the plant	
Block	Cultivar	Variable	Without SAG (ppm)	With SAG (ppm)	Optimum range in soil (ppm)	Extraction method	Without SAG	With SAG (% and mg kg^{-1})	Optimum range in the plant (% and mg kg^{-1})	Variation in% of assimilation by the plant	Without SAG	With SAG
1	Fre	N	3029.00	2860.25	1000-1500	Kjeldhl/dumas	3.87	3.62	3-5%	-6.43	Normal	Normal
6	Ven	N	2037.00	2046.00	1000-1500	Kjeldhl/dumas	4.49	3.99	3-5%	-11.25	Normal	Normal
1	Fre	P	213.00	168.25	30-60	Olsen	0.26	0.31	0.20-0.30%	19.23	Normal	High
6	Ven	P	207.00	249.00	30-60	Olsen	0.31	0.33	0.20-0.30%	5.16	Normal	High
1	Fre	K	1305.90	957.95	195-312	Ammonium Acetate	2.01	2.15	1.6-2.5%	7.05	Normal	Normal
6	Ven	K	887.60	610.00	195-312	Ammonium Acetate	1.99	2.22	1.6-2.5%	11.46	Normal	Normal
1	Fre	Ca	4909.60	4639.03	1600-2800	Ammonium Acetate	1.05	1.02	1-2%	-2.54	Normal	Normal
6	Ven	Ca	3687.20	2965.80	1600-2800	Ammonium Acetate	1.47	1.40	1-2%	-5.10	Normal	Normal
1	Fre	Mg	1227.40	936.95	180-300	Ammonium Acetate	0.44	0.36	0.3-0.4%	-17.42	High	Normal
6	Ven	Mg	851.90	669.60	180-300	Ammonium Acetate	0.44	0.37	0.3-0.4%	-15.68	High	Normal
1	Fre	S	-	-	-	-	0.16	0.25	0.20-0.40%	53.13	Low	Normal
6	Ven	S	-	-	-	-	0.18	0.27	0.20-0.40%	50.00	Low	Normal
1	Fre	Na	344.80	235.63	58-174	Ammonium Acetate	249	260.44	0.01-0.04%	4.60	Very High	Very High
6	Ven	Na	186.20	128.70	58-174	Ammonium Acetate	249	264.40	0.01-0.04%	6.18	Very High	Very High
1	Fre	B	4.34	7.03	0.6-1.0	DPTA	251	262.00	40-80 mg kg^{-1}	4.38	Very High	Very High
6	Ven	B	4.63	6.77	0.6-1.0	DPTA	252	262.30	40-80 mg kg^{-1}	4.09	Very High	Very High
1	Fre	Mn	19.20	8.49	1-5	DPTA	49.8	105.00	100-300 mg kg^{-1}	110.84	Very Low	Normal
6	Ven	Mn	33.00	12.50	1-5	DPTA	52.9	147.33	100-300 mg kg^{-1}	178.51	Very Low	Normal
1	Fre	Cu	7.87	6.27	0.4-1.0	DPTA	5.93	6.49	7-17 mg kg^{-1}	9.42	Low	Bajo
6	Ven	Cu	13.00	12.00	0.4-1.0	DPTA	4.9	7.84	7-17 mg kg^{-1}	59.95	Very Low	Normal
1	Fre	Zn	11.70	12.43	1-2	DPTA	47.4	62.80	15-50 mg kg^{-1}	32.49	Normal	High
6	Ven	Zn	25.00	28.80	1-2	DPTA	11.5	44.15	15-50 mg kg^{-1}	283.91	Low	Normal
1	Fre	Fe	39.90	22.26	4-10	DPTA	403	192.33	80-150 mg kg^{-1}	-52.27	Very High	High
6	Ven	Fe	78.40	32.00	4-10	DPTA	339	146.33	80-150 mg kg^{-1}	-56.83	Very High	Normal

Tabla 1. Macro and micronutrients behavior in the soil and ranges of absorption by the plant in Freedom and Vendela cultivars with SAG machine. Note: Taken from the soil and foliar analyses by AGQ Labs & Technological Services (2014-2018)

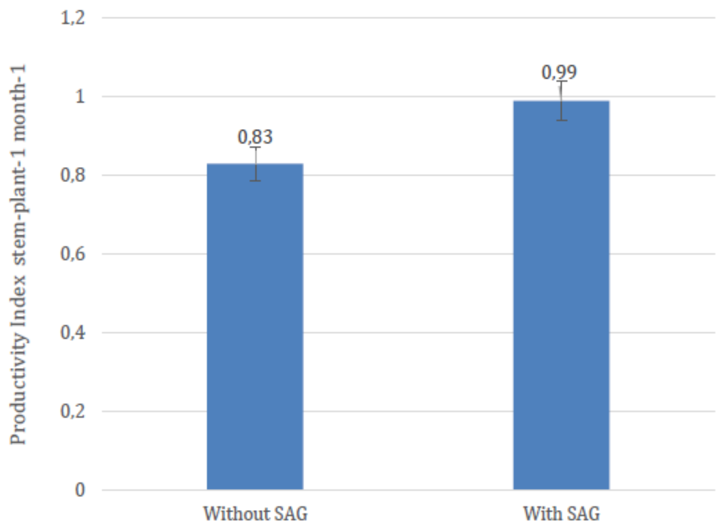

Figura 2. Productivity Index of Freedom and Vendela cultivars with SAG machine.

In Pakistan, Ahmad[10] indicated the maximum yield was obtained in the barley lots where it was irrigated exclusively with water treated with SAG machine, and zero tillage. The increase in productivity was 19% and 15%. Soil pH dropped using SAG-treated water, while irrigation with untreated water increased pH.

On the other hand, there was not a statistic effect on the stem-length (S.L.) by use SAG machine.

Conclusions

The quality of irrigation water for rose cultivation at the OK Roses S.A. flower farm improved in two parameters after using the SAG machine as an alternative means of agricultural production. It lowered the pH from 8.28 to an average of 6.47. It decreased bicarbonates (HCO_3) from 319 ppm to an average of 64.77 ppm. The data indicated that the ionic availability of micronutrients like Fe, Mn, and Cu; also, secondary nutrients like Mg and S was improved, which was verified in the increase of productivity indexes of Freedom and Vendela cultivars. The productivity indexes were 0.99 stem-plant^{-1} month^{-1}, that is, 16.16% more than 0.83 stem-plant^{-1} month^{-1} before establishing the SAG machine. Framed in the results, the alternative hypothesis was accepted "The productivity of rose Freedom and Vendela cultivars is greater with the implementation of the SAG machine as an alternative means of production in the Ecuadorian flower farm."

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