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Climate Variability and Mineral Fertilization Programs Influences Nitrogen Losses in Coffee

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Introduction

Nitrogen (N) is the most demanded and applied nutrient in Coffee production systems[1]. Reduce N losses by ammonia (NH_3) volatilization and nitrate (NO_3^-) leaching and understand the interaction between Fertilization programs and climate variability it important to improves NUE and reduces indirect green house gases emissions. We aimed to quantify N losses via leaching and volatilization under two contrasting fertilization programs in a Colombian coffee plantation and assess their sensitivity to El Niño/La Niña-Southern Oscillation (ENSO) phases[2].

Figure 1: Lysimeters and volatilization chambers in the field study

Materials/Methods

Two years trials (2022 to 2024) located in Central-west Coffee region of Colombia. 3 treatments 4 replication: T1:Urea-based NPK (UB-NPK) T2: ammonium-nitrate based NPK (ANB-NPK), and T3: control without N. During 2022 to January 2023 La Niña-ENSO conditions dominated and during April 2023 to December 2024 El Niño-ENSO dominated. N leaching was measured using drainage type Lysimeters and volatilization semi-static PVC chamber (Figure 1)

Period/ENSO conditions	N Source	N-applied ($g.m^{-2}$)	N-losses			Relative Losses (%)
			Leaching ($g.m^{-2}$)	Volatilization ($g.m^{-2}$)	Total ($g.m^{-2}$)	
Sep 2022 to Jan 2023 "La Niña"	UB-NPK	22.7	15.3	-	15.3	54.5
	ANB-NPK	18.1	8.6	-	8.6	31.3
	Control without N	0.0	2.9	-	2.9	--
Jan 2023 to Apr 2023 "La Niña-neutral"	UB-NPK	40.8	3.3	14.6	17.8	24.9
	ANB-NPK	31.7	10.7	8.7	19.5	37.5
	Control without N	0.0	1.7	5.9	7.6	--
Apr 2023 to Sep 2023 "Neutral-El Niño"	UB-NPK	54.4	0.75	14.5	15.3	17.4
	ANB-NPK	49.9	4.44	4.1	8.5	5.4
	Control without N	0.0	0.5	5.3	5.8	--
Sep 2023 to Jan 2024 "El Niño"	UB-NPK	22.7	0.8	12.5	13.3	37.0
	ANB-NPK	13.6	3.4	4.2	7.6	19.9
	Control without N	0.0	1.3	3.6	4.9	--
Jan 2024 to Mar 2024 "El Niño"	UB-NPK	54.4	0	48.21	48.21	65.3
	ANB-NPK	40.1	0	15.1	15.1	6.1
	Control without N	0.0	0	12.6	12.6	--
Mar 2024 to Aug 2024 "El Niño"	UB-NPK	63.5	0.16	32.4	32.5	29.5
	ANB-NPK	54.4	0.73	14.8	15.3	3.6
	Control without N	0	0.22	13.8	13.6	--
Total	UB-NPK	258.5	20.3	122.2	142.6	37.0
	ANB-NPK	207.8	27.9	47.3	74.9	13.0
	Control without N	0	6.62	40.9	47.5	--

Table 1: Nitrogen losses during La Niña/El Niño ENSO conditions for two mineral N programs.

Results/Discussion

Nitrogen losses were influenced by the climate variability conditions. During the negative phase of the ENSO-La Niña nitrate (NO_3^-) leaching dominated the losses in both N sources, with 39% of total N applied leached in the UB-NPK and 35% in the ANB-NPK treatment.

During the positive phase of the ENSO, N losses were dominated by NH_3 volatilization where UB-NPK resulted in significantly higher volatilization losses compared to ANB-NPK, with 40 and 10% of total N lost with the two fertilizer treatments, respectively. After two years trial with six mineral fertilizer applications, total mean N losses by leaching and volatilization were 37% for the UB-NPK and 13% for the ANB-NPK (Table 1).

Conclusion/Perspectives

Ammonium nitrate-based fertilizers proved to be more efficient nitrogen sources due to lower nitrogen losses, showing higher flexibility in application timing under extreme weather conditions like those generated during the climate variability scenarios of El Niño/La Niña-Southern Oscillation and promoting better nitrogen use efficiency (NUE) under tropical conditions.

References:

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