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KINETICS OF CADMIUM BIOACCUMULATION IN SEEDS OF FIVE CACAO VARIETIES

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OBJECTIVES.

Cadmium (Cd) is a non-essential heavy metal for cocoa which one accumulates in the seeds and its consumption as chocolate is harmful to health; however, exist hypo-accumulative varieties which can guarantee its innocuousness. To study the kinetics of Cd bioaccumulation in the seeds of five cocoa varieties identifying those with the lowest accumulation, it was our objective.

METHODOLOGY.

Five varieties of cocoa S-08 (ICS-95 x UF-296), S-12 (ICS-1 x SCA6), S-23 (IMC-67 x U-68), S-28 (ICS-39 x U-45), and C-60 (farmer's variety), were used. The soil chemical analyzes (initial and final), microelements and Cd by atomic absorption spectroscopy in the seeds were carried out monthly during the harvest. Dispersion data were fitted to a curvilinear polynomial regression model ($Y = b_0 + b_1X_1 + b_2X_2$) and then were analyzed in a randomized complete block design and Tukey's test ($\alpha \leq 0,05$). Likewise, Pearson's correlation and biplot analyzes were performed. To determine the maximum Cd level in the cocoa mass, the Meter's et al. (2019) formula was used. Statistical analyzes were performed with the PAST software (2020), vers. 4.04.

RESULTS.

The kinetics of the accumulation of Cd in the seeds showed a reductional trend from June to September (summer) characterized by the scarcity of rains, and a slight increase from October to November (beginning of winter) with more frequent rains, accumulating 0,894 ppm of Cd on average (Table 1, Figure 1).

Table 1. Cd accumulation (ppm) in seeds of five cocoa varieties.

Variety	Cadmium (ppm)						Average (ppm)	Tukey ($\alpha \leq 0.05$)
	Jun.	Jul.	Ago.	Sept.	Oct.	Nov.		
S-12	1,875	0,450	0,775	0,713	0,875	1,050	0,956 ± 0,20	a
S-23	2,538	0,488	0,788	0,913	0,713	1,413	1,142 ± 0,31	a
C-60	1,400	0,738	0,575	0,738	0,725	0,713	0,815 ± 0,29	a
S-08	1,213	0,700	0,400	0,563	0,513	0,513	0,650 ± 0,29	a
S-28	1,573	0,713	0,450	0,863	0,938	0,900	0,906 ± 0,37	a
Average	1,720	0,618	0,598	0,758	0,753	0,918		

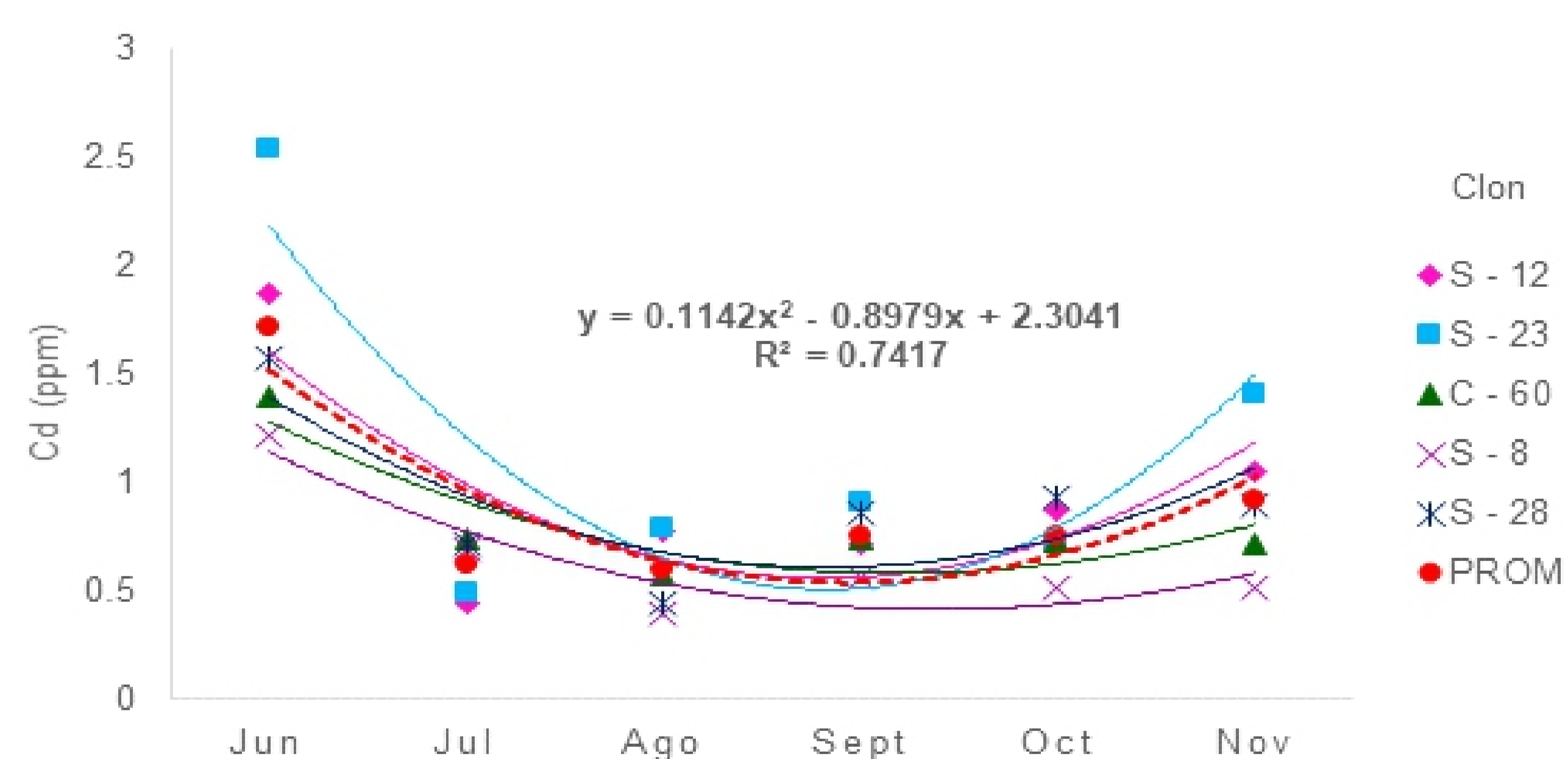


Figure 1. Cd accumulation polynomial regression curves in seeds of five cocoa varieties

A differential response between varieties was found, being S-8 and C-60 the ones with the lowest accumulation (0,650 and 0,815 ppm of Cd) respectively, being less than and equal to maximum permissible limit established by the European Community for chocolates with dry cocoa solids $\geq 50\%$, respectively. Likewise, positive, and highly significant

correlations between Cu/Zn ($r = 0,869$), Mn/Fe ($r = 0,755$), Fe/Zn ($r = 0,655$), and negative, and highly significant negative correlations between Cd/Zn ($r = -0,667$) and Cd/Cu ($r = -0,531$) and only significant between Cd/Mn, were found (Table 2).

Table 2. Correlation coefficients between Cd and microelements in the seeds of five cocoa varieties.

METALS	Cd	Zn	Fe	Cu	Mn
Cd	1				
Zn	-0,667**	1			
Fe	0,056	0,655**	1		
Cu	-0,531**	0,869**	0,439*	1	
Mn	0,365*	0,355	0,755**	0,303	1

The biplot analysis showed that Cu and Zn with positive values in PC1, are closer to S-08 than to S-28, while Mn and Cd, with negative values in PC2, are closer to the S-23 variety. The very distant Zn and Cd positions with positive values in PC1 and negative in PC2, would show dissimilarity or antagonism as shown in the correlation matrix. The values of soil chemical analysis (initial and final) for pH, O.M., C.E.C., N, P, K and Cd, did not show conspicuous differences.

CONCLUSIONS.

The kinetics of Cd accumulation in seeds of five cocoa varieties showed a reductional behavior in the dry season with tendency to increase at the beginning of the rainy season. The varieties S-08 and C-60 with 0,650 and 0,815 ppm, respectively, had the lowest accumulations below maximum permissible limit. The correlations shown antagonisms relationships between Cd/Zn and Cd/Cu, and synergistic ones between Zn/Cu, Zn/Fe and Fe/Mn. The soil chemical analysis (initial and final) did not show substantial differences.

RECOMMEDATIONS.

Future studies on Cd bioaccumulation in cocoa seeds must be done for all year and to include a greater number of genotypes of different genetic origin and hypoaccumulative potential.

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REFERENCES.

- Arévalo, E., Arévalo, C., Baligar, V., & He, Z. (2017). Heavy metal accumulation in leaves and beans of cacao (*Theobroma cacao* L.) in major cacao growing regions in Perú. *Science Total Environment*, 605-606, 792 - 800. <http://dx.doi.org/10.1016/j.scitotenv.2017.06.122>
- García, J.J. (2019). *Selección por hipoacumulación de metales pesados en órganos vegetativos y reproductivos de clones de cacao (Theobroma cacao L.) en la Estación Tulumayo*. Tesis de Ingeniero Agrónomo. Universidad Nacional Agraria de la Selva. Tingo María. Perú.
- García, L.F. (2014). *Catálogo de cultivares de cacao del Perú*. 2^{da} reimpression. Ministerio de Agricultura-DGCA. Lima, Perú. 112 p.
- Meter, A., Atkinson, E.J. & Laliberté, B. (2019). *Cadmio en el cacao en América Latina y el Caribe-Análisis de la investigación y soluciones potenciales para la mitigación*. Bioversity International, Roma.