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Linking Sanitation to Agriculture: Recycling Nutrients from Human Excreta in Food Production

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Academic Work

SANITATION ISSUES IN DEVELOPING COUNTRIES

- **Diarrhea:** main cause of infant (>4 billion of cases/year)
- **Brazil:** ≅ 50% municipalities without sewage collection
- **Existing sanitation solutions**: many impacts to environment

Sanitation technologies should be adjusted local situation:

- Economic aspects
- Cultural aspects
- Social aspects

SUSTAINABLE SANITATION

- **Alternatives to conventional wastewater treatment:**
  - Excreta segregation
  - Reuse of its nutrients
- **Examples around the world:**
  - Treatment of feaces and urine to use in agriculture
  - Sweden, Germany, Mexico, China, Zimbabwe...

HUMAN URINE AS FERTILIZER

- **Experiences:**
  - positive results for various species[7]
  - urine contains: N, P and K [8].

- **Household level:**
  - urine storage is not necessary (low risk)[9]

- **Urinals:**
  - faecal cross-contamination is excluded[10].

Source:http://www.wecf.eu/english/articles/2005/09/maize_urine.php. http://www.grida.no/publications/et/ep5/page/2823.aspx

RESEARCH OBJECTIVES

- **To evaluate**: human urine as fertilizer for corn and lettuce cultivation - effects on soil and plants;

- **To recommend:** appropriate dosages for better development of these species.

METHODOLOGY

- **Urine Collection:**
  - Waterless urinal (*Uridan*®)
  - Male toilet of university

System with a sealant liquid (blocking fluid) which is biodegradable and constitutes an effective odour barrier.

Table 1: Urine application rate for the corn and lettuce crops.

Treatment/Species	Corn	Lettuce
A	200,000 L/ha of neat urine, distributed in 8 applications once a week.*	12,000 L/ha of neat urine distributed in 3 applications (15, 30 and 45 days after seeding).
B	10,800 L/ha of neat urine, 35 days after seeding.	1,500,000 L/ha of diluted urine, distributed twice per week at a dilution of 3:1 (water: urine) during the first month, a dilution of 5:1 during the second month, and a dilution of 5:1 once per week in the third month.*
C	No urine (control).	20,000 L/ha of neat urine, one application 48 days after seeding.**
D	—	No urine (control).

* Based on Morgan. ** Based on Guadarrama*et al.*

Baseadas nas recomendações brasileiras de adubação com nitrogênio [13,14].

- 10 replicates (pots) per group.
- **Corn:** up to 3 plants / pot;
- **Lettuce**: up to 6 plants / pot.
- Substrate was commercial topsoil for planting.
- **Growth Period:**
  - 5 months to 17 days (corn)
  - 3 months and 8 days (lettuce).

METHODS

- **Small-scale experiment:**
  - Flower pots (10 / 8 / 5 L)
- **Urine applied to soil in holes:**
  - 10 cm from each plant
  - 10 cm depth[15]

- Urine storage only for treatment B of corn.
- Plant biological parameters: data analyzed by ANOVA.
- Physicochemical soil analysis: before and after cultivation period.

RESULTS - CORN

- Significant difference between treatments (p-value < 0.05)
  - **Treatment A** (highest urine concentration) had better growth and development:
    - Higher number of leaves;
    - Height;
    - leaf area;
    - Shoot dry weight;
    - Root weight;
    - Number of ears

PLANTS GROUPS

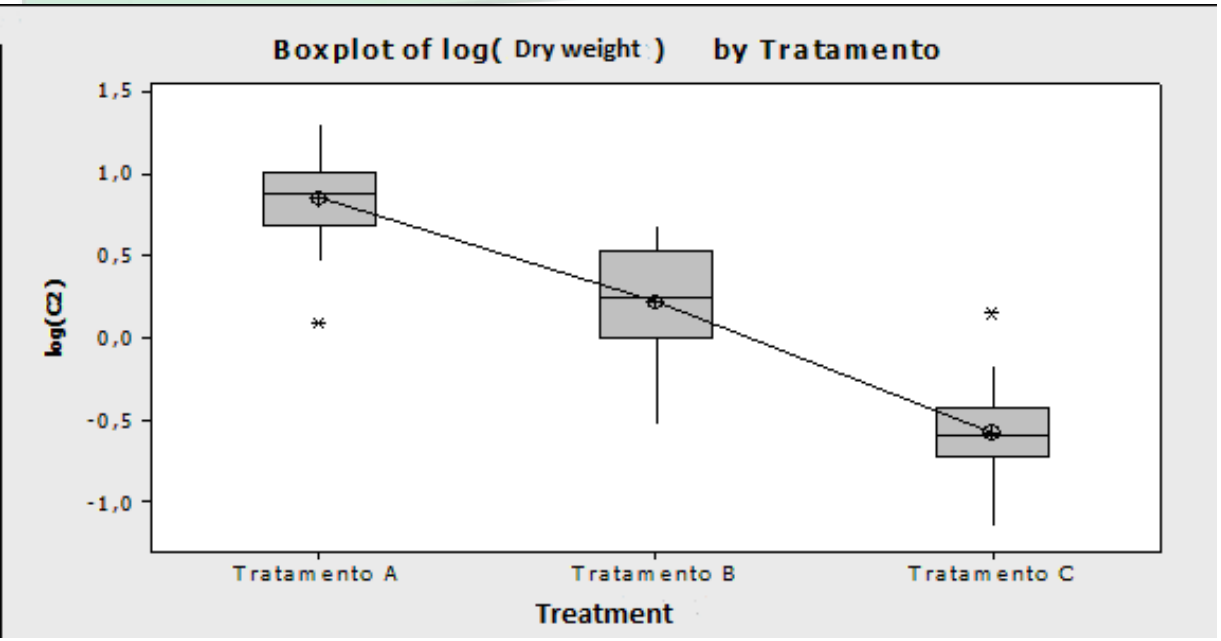
None of the plants reached physiological maturity.

Reproductive stage

N defficiency

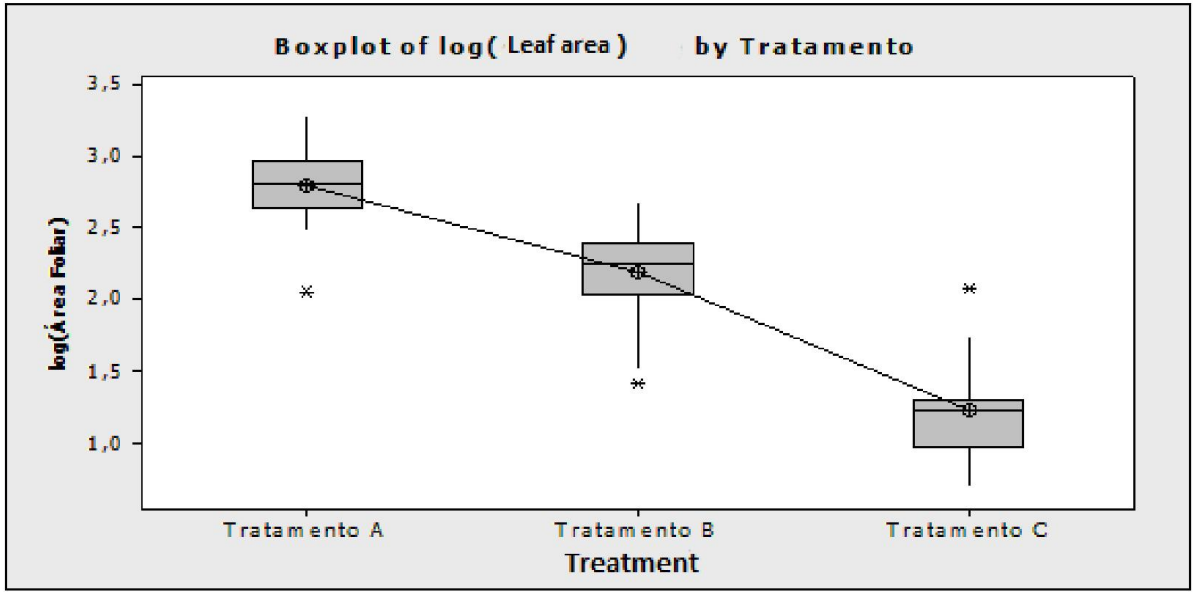
N and P defficiency

ANOVA - CORN



shoot dry weight

Leaf area



RESULTS

- **Related to:**
  - Higher nutrient uptake
  - Lower hydric deficit
  - Higher photosynthesis[16]

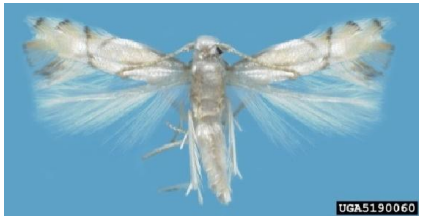
- **Soil analysis:** physicochemical characteristics did not vary significantly among the groups.

Highest dosage → lowest pH / highest electrical conductivity

RESULTS - LETTUCE

Attack of insects: mortality in all treatments (ten days)

Doru luteipes

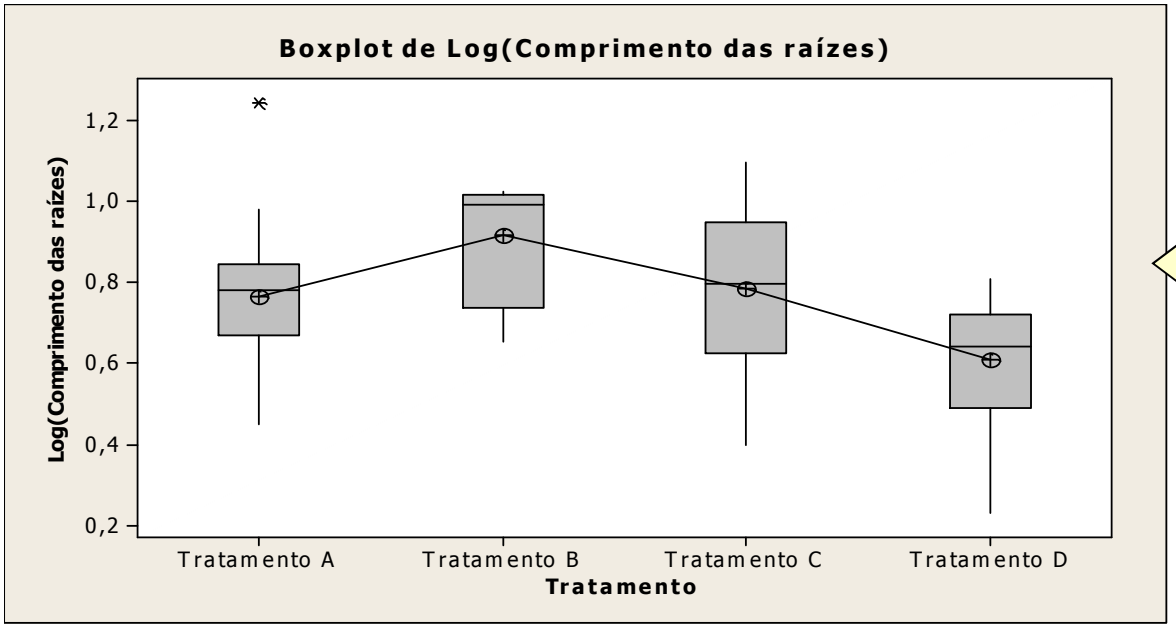


Lepdoptera: Gracilariidae

Group B: highest mortality

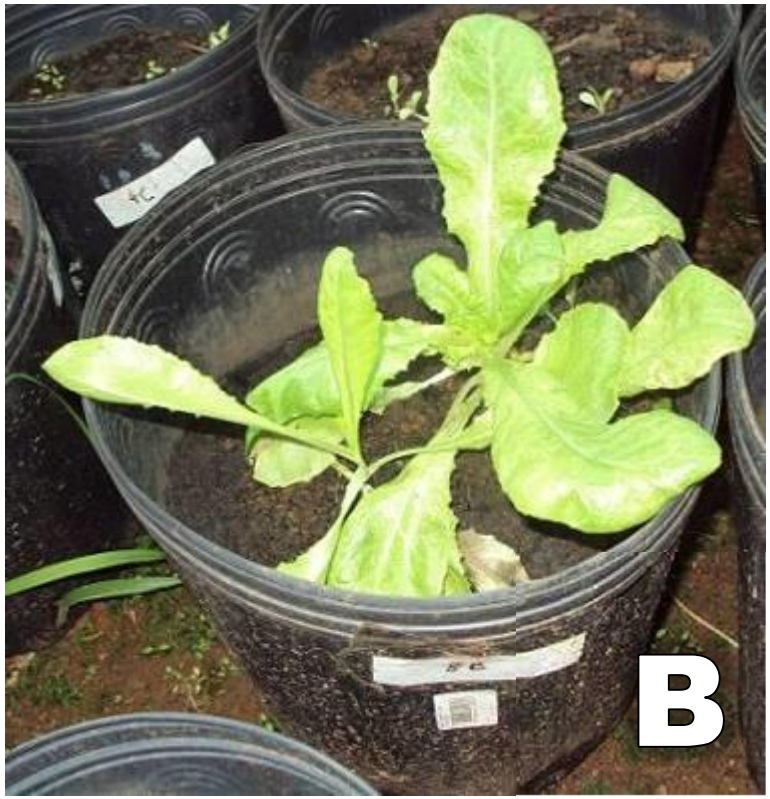
- **Biological parameters:**
  - Treatment B showed best results.
  - Control group showed the lowest values

RESULTS - LETTUCE



Root length

LETTUCE



Fertilized with urine

Non-fertilized (tap water)

Nitrification
Plant uptake

SOIL ANALYSIS

Group	pH	B	Cu	Fe	Mn	Zn	P	S	K	Ca	Mg
A	6.5	0.3	4.4	19.3	0.8	1.9	54.7	0	5.5	79.8	27.1
B	5.6	0.4	5.2	20.0	6.7	2.3	67.6	0	6.5	61.4	22.1
C	6.7	0.3	3.9	21.4	1.7	1.9	53.6	0	4.9	77.2	23.4
D	6.8	0.3	3.1	19.9	1.1	1.6	49.3	0	3.9	69.3	20.9

Units: P(mg/dm^3); K ($mmol/dm^3$); Ca ($mmolc/dm^3$); Mg ($mmol/ dm^3$); B, Cu, Fe, Mn, Zn (mg/dm^3)

Sample	Total Nitrogen (g/Kg)
A	2.32
B	3.48
C	1.93
D	1.54

Nitrogen Content Analysis

PAYBACK STUDY

Considering replacement of all flush urinals of *campus* with waterless urinals.

- Simple Payback: 9 months.
- Discounted Payback: 10 months.

ANNUALLY THE ECONOMY IN WATER BILLS WOULD BE ABOUT:

U$ 46,966.00 (USD)

FINAL REMARKS

- **Both in corn and lettuce cultivation**

Urine doses significantly better than the control: higher values in all of the biological parameters measured.

- **CORN**: dosages of groups A and B are recommended
- **LETTUCE:** dosages of group B and group C are recommended

- The high mortality in treatment B might be due to the following causes: soil salinity, low soil pH.

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