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EFFICIENT AND SAFE PRODUCTION PROCESSES IN SUSTAINABLE AGRICULTURE AND FORESTRY

Evaluation of Seed Trajectories in a Pneumatic Dosage System

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Introduction

Motivation of this work:

- The goal of this work is to test, numerically and under laboratory conditions, soybeans trajectories, from the outlet of a seed meter until the end of the drop tube.
- The specific objective is to develop software to predict soybean paths, in order to prevent seed rebound inside the drop tube.

Main topics:

- This is both, a numerical and experimental work.
- The experimental part is the filming of trajectories of seeds. Initial conditions of movement of seeds are obtained from these films.
- These data are used in an algorithm, which calculates the limit trajectories of seeds.

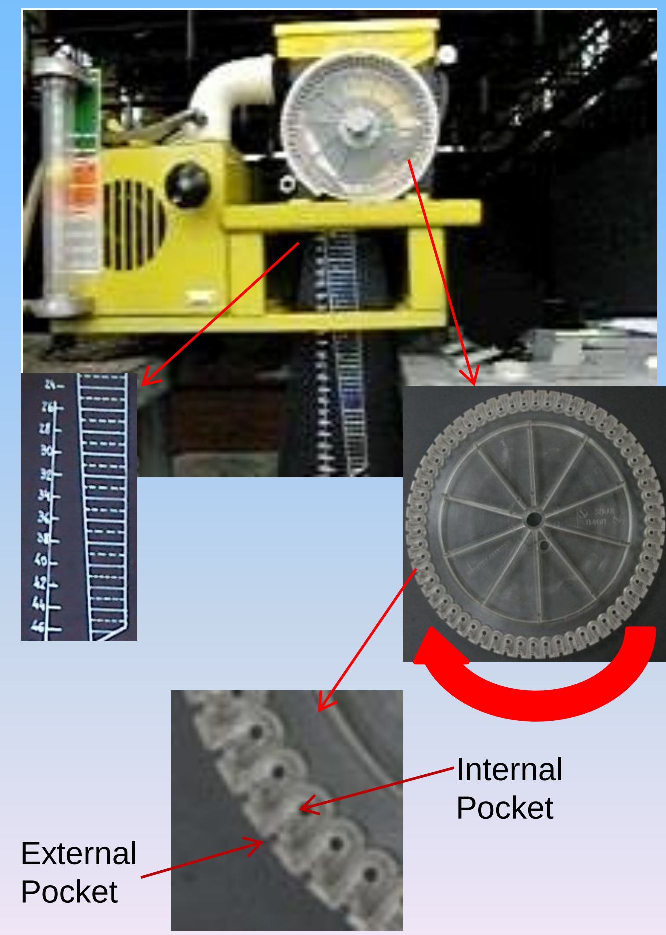
Material & Methods

- It was used a seeds meter test bank from the Electronic Engineering School of FCEIA – UNR.

- The seed plate used for these experiments is a soybean type which has an external diameter of 252.8 mm, with 60 cells, holding 2 seeds each one. Therefore, in each turn, the plate can meter up to 120 seeds. The air pressure, delivered by an air blower, holds the seeds inside the seed plate pockets. Each seed is released at the drop point, where they fall due to gravity.

- The drop tube was replaced by a black background with boundaries and a graduated scale sketched on it, in order to record the trajectories of seeds that cross the limits of the tube.

- The seed used in this experiment is soybean (Glycine Max L.), with 0.0027 m, 0.0027 m and 0.0033 m of mid-size.



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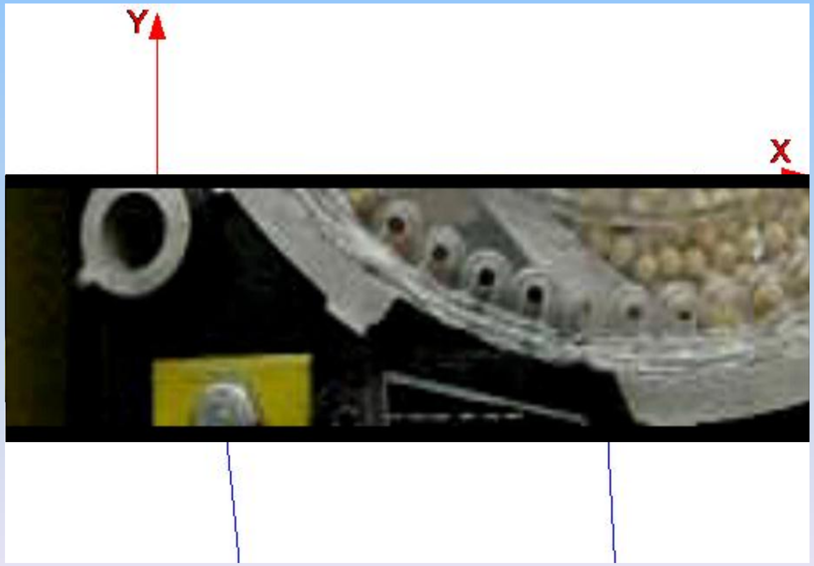
Material & Methods

The images recording was done with a high speed camera Casio HS Exilim EX-FS10, at two different shooting speeds:

1. 1000 fps in order to acquire initial conditions of seeds
2. 420 fps for seeds trajectories



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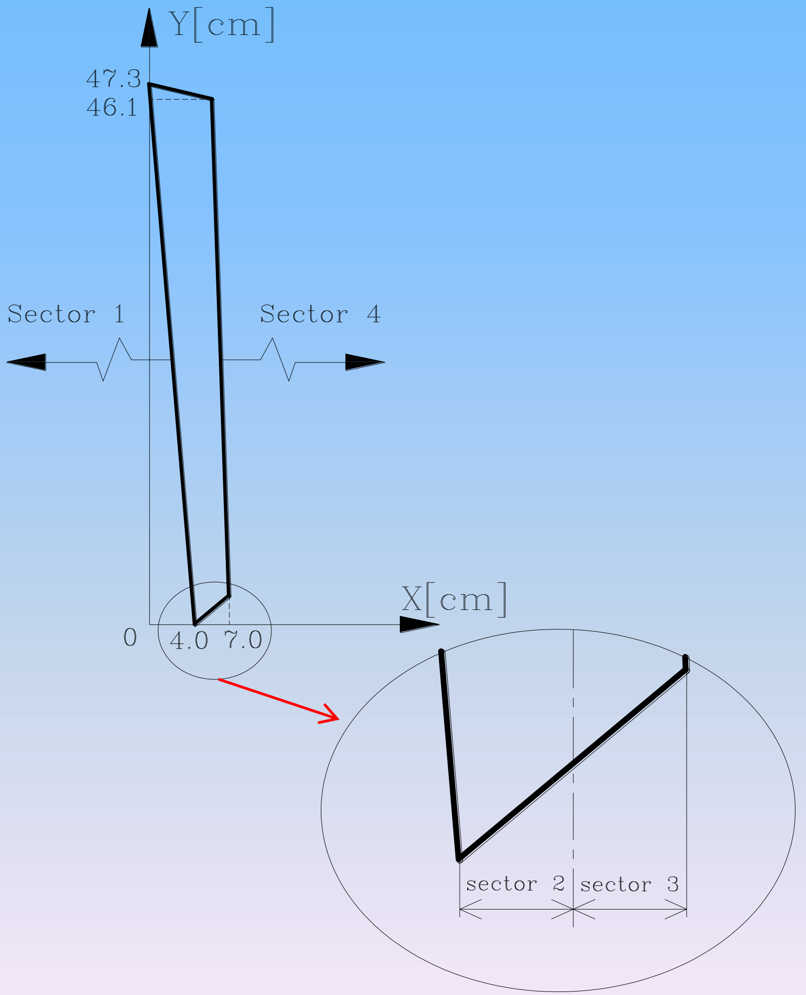
Material & Methods

In order to evaluate both, qualitatively and quantitatively seed trajectories, 4 or sectors were defined.

- Sector 1 corresponds to seed that crosses the left boundary of the drop tube.
- Sector 2 includes the left border and the middle part of the tube.
- Sector 3 corresponds to the middle and the right boundary of the tube. If some trajectory passes through the Sectors 2 and 3 no bounce will occur inside the tube.
- Sector 4 belongs to the trajectories which cross the right border of the tube.



Numerical Model

Soybeans are treated as spherical, rigid and uniform size (diameter D_p) particles

Motion Equations:

$$\frac{dx_{pi}}{dt} = u_{pi} \quad (1)$$

$$m_p \frac{du_{pi}}{dt} = F_{Di} + F_{LMi} + m_p g_i \quad (2)$$

$$I_p \frac{d\omega_{pi}}{dt} = T_i \quad (3)$$

Where:

x_{pi}	Particle global coordinate.
u_{pi}	Velocity component along each axis direction.
$m_p = \frac{\pi}{6}\rho_p D_p^3$	Particle mass.
$I_p = 0.1 m_p D_p^2$	Particle momentum of inertia .

Numerical Model

From equation (2):

$$F_{Di} = \frac{\pi}{4} D_p^2 \, \rho_{air} \left| u - u_p \right|^2 \left(1.84 \, Re_p^{-0.31} + 0.293 \, Re_p^{0.06}\right)^{3.45}$$

Drag force along the axis i (Khan & Richardson, 1987).

$$F_{Mi} = \pi \, \rho \, V_R \, {D_p}^2 \left[C_L \frac{\omega_Z}{|\omega|} (u_i - u) \right]$$

Magnus force the axis i (Tashiro et. al., 1997).

Where:

$$Re_p = \frac{\rho_{aire} D_p \left| u - u_p \right|}{\mu}$$

Particle Reynolds number.

ω Particle angular velocity.

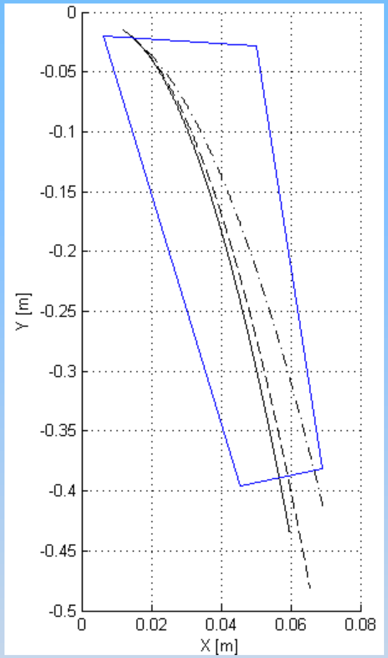
C_L Magnus coefficient.

Results and Discussion

Test.	Test nº	Sector 1		Sector 2		Sector 3		Sector 4		Rebounds sect 1 & 4 aver. %	Quantity of tested seeds
		Quantity	%	Quantity	%	Quant.	%	Quant.	%		
Internal pocket covered	I	35	13.9	111	44.0	78	31.0	28	11.1	23.0	252
	II	34	13.2	106	41.1	98	38.0	20	7.7		258
External pocket covered	I	75	29.9	109	43.4	53	21.1	14	5.6	35.0	251
	II	74	29.0	94	36.9	74	29.0	13	5.1		255
No pocket covered	I	31	12.2	103	40.4	88	34.5	33	12.9	24.5	255
	II	25	9.8	78	30.7	115	45.3	36	14.2		254

In the case of external pocket covered, the bounces rates are higher than other configurations. This may be because the seeds have a greater path within the pocket and acquire a higher angular velocity at the outlet of the meter.

Resultados y discusión

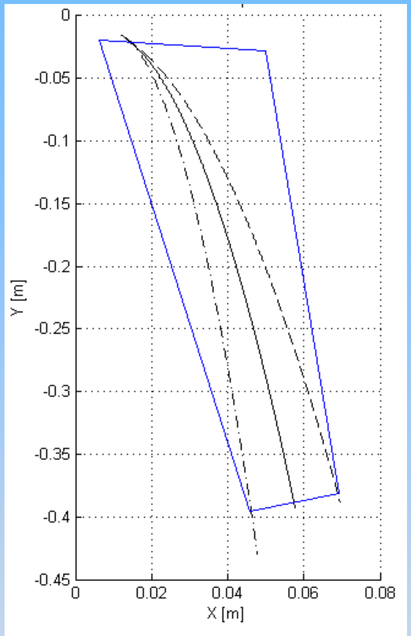


———— ω_1= 117.4 rad/s

— — — — ω_2= 29.1 rad/s

— · — · — · — ω_3= -168.0 rad/s

Values of initial linear and angular velocities, obtained from filmed tests at 1000 fps, are used. From these calculations, paths shown are obtained.



———— ω_1= 90 rad/s

— — — — ω_2= -170 rad/s

— · — · — · — ω_3= 600 rad/s

- initial conditions that generate limit trajectories, contained entirely within the boundaries of the drop tube, are looked for.
- These are the initial angular velocity between -170 rad/s and 600 rad/s

- It is considered an ideal path where the seed passes through the center of the lower boundary of the tube (continuous line). For this path there is an initial angular velocity of 90 rad/s, which should be considered for the design of meters and drop tubes.

- Negative rotation is produced by the friction between the seed and the rough surface between the metering disk and the frame. This phenomenon is responsible for the different rotations verified on films.

Conclusions

- Some simulated trajectories go through the boundaries of the drop tube.

- Laboratory tests confirm the existence of such trajectories, which implies that some seeds will rebound on walls tube, resulting in a loss of trajectories control, not guaranteeing nor the seed position in the furrow, nor the distance between each other.

- Future work will seek to ensure the seed s initial conditions which should be inside the suitable limits, such they do not strike against the drop tube walls, and should allow to guarantee a constant distance between seeds in the furrow.

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