Polyhalite use in pasture

杂卤石在牧草上的应用

Alberto Bernardi

13th IPI-CAU-ISSAS International Symposium
第13届IPI-CAU-ISSAS国际研讨会

Potash and Polyhalite: Potassium, Sulphur, Magnesium and Calcium for Efficient Balanced Plant Nutrition
钾肥和杂卤石：钾、硫、镁和钙提供高效平衡的植物营养

6-8 November 2019, Kunming, China
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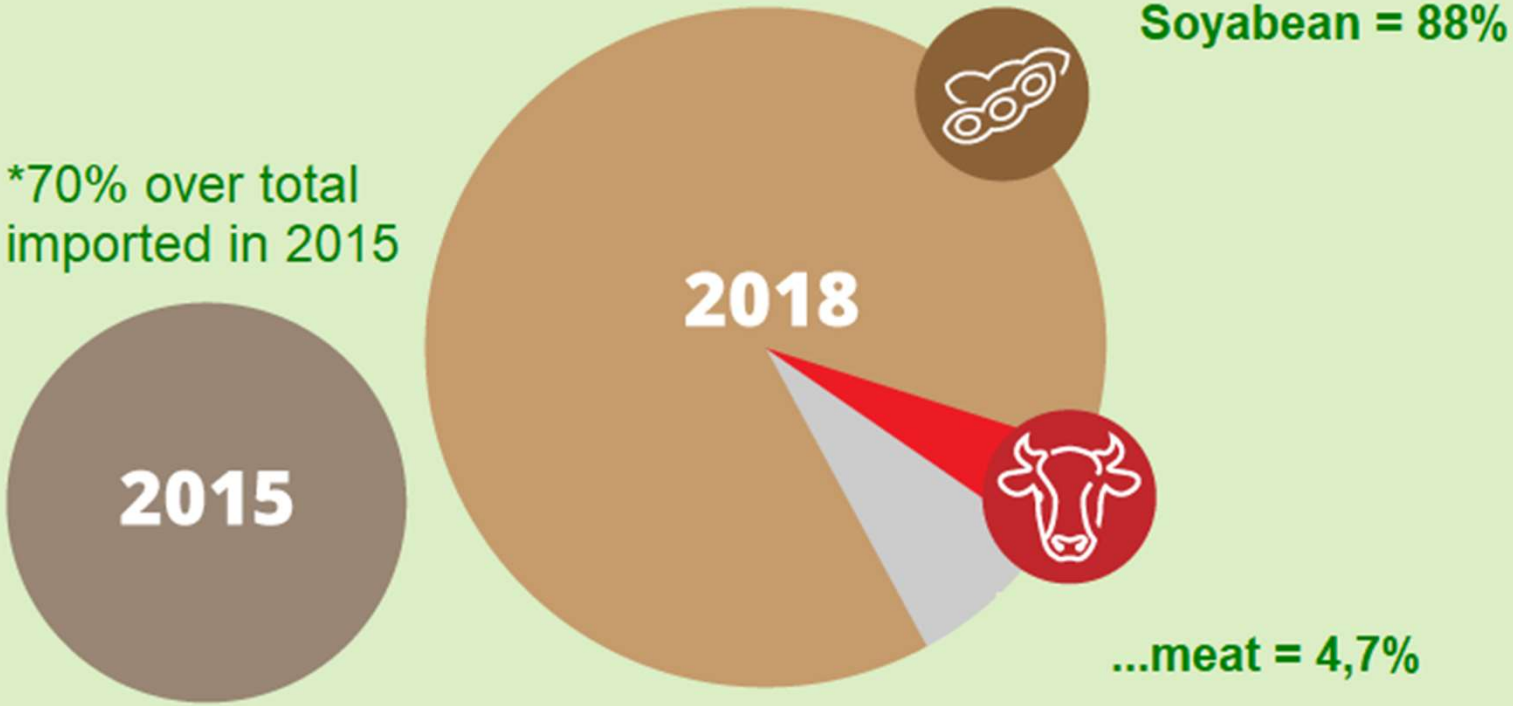
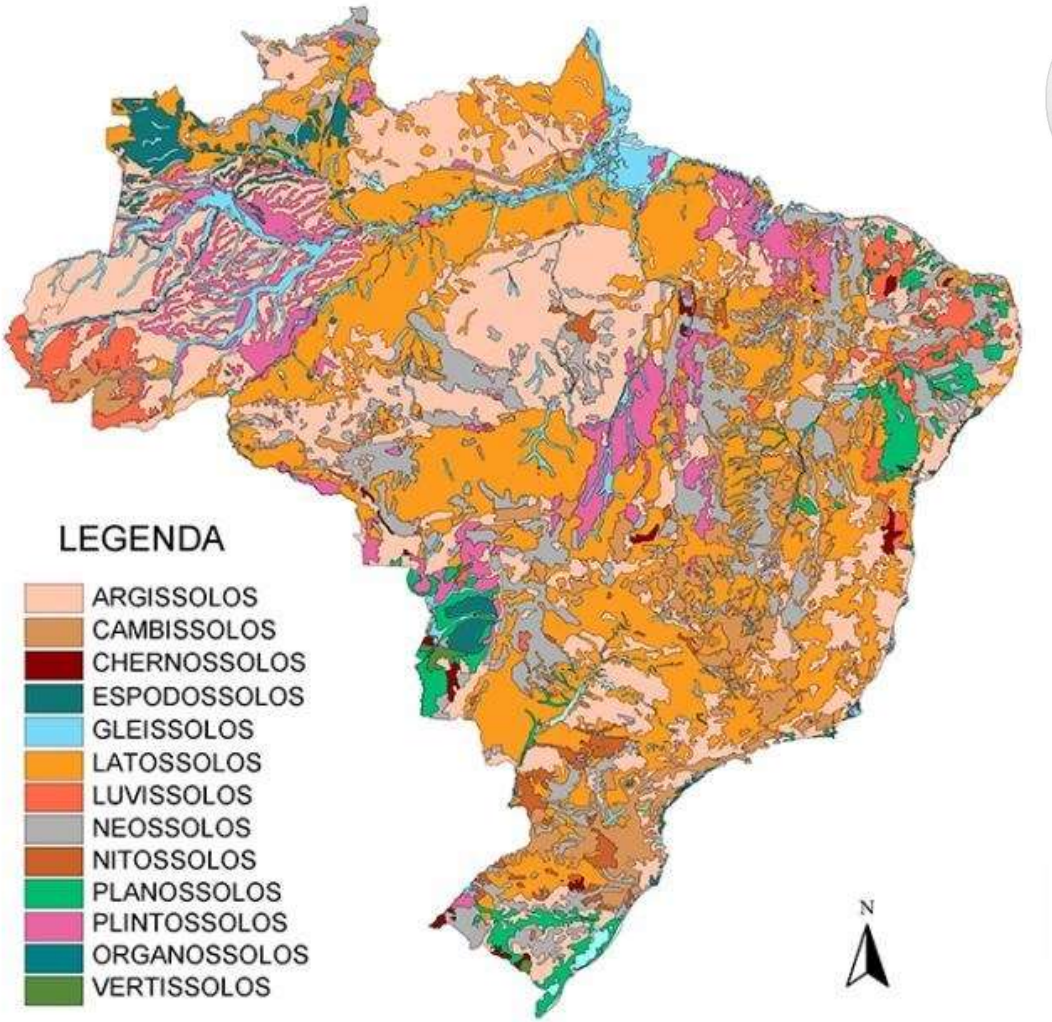
2018: China imported **U$31 billions** of Brazilian agriculture products



Brazilian soils

- **Large diversity of soil types**

resulting from the interaction of the different reliefs, climates, parent material, vegetation and associated organisms.



SANTOS, H.G. et al. O novo mapa de solos do Brasil: legenda atualizada. Rio de Janeiro: Embrapa Solos, 2011. 67 p. (Embrapa Solos. Documentos, 130).

Brazili

Brazilian taxonomy		%
Argissolos		26,9
Cambissolos		5,3
Chernossolos		0,4
Espodossolos		2,7
Gleissolos		4,7
Latossolos		32,7
Luvissolos		2,9
Neossolos		13,4
Nitossolos		1,1
Planossolos		2,7
Plintossolos		7
Vertissolos		0,2

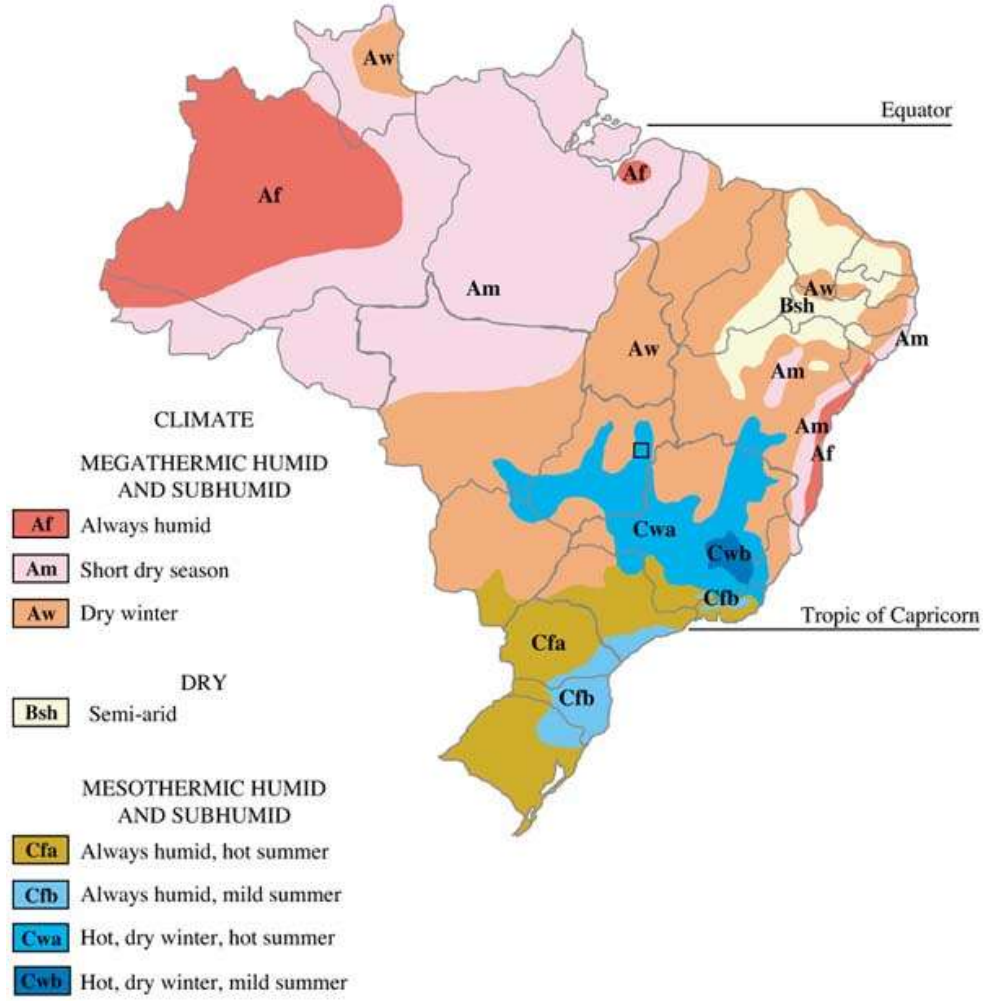
- Soils are usually deep and have favorable physical properties,
- High-weathered, acids and low natural fertility
- Easily corrected by liming and fertilization;

SANTOS, H.G. et al. O novo mapa de olos, 2011. 67 p. (Embrapa Solos. Documentos, 130).

Embrapa

Brazilian climate

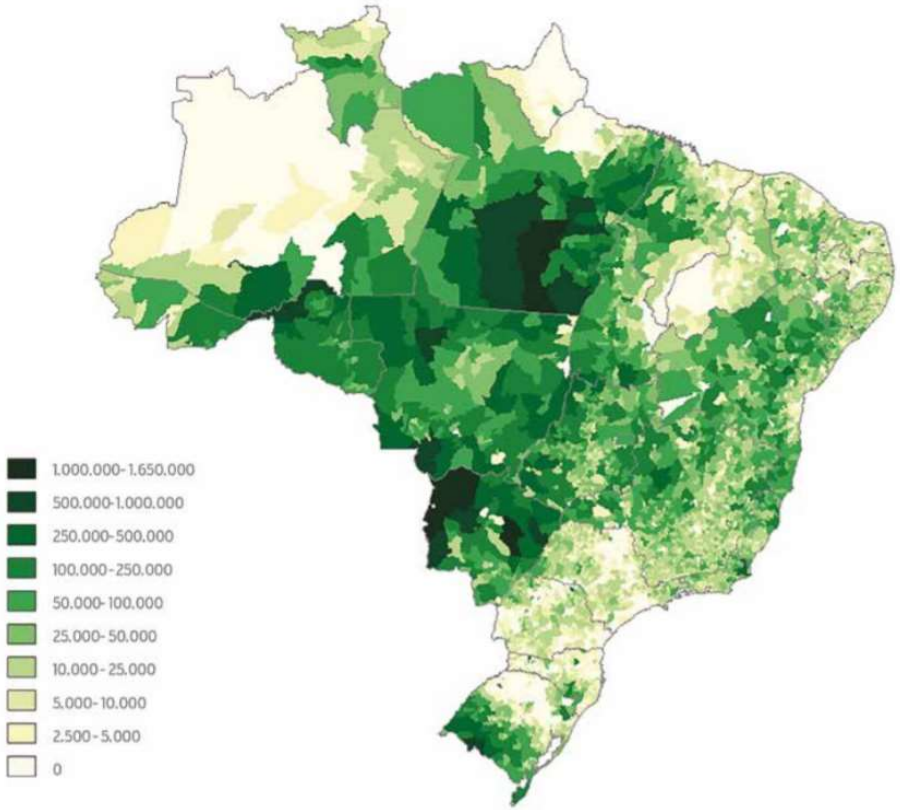
- Tropical and low altitudes = 92% of the territory
- Predominance of hot climates, with average temperatures above 20°C: equatorial, tropical, tropical of altitude, tropical Atlantic, semi-arid and subtropical



http://www.fao.org/3/y5376e/y5376e06.htm#TopOfPage

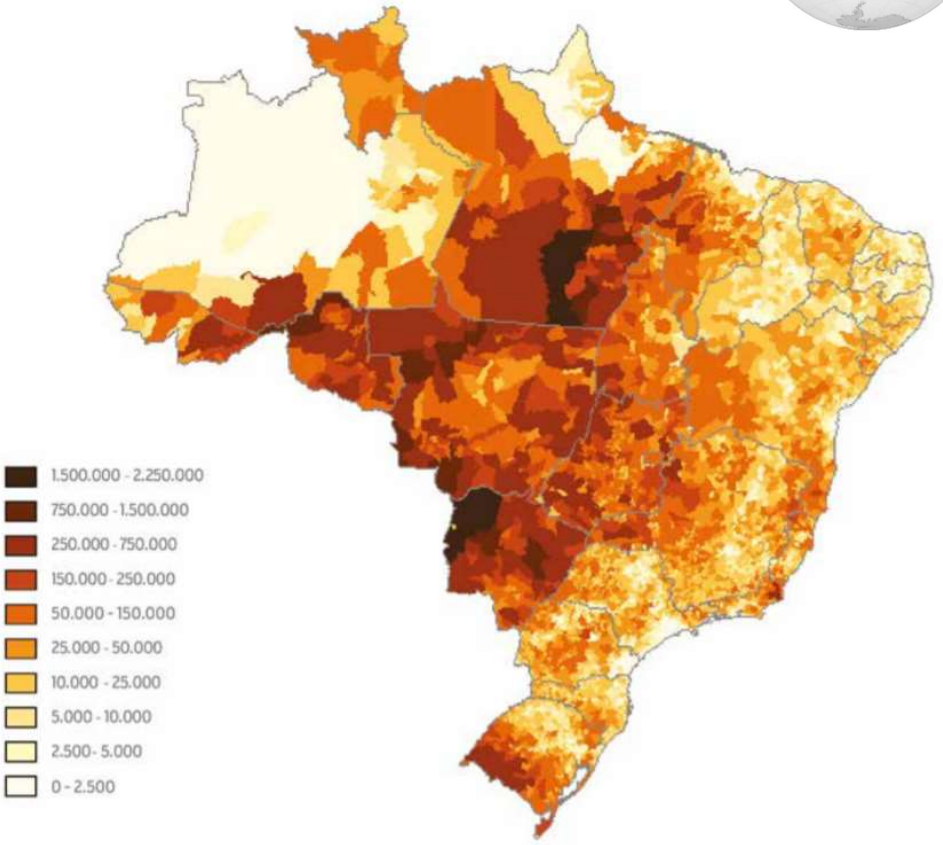
Brazilian pasture: 150 million ha

20% Brazilian land



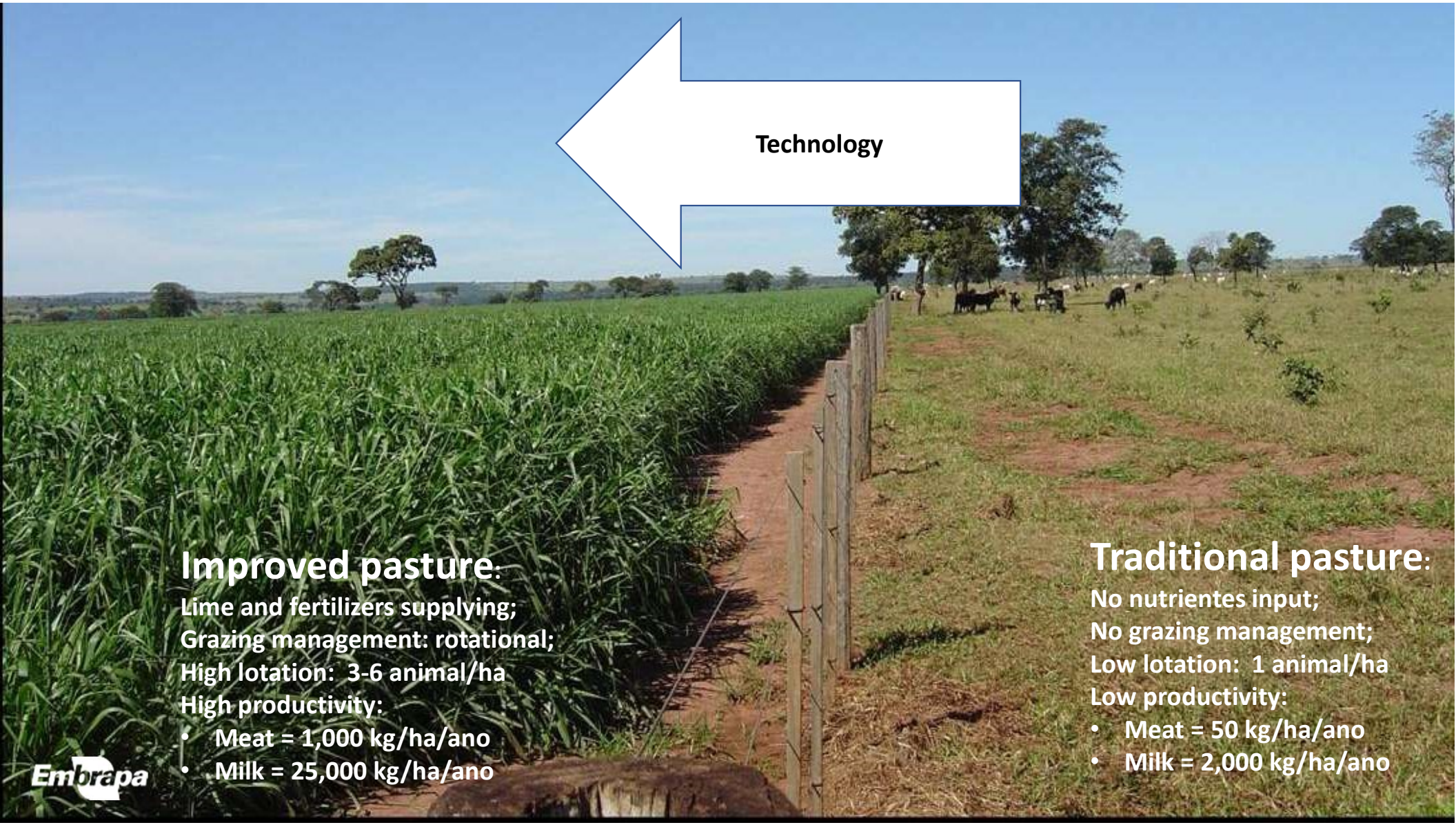
Brazilian livestock: 214 million ha

World's 1st commercial herd



Source: IBGE (https://sidra.ibge.gov.br/pesquisa/ppm/quadros/brasil/2018)

Embrapa


Technology
Improved pasture:
Lime and fertilizers supplying;
Grazing management: rotational;
High lotation: 3-6 animal/ha
High productivity:
• Meat = 1,000 kg/ha/ano
• Milk = 25,000 kg/ha/ano
Traditional pasture:
No nutrientes input;
No grazing management;
Low lotation: 1 animal/ha
Low productivity:
• Meat = 50 kg/ha/ano
• Milk = 2,000 kg/ha/ano
Embrapa

Providing an adequate supply of nutrients is important for high yields and is essential to maintain high quality and profitable yields forage systems.

K, Ca, Mg and S: soil content and exportation

Nutrient	Soil level (medium)
	$mmol_c/dm^3$
K	1.6 - 3.0
Ca	7.0
Mg	5.0 - 8.0
	---mg/dm^3---
$S\text{-}SO_4^{2-}$	5 - 10

- ✓ **Brazil is the world's 4th consumer of fertilizers, after China, India and the United States;**
- ✓ **KCl (58 to 62% of K_2O) = the most potash fertilizer used in Brazil accounting for over 95% of the market.**
- ✓ **Great opportunity to other sources = polyhalite**
- ✓ **Tropical soils typically increase yileds with addition of K, Ca, Mg, and S fertilizers, and polyhalite may provide an adequate fertilizer source;**

Alfalfa experiment

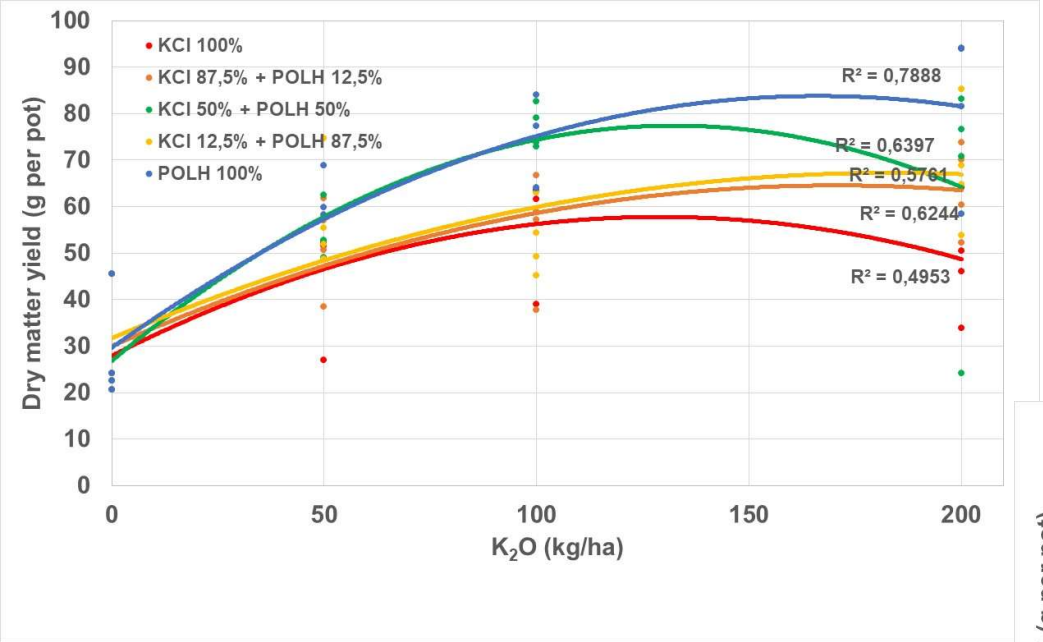
Green house

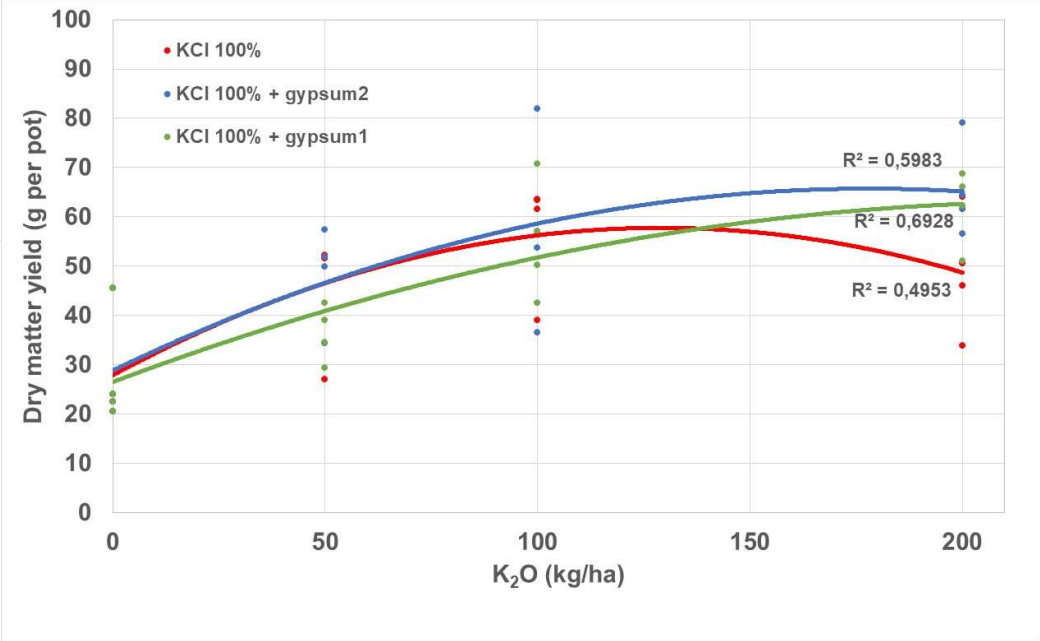
- ✓ Alfalfa (*Medicago sativa*): 6 cuts were evaluated
- ✓ Green house experiment (in pots with 3 kg)
- ✓ Red-yellow Latosol, i.e. Haplorthox
- ✓ Soil testing samples (0-0.2 m): pH$CaCl_2$ = 5.2, organic matter = 24 g/dm^3, P_{resine} = 2 mg/dm^3, K = 1.6 mmol$_c$/dm^3, Ca = 19 mmol$_c$/dm^3, Mg = 8 mmol$_c$/dm^3, CEC = 52 mmol$_c$/dm^3, V= 55%; S-SO_4 = 12 mg/dm^3. 265 g/kg of sand, 198 g/kg of silt and 537 g/kg of clay.
- ✓ Lime V = 80% before planting,
- ✓ Fertilizer at planting: 458 mg/kg of P_2O_5, and 25 mg/kg of FTE-BR12 (1.8% of B, 0.8% Cu, 3% Fe, 2% Mn, 0.1% Mo, 9% Zn).

Embrapa

- ✓ Treatments comprised two K sources: polyhalite and KCl (60% K_2O), 5 ratios (polyhalite:KCl) and four K_2O levels (0, 50, 10 e 200 kg/ ha):
  - Control (no K, S, Mg or Ca);
  - KCl 100%;
  - KCl 87,5% + Polyhalite 12,5%;
  - KCl 50% + Polyhalite 50%;
  - KCl 12,5% + Polyhalite 87,5%;
  - Polyhalite 100%;
  - KCl 100% + gypsum (12,5%;
  - KCl 100% + gypsum 50%.

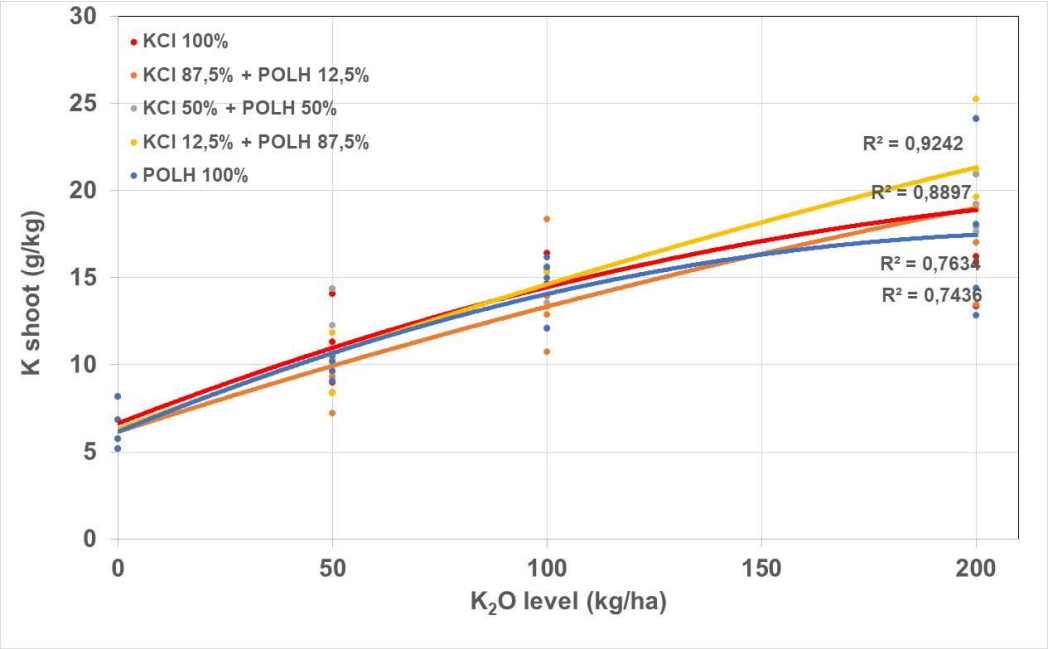
Embrapa

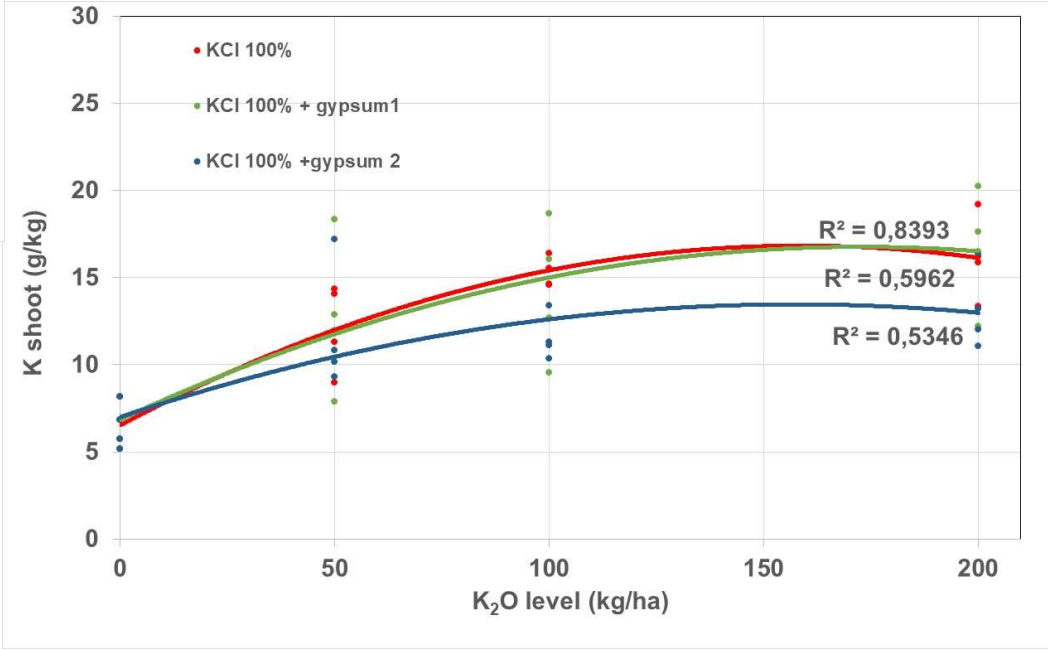




Dry matter yield

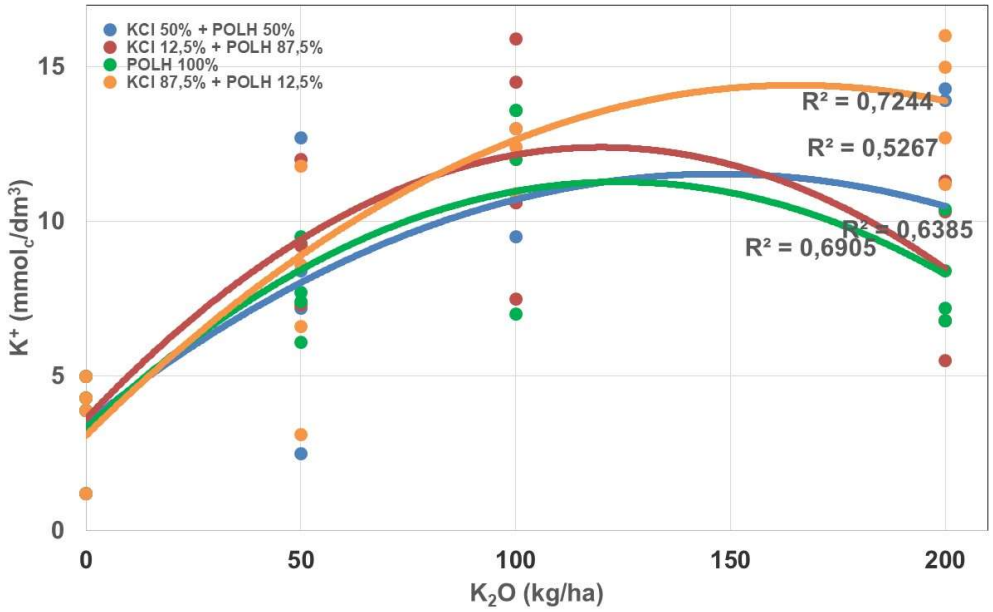
Embrapa

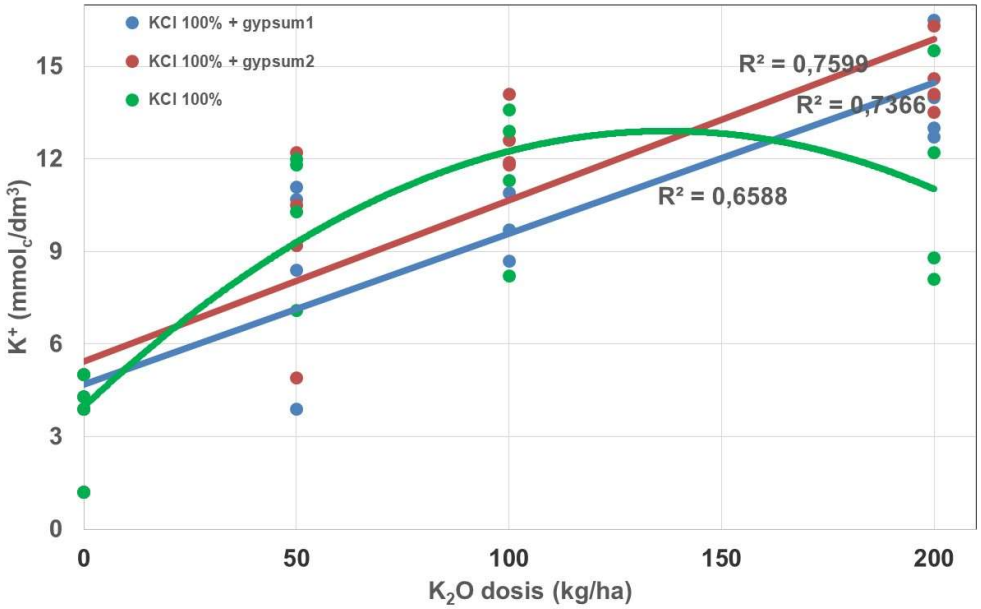




K shoot dry matter

Embrapa

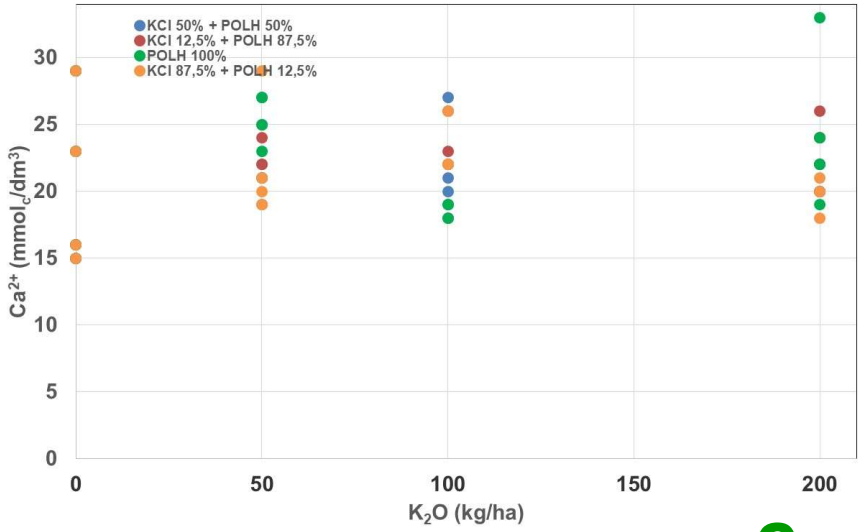


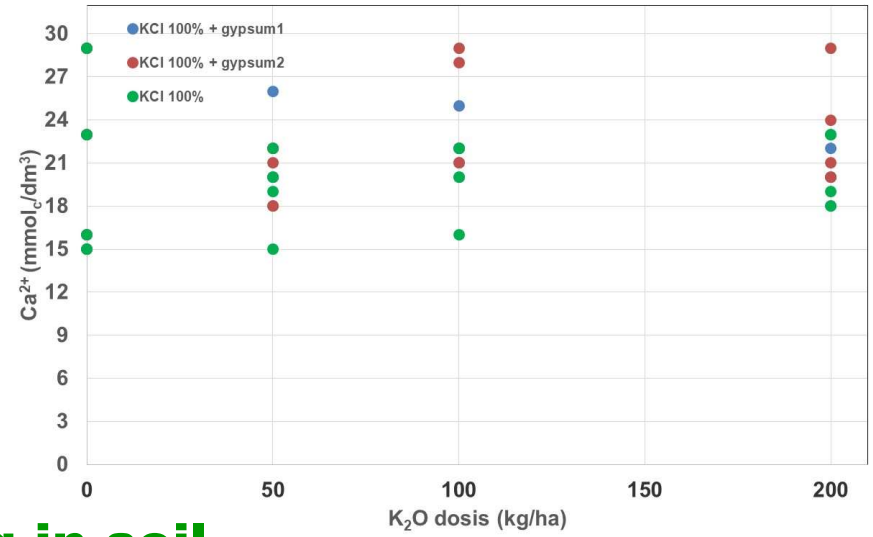


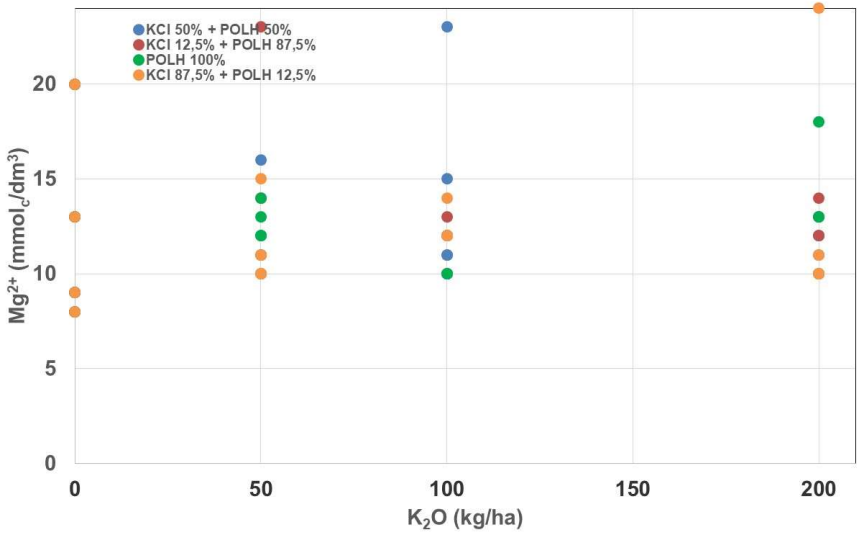
K⁺ in soil

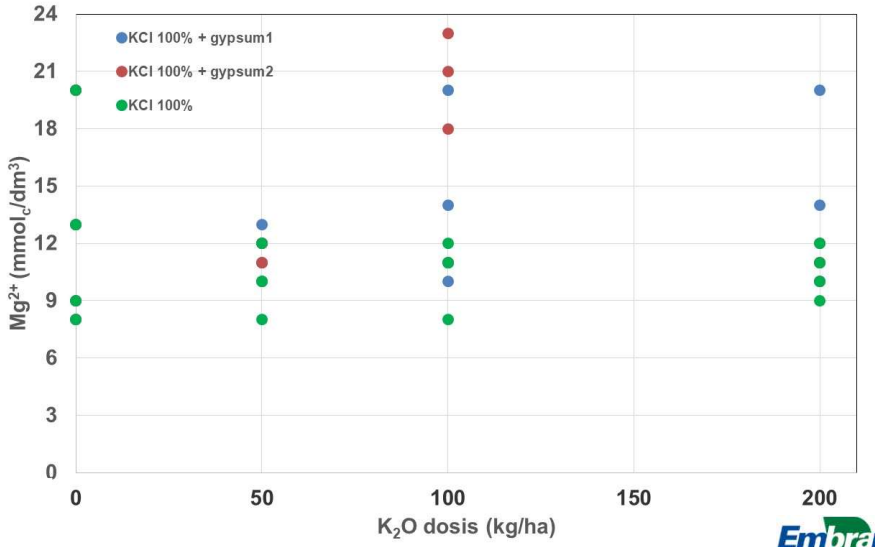
Embrapa

Ca and Mg in soil









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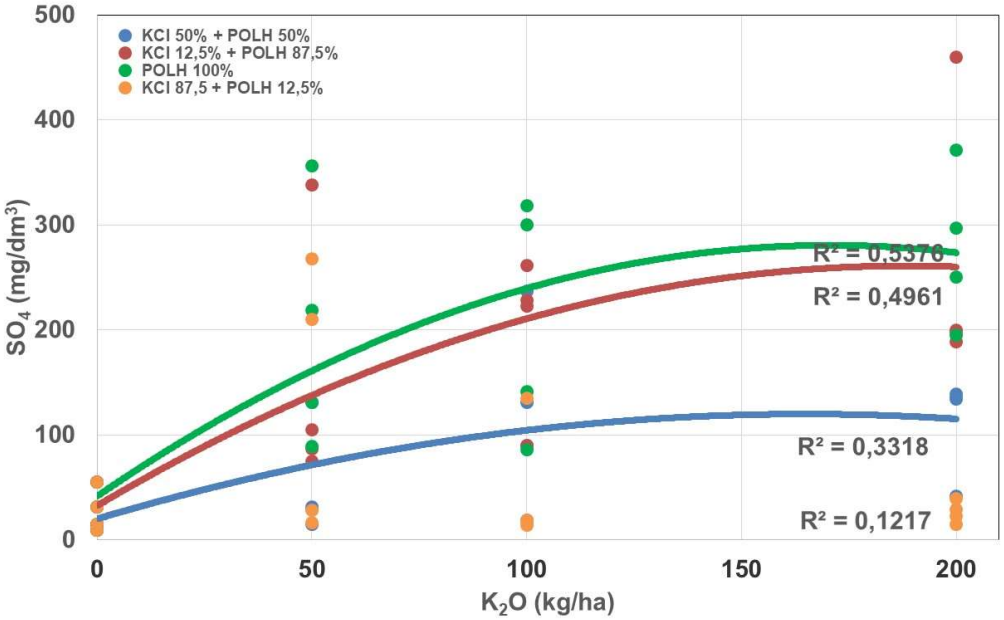
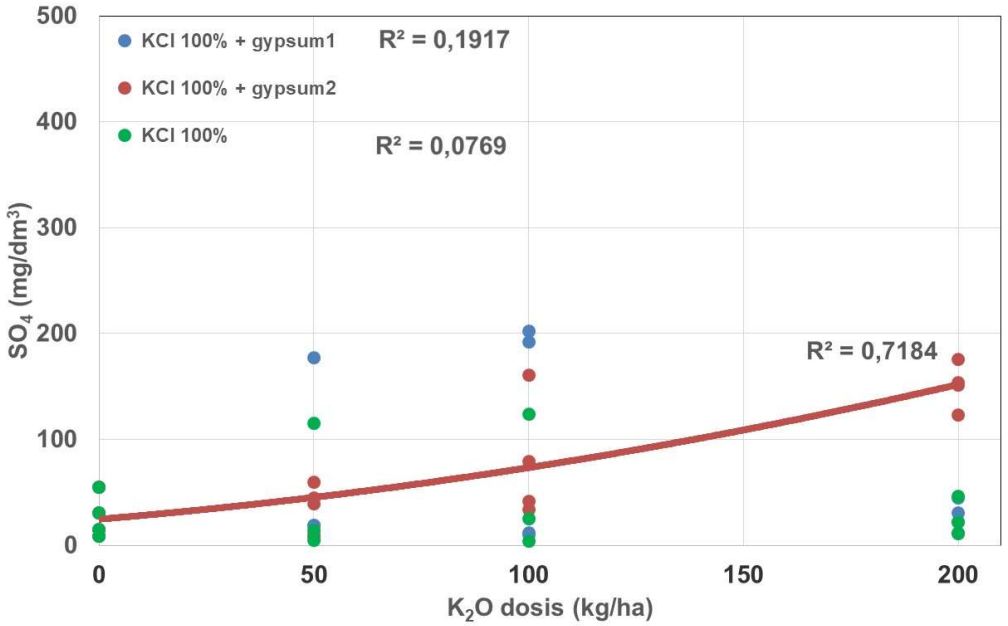
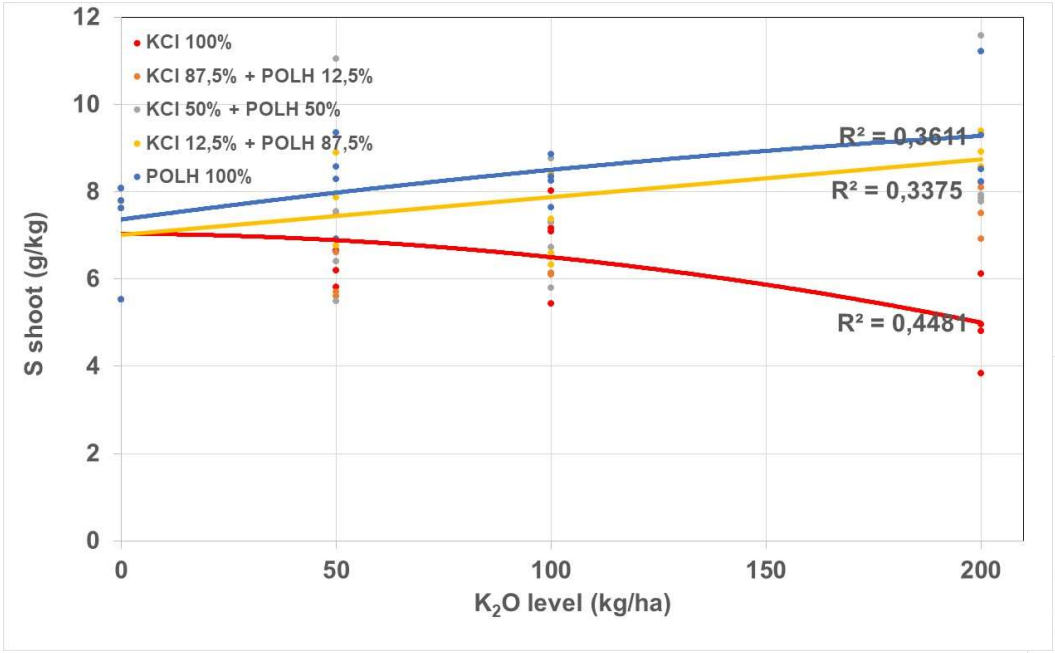
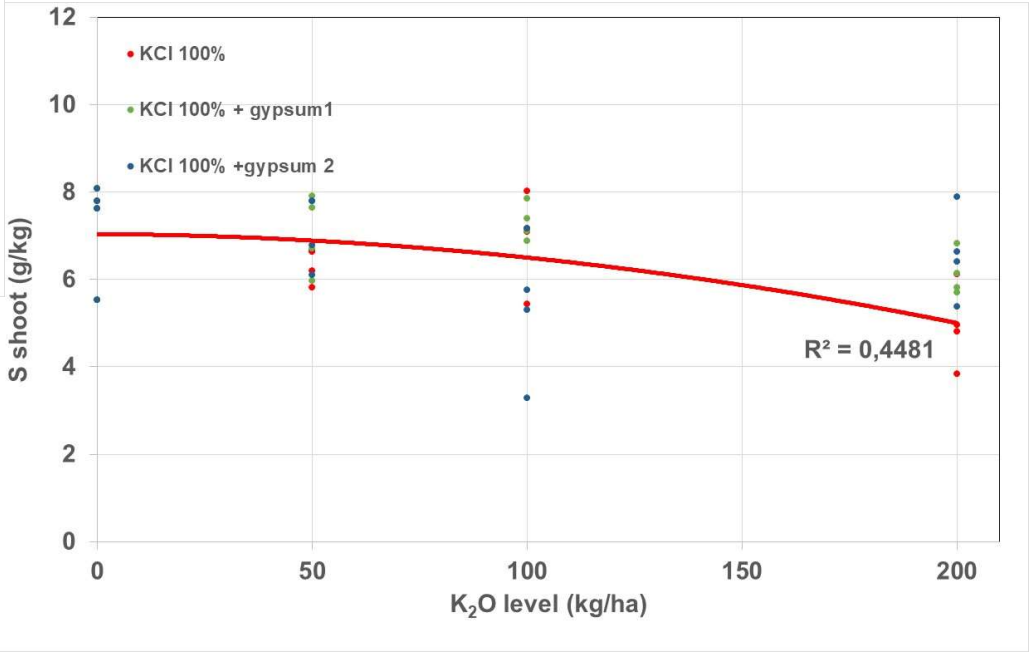


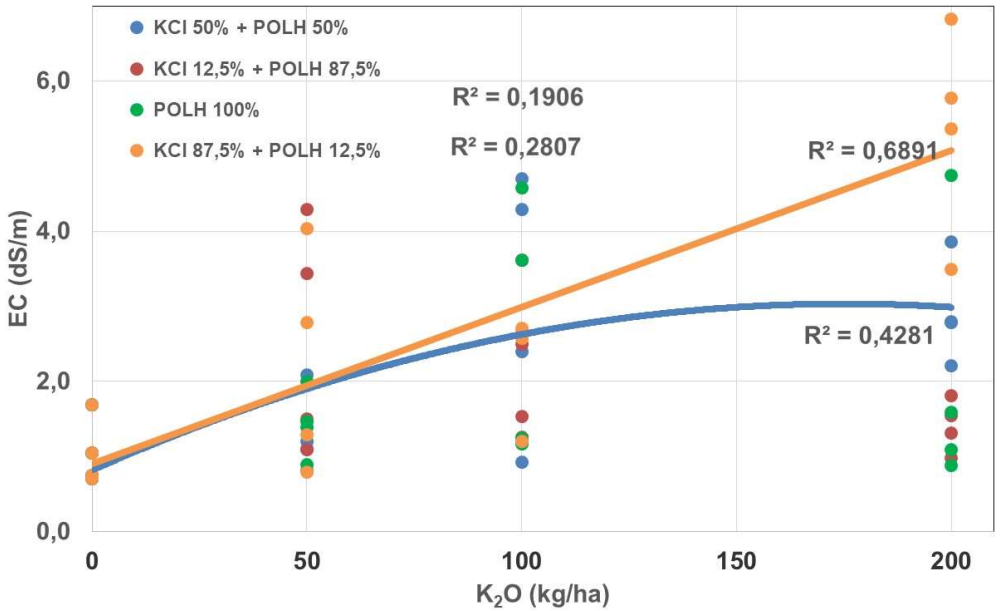


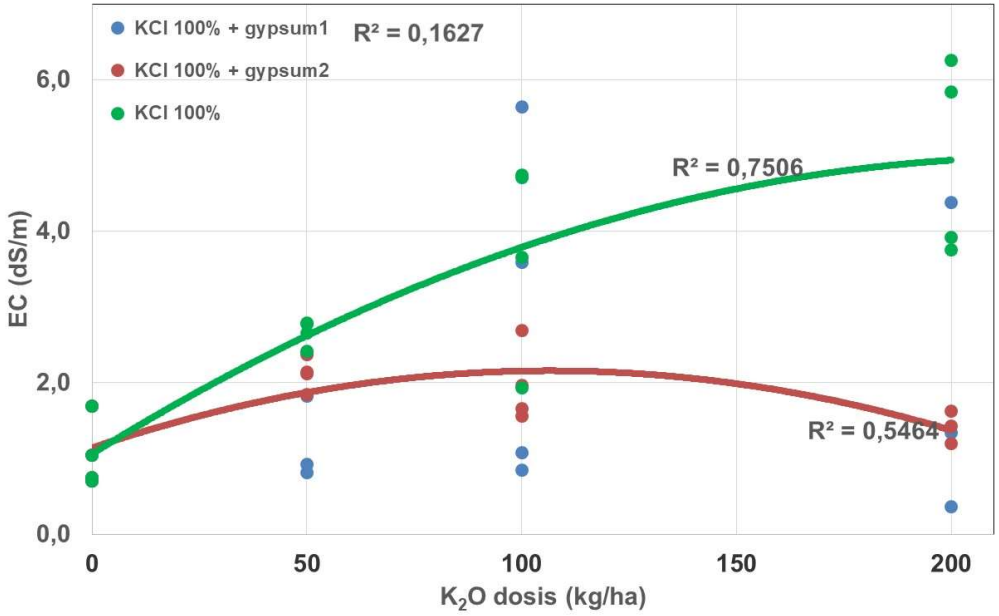
S-SO_4^{2-} in soil





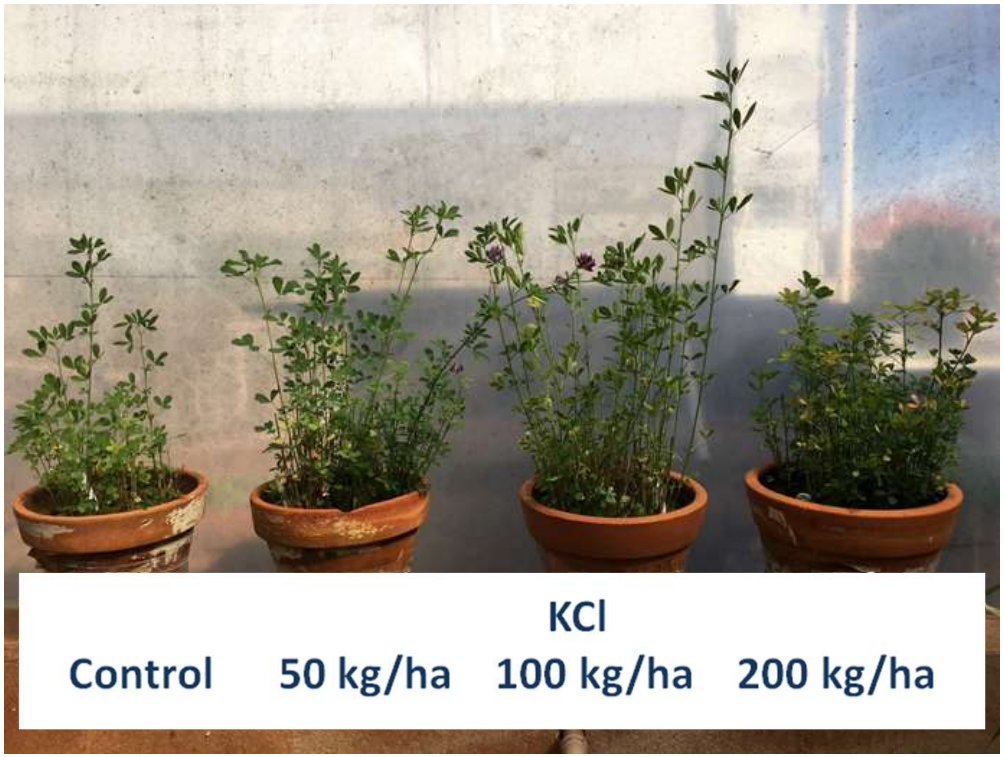
S shoot dry matter

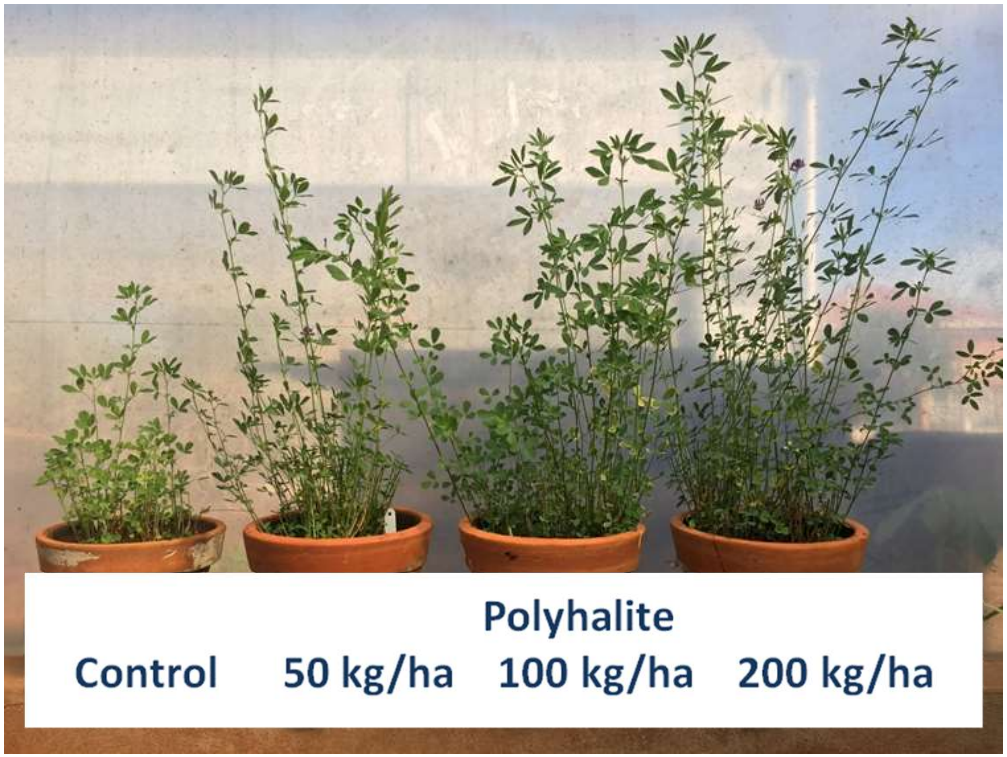


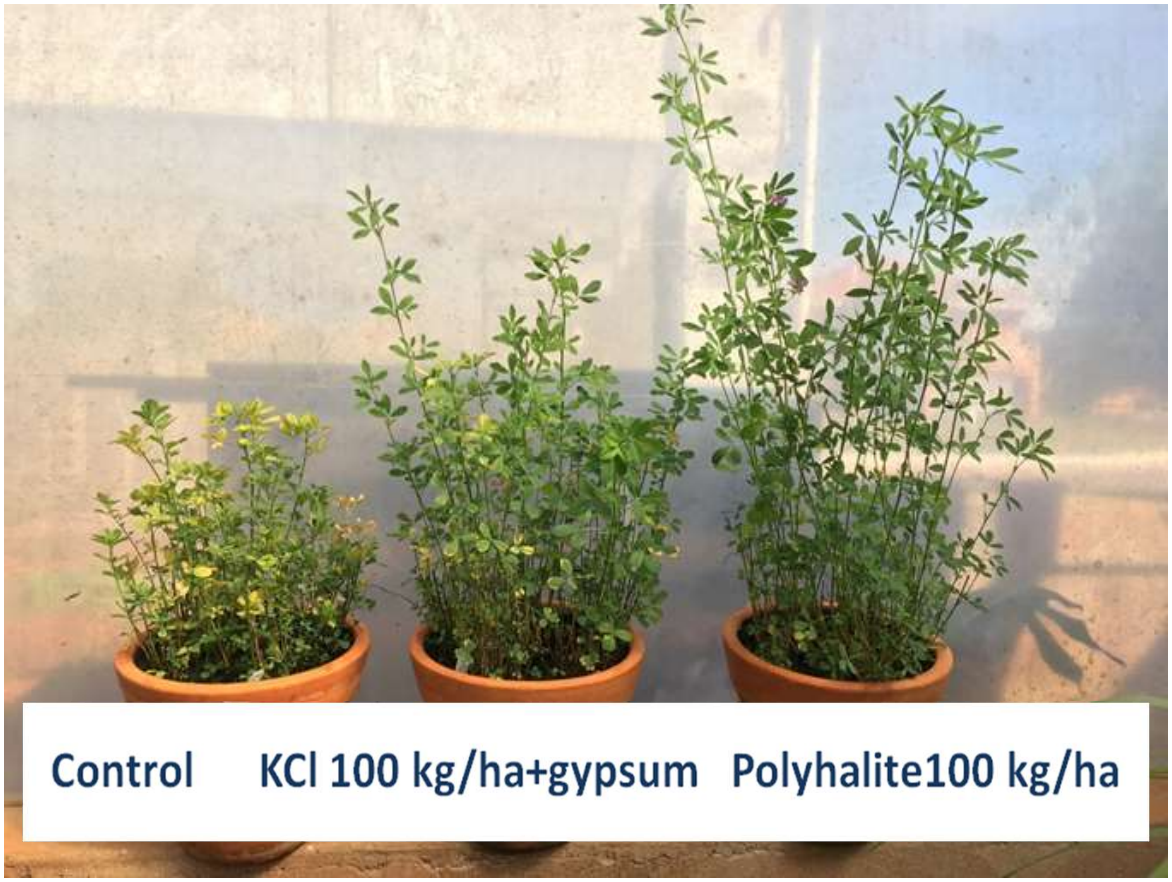


Soil electrical conductivity

Embrapa

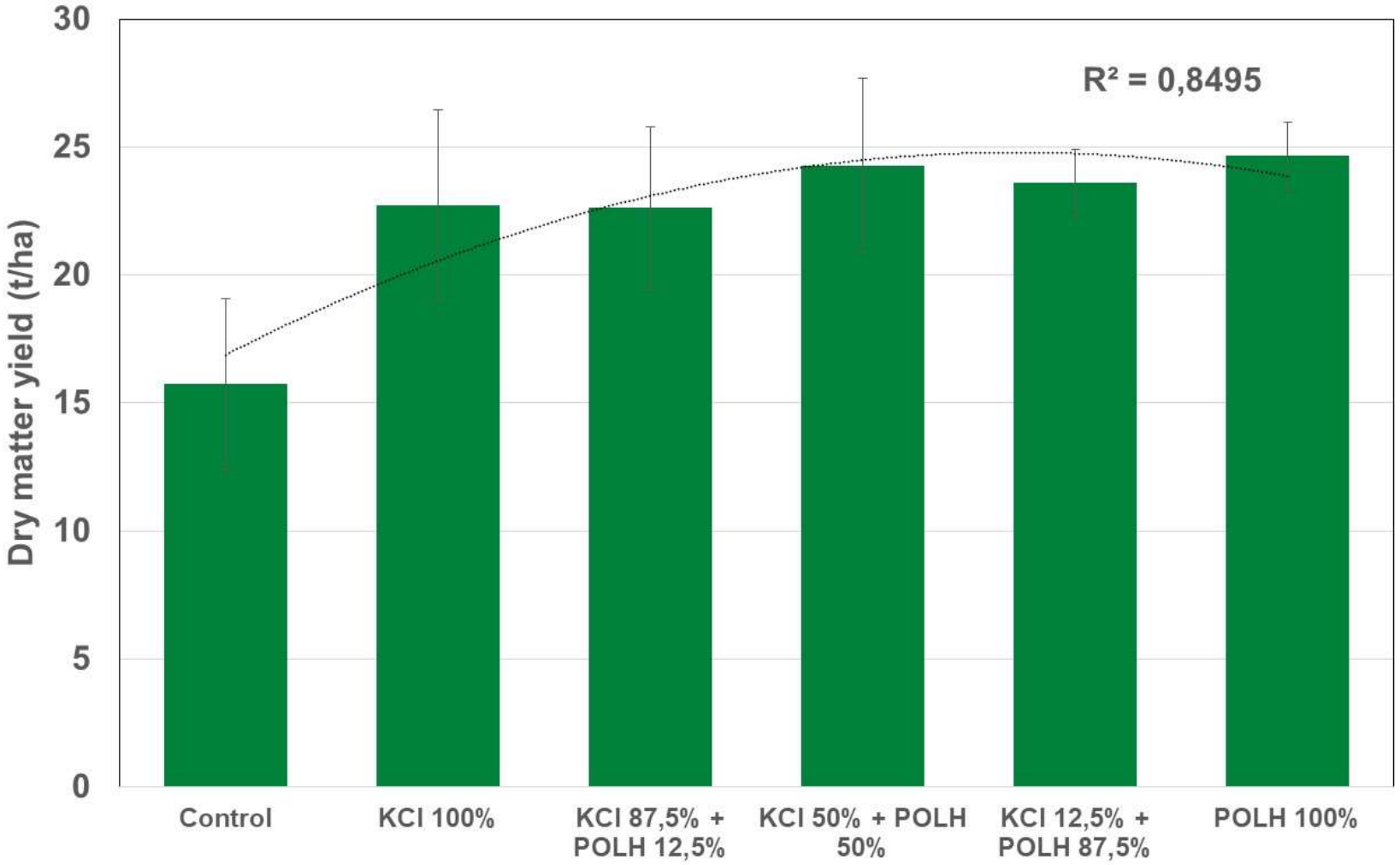

KCl
Control
50 kg/ha
100 kg/ha
200 kg/ha

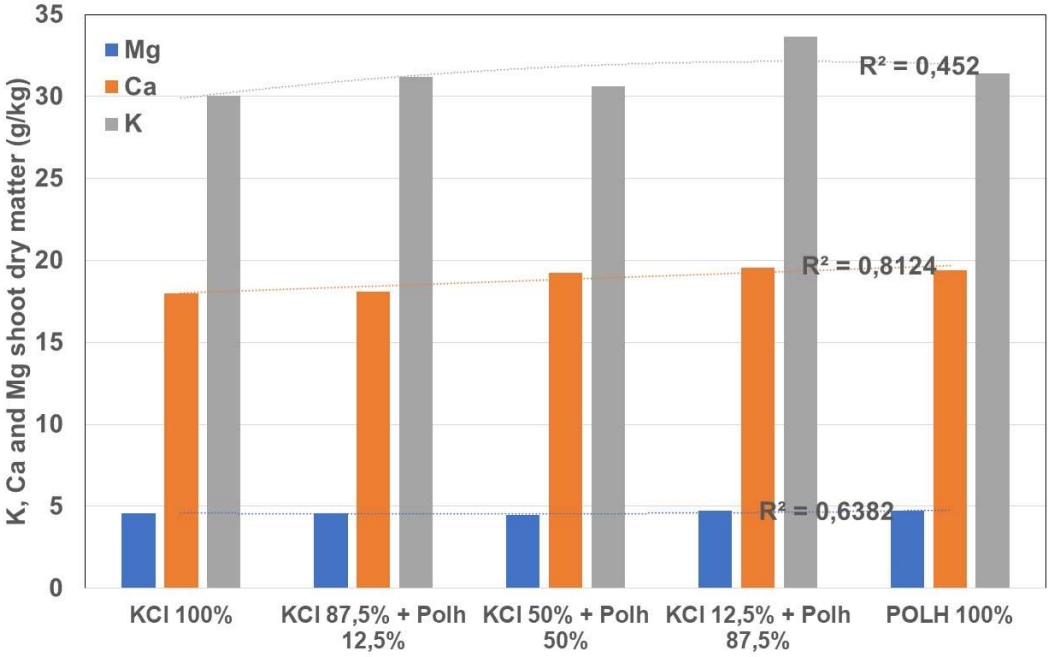

Polyhalite
Control
50 kg/ha
100 kg/ha
200 kg/ha

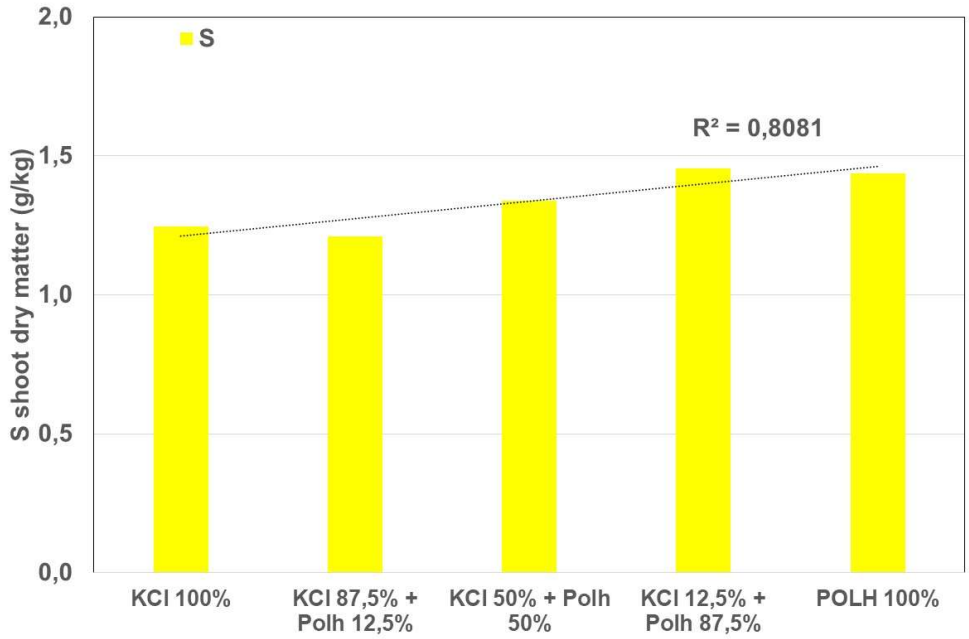

Control
KCl 100 kg/ha+gypsum
Polyhalite100 kg/ha

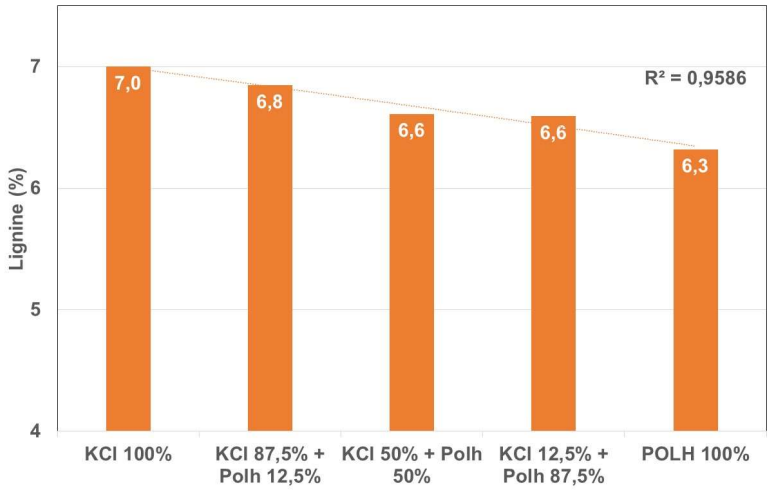
Alfalfa experiment

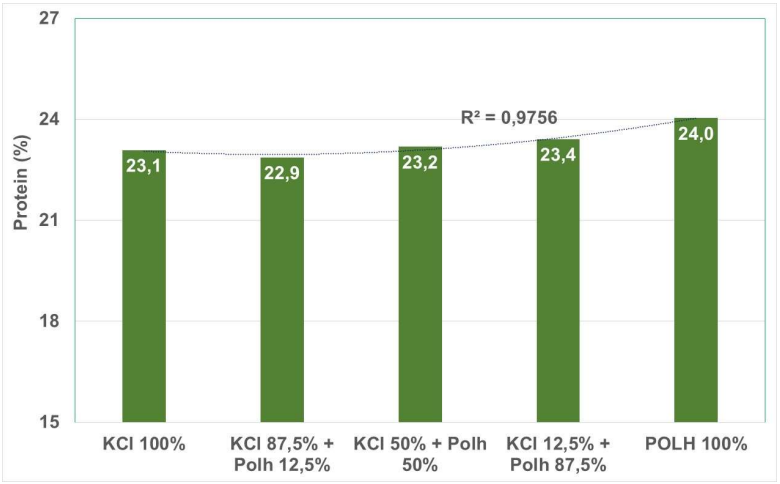
Field


30
25
20
15
10
5
0
Dry matter yield (t/ha)
R² = 0,8495
Control
KCl 100%
KCl 87,5% + POLH 12,5%
KCl 50% + POLH 50%
KCl 12,5% + POLH 87,5%
POLH 100%


35
30
25
20
15
10
5
0
K, Ca and Mg shoot dry matter (g/kg)
Mg
Ca
K
R² = 0,452
R² = 0,8124
R² = 0,6382
KCl 100%
KCl 87,5% + Polh 12,5%
KCl 50% + Polh 50%
KCl 12,5% + Polh 87,5%
POLH 100%


2,0
1,5
1,0
0,5
0,0
S shoot dry matter (g/kg)
S
R² = 0,8081
KCl 100%
KCl 87,5% + Polh 12,5%
KCl 50% + Polh 50%
KCl 12,5% + Polh 87,5%
POLH 100%


Lignine (%)
7
6
5
4
R² = 0,9586
7,0
6,8
6,6
6,6
6,3
KCl 100%
KCl 87,5% + Polh 12,5%
KCl 50% + Polh 50%
KCl 12,5% + Polh 87,5%
POLH 100%


Protein (%)
27
24
21
18
15
R² = 0,9756
23,1
22,9
23,2
23,4
24,0
KCl 100%
KCl 87,5% + Polh 12,5%
KCl 50% + Polh 50%
KCl 12,5% + Polh 87,5%
POLH 100%

Crop-livestock integrated systems

✓ CLIS have been used as a strategy of sustainable agricultural intensification which integrates annual crops and livestock activities on the same area and in the same season.


Corn sowing + grass
(Summer)
18 2 2004


Corn harvest + grass
(Summer)

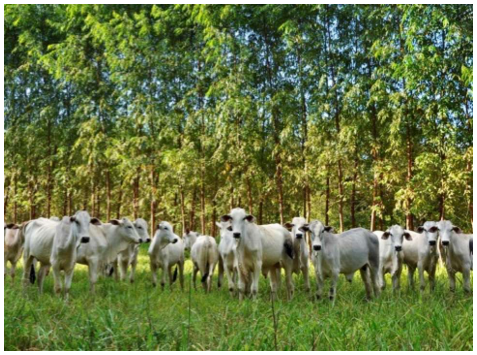

Corn residues + grass
(Summer)
21 2 2001


Renewd grass
(Fall)

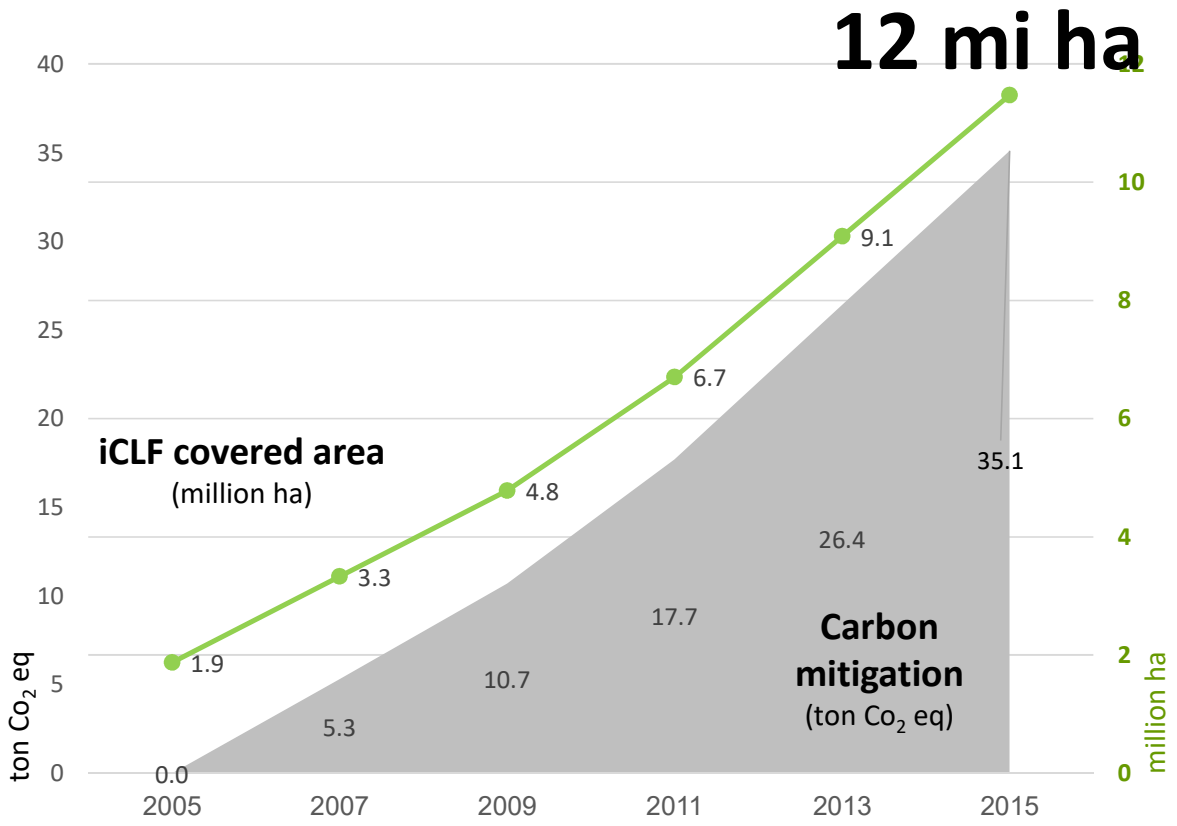

Cattle grazing rewed pasture
(Winter)

Integrated Crop Livestock Forest Systems

in Brazil

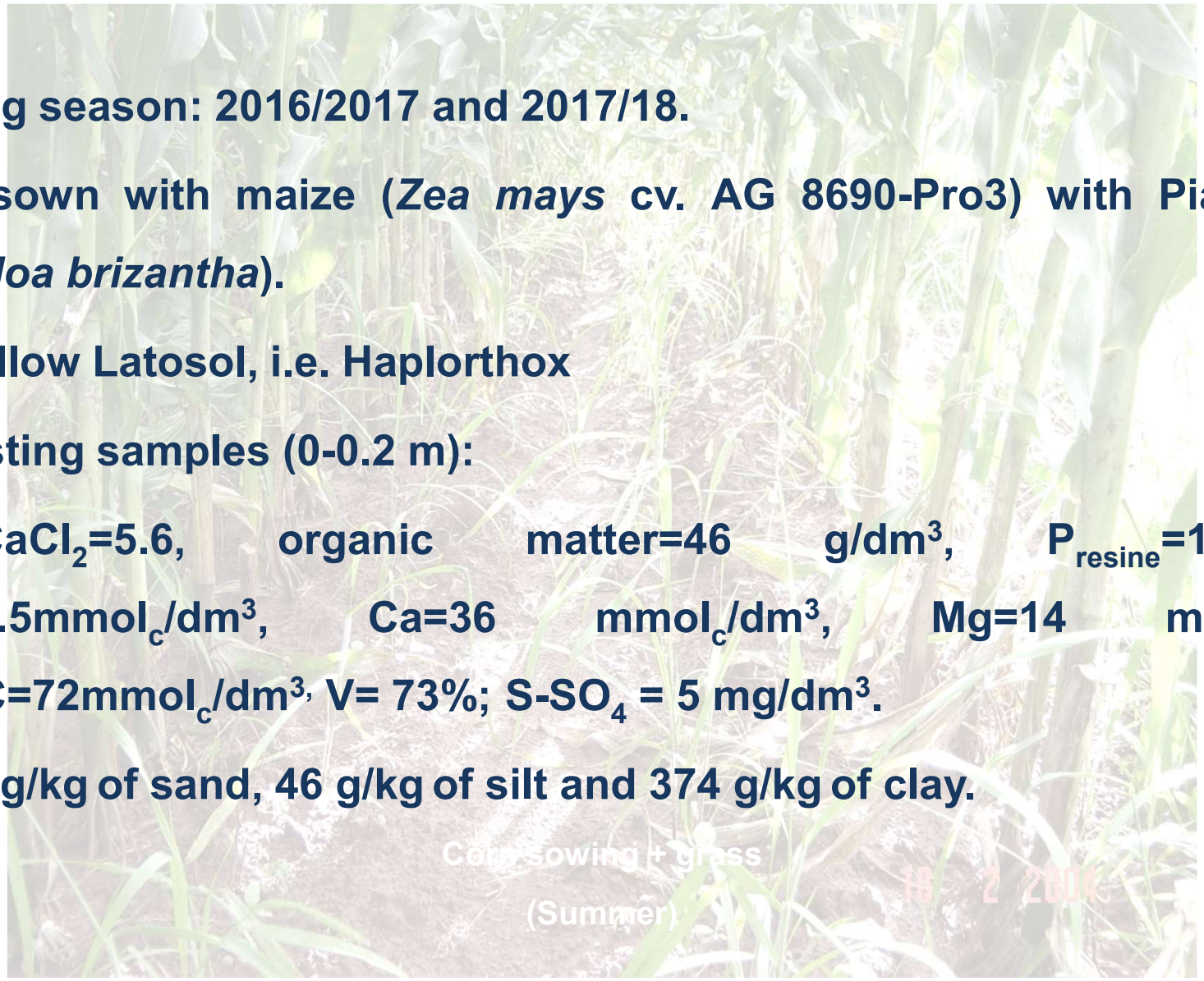


Low-Carbon Agriculture

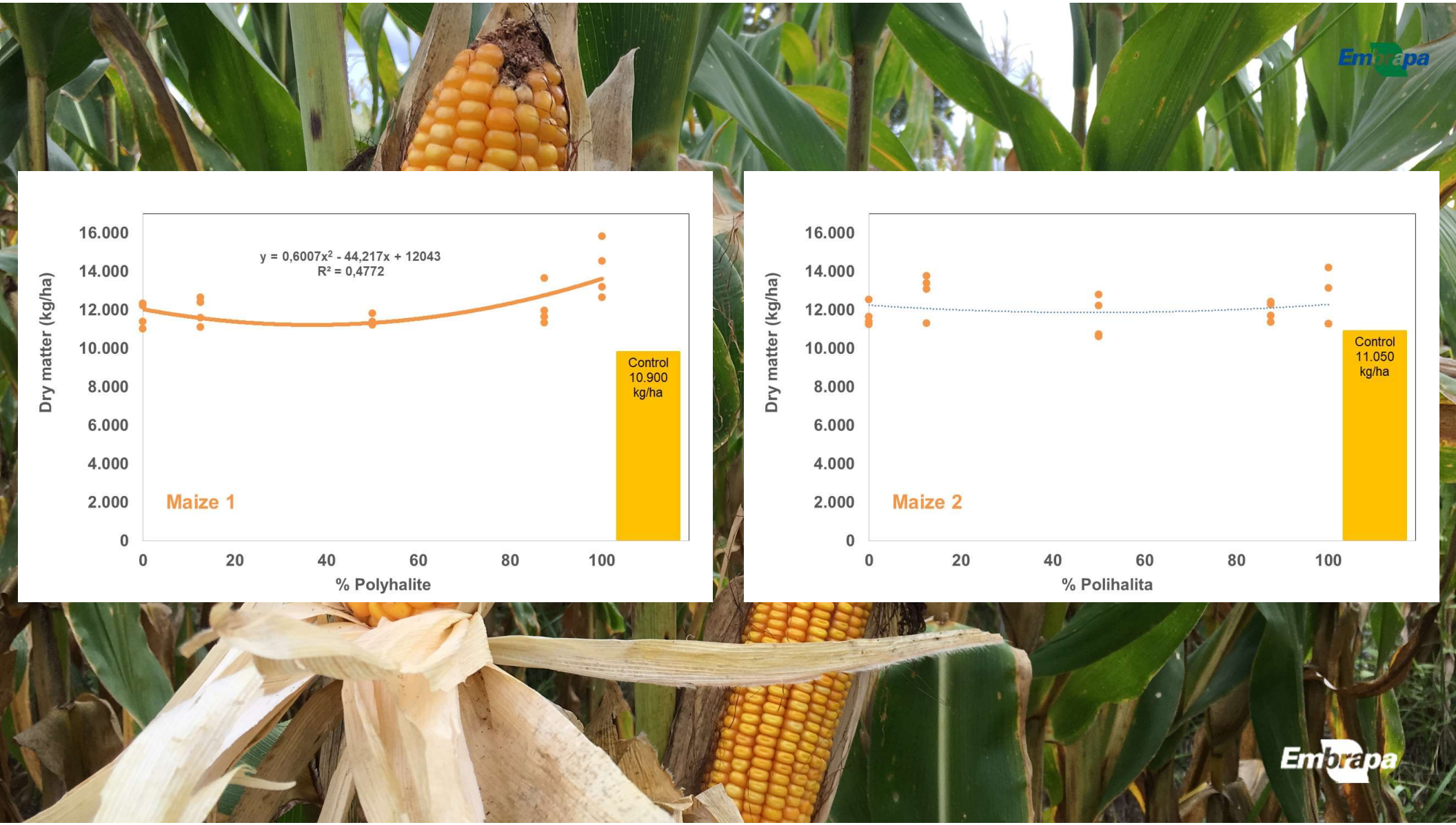


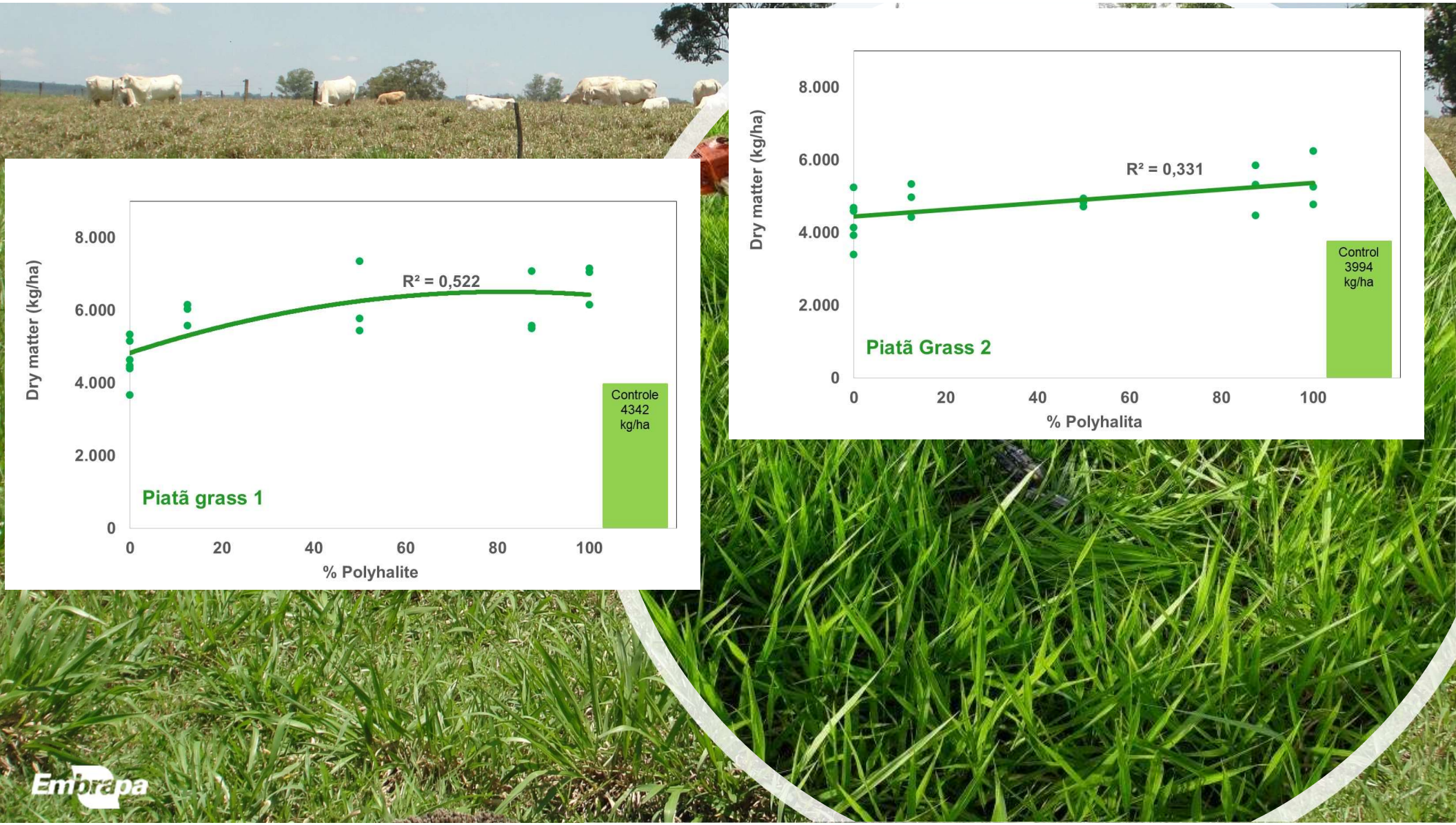
Maize & grass rotation experiment

- ✓ Growing season: 2016/2017 and 2017/18.
- ✓ ICLS: sown with maize (*Zea mays* cv. AG 8690-Pro3) with Piatã grass (*Urochloa brizantha*).
- ✓ Red-yellow Latosol, i.e. Haplorthox
- ✓ Soil testing samples (0-0.2 m):
  - ❑ $pHCaCl_2$=5.6, organic matter=46 g/dm^3, P_{resine}=11mg/dm^3, K=1.5mmol$_c$/dm^3, Ca=36 mmol$_c$/dm^3, Mg=14 mmol$_c$/dm^3, CEC=72mmol$_c$/dm^3, V= 73%; S-SO_4 = 5 mg/dm^3.
  - ❑ 580 g/kg of sand, 46 g/kg of silt and 374 g/kg of clay.



- ✓ Lime was not necessary,
- ✓ Fertilizations
  - Sowing : N, 40 kg/ha, P_2O_5, 140 kg/ha; K_2O, 80 kg/ha
  - Topdressing: N, 100 kg/ha, P_2O_5, 20 kg/ha; K_2O, 100 kg/ha
- ✓ Treatments comprised two K sources: polyhalite and KCl (five ratios (polyhalite:KCl) with 4 replications:
  - i) Control (no K, S, Mg or Ca);
  - ii) KCl 100%;
  - iii) KCl 87,5% + Polyhalite 12,5%;
  - iv) KCl 50% + Polyhalite 50%;
  - v) KCl 12,5% + Polyhalite 87,5%;
  - vi) Polyhalite 100%;


Dry matter (kg/ha)
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0
y = 0,6007x² - 44,217x + 12043
R² = 0,4772
Maize 1
Control
10.900
kg/ha
0
20
40
60
80
100
% Polyhalite
Dry matter (kg/ha)
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0
Maize 2
Control
11.050
kg/ha
0
20
40
60
80
100
% Polihalita


8.000
6.000
4.000
2.000
0
Dry matter (kg/ha)
R² = 0,522
Piatã grass 1
Controle
4342
kg/ha
0
20
40
60
80
100
% Polyhalite
8.000
6.000
4.000
2.000
0
Dry matter (kg/ha)
R² = 0,331
Piatã Grass 2
Control
3994
kg/ha
0
20
40
60
80
100
% Polyhalita

Leaf analysis

Treatments	K		Ca		Mg		S	
	g/kg							
POLH 100%	16,58	-	2,60	B	1,79	B	1,56	-
KCl 12,5% + POLH 87,5%	16,89	-	2,64	B	1,72	B	1,68	-
KCl 50% + POLH 50%	16,47	-	2,44	B	1,57	B	1,50	-
KCl 87,5% + POLH 12,5%	16,62	-	2,51	B	1,66	B	1,50	-
KCl 100%	16,74	-	2,59	B	1,69	B	1,49	-
Controle	15,54	-	3,37	A	2,31	A	1,67	-

Nutrient exportation

Treatments	K		Ca		Mg		S	
	kg/ha							
POLH 100%	125,0	A	12,2	-	19,4	A	13,4	A
KCl 12,5% + POLH 87,5%	110,2	AB	11,7	-	16,5	ABC	11,9	AB
KCl 50% + POLH 50%	104,2	AB	11,7	-	15,5	ABC	10,9	B
KCl 87,5% + POLH 12,5%	94,4	BC	9,0	-	14,8	BC	10,4	BC
KCl 100%	93,8	BC	9,2	-	13,9	C	8,9	C
Controle	74,0	C	12,3	-	18,3	AB	10,7	BC

Soil testing

Tratamentos	K				Ca				Mg				S			
	mmol$_c$/dm^3												mg/dm^3			
	0-20		20-40		0-20		20-40		0-20		20-40		0-20		20-40	
POLH 100%	1,25	A	1,0	B	31,0		27,0		11,8	A	7,5	B	9,0	Ba	24,5	Aab
KCl 12,5% + POLH 87,5%	1,08	A	0,9	B	37,5		41,3		10,3	A	7,3	B	9,0	Ba	31,0	Aa
KCl 50% + POLH 50%	1,15	A	0,7	B	27,8		31,3		8,8	A	6,0	B	8,0	Ba b	25,0	Aab
KCl 87,5% + POLH 12,5%	1,18	A	0,88	B	40,0		29,0		11,0	A	7,0	B	5,3	Bb	19,0	Abc
KCl 100%	1,50	A	0,93	B	26,3		28,5		10,8	A	7,5	B	6,3	Ba b	16,3	Ac
Controle	0,98	A	0,95	A	31,3		27,0		10,8	A	7,8	B	7,0	Ba b	18,5	Abc

Summary

✓The best results of dry matter yield of alalfa, maize and Piatã grass were obtained with the treatments with the highest ratios of polyhalite.

✓Polyhalite = better than KCl alone or plus gypsum

✓Polyhalite is a source of K, Ca, Mg, and S and can meet the nutritional requirements of annual crops and pastures and high yields high quality products.

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Obrigado
Thank you
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