U.S. Borax

Final Report – Coffee Trial

“Study of Boron in Brazilian Agriculture”

Dr. Fabio Vale

Piracicaba, March / 2016

Coffee Trial

First harvest – 2014

Coffee Trial

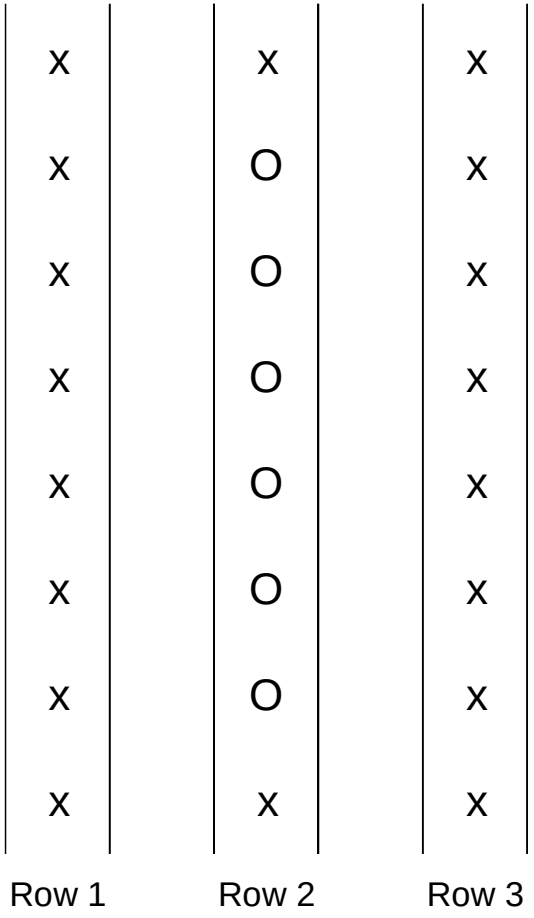
- Place – Sítio São João
- City – Espirito Santo do Pinhal/SP
- Variety – Catuai Amarelo ICA 62 (Yellow Catuai)
- Age – 5 years
- Application treatments date : 11/11/2013
- Spacing between rows: 3.2 m
- Spacing between trees: 0.7 m
- Trees per hectare: 4465
- Plots – 3 rows x 8 trees
- 9 treatments and 4 replications = 36 parcels
- Blocks randomized

Details of the Plots

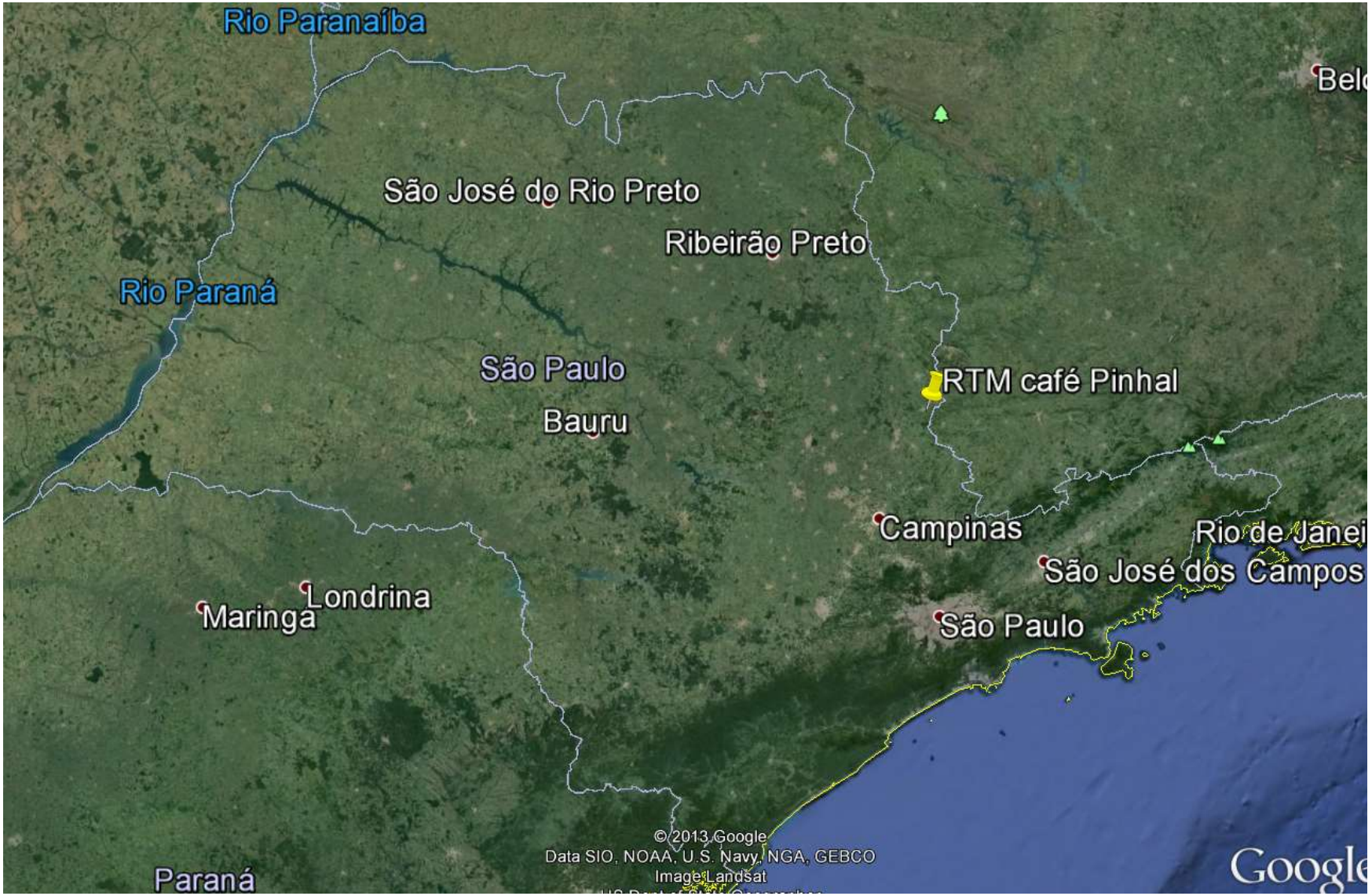
- Plots – 3 rows x 8 trees
- The six central plants of line 2 were harvested.

x = unharvested plants

O = harvested plants



Coffee Trial



Coffee Trial

Coffee Trial

Treatments

Treatment	Source	B rate	Source rate	
		kg/ha	kg/ha	g/tree
1	Control	0	0	0
2	Ulexite	1.5	15.0	3.4
3	Ulexite	3	30.0	6.7
4	*Granubor®*	1.5	10.7	2.4
5	*Granubor*	3	21.4	4.8
6	Boric acid	1.5	8.8	2.0
7	Boric acid	3	17,6	4.0
8	*Solubor®*	1.5	7.5	1.7
9	*Solubor*	3	15.0	3.4

All parcels were fertilized with:

- 50 g/tree of single superphosphate in October/13
- 200 g/tree of the blend 20-00-15 in November/13 (same day of treatment application)
- 200 g/tree of the blend 20-00-15 in January/14
- 60 g/tree of urea in March/14

Sketch

Block I		Block II		Block III		Block IV	
Parcel	Treatment	Parcel	Treatment	Parcel	Treatment	Parcel	Treatment
1	1	10	8	19	3	28	9
2	2	11	7	20	4	29	8
3	3	12	2	21	9	30	5
4	4	13	5	22	1	31	2
5	5	14	9	23	6	32	7
6	6	15	1	24	8	33	3
7	7	16	3	25	7	34	6
8	8	17	6	26	5	35	4
9	9	18	4	27	2	36	1

Soil Samples (0-20 cm depth), Before Fertilizers Application (in June/13)

Depth	pH $CaCl_2$	OM	P resina	K	Ca	Mg	Al	H+Al	S	B	Cu	Fe	Mn	Zn
cm		g dm^{-3}	mg dm^{-3}	----------mmol$_c$ dm^{-3} ----------					----------mg dm^{-3} ----------					
0-20	5,3	21	29	2,3	16	3	1	28	7	0,5	2,4	48	1,9	2,3

Depth	SB	CEC	V	m
cm	------mmol$_c$ dm^{-3} ------		----------%----------	
0-25	21,4	49,4	43	4,5

- Soil with medium organic matter content
- Medium P concentration; medium K concentration; medium Ca concentration and low Mg concentration
- Low B concentration

Area Before Fertilization

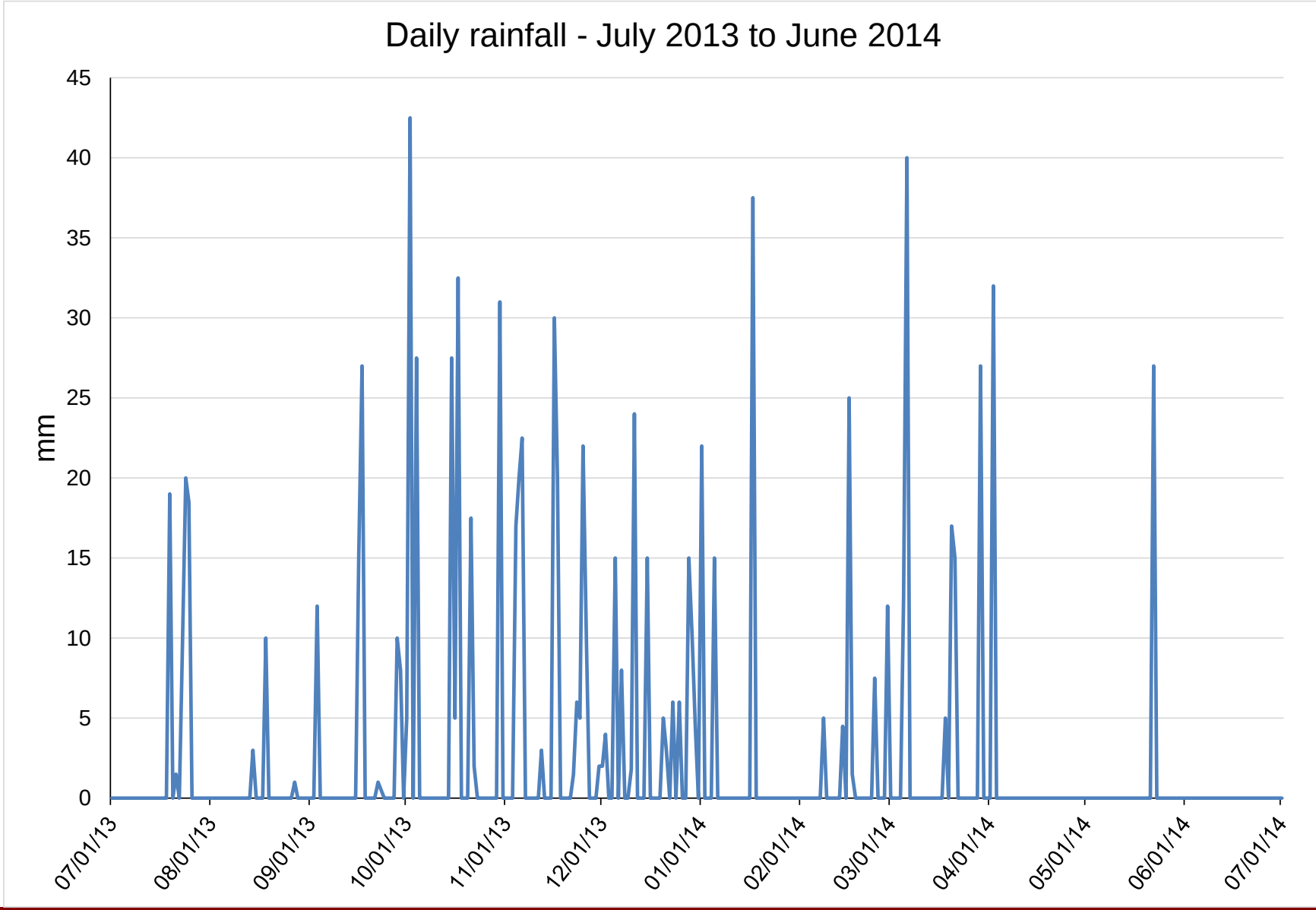
Blend Granubor® + NPK

Solid B Sources Application

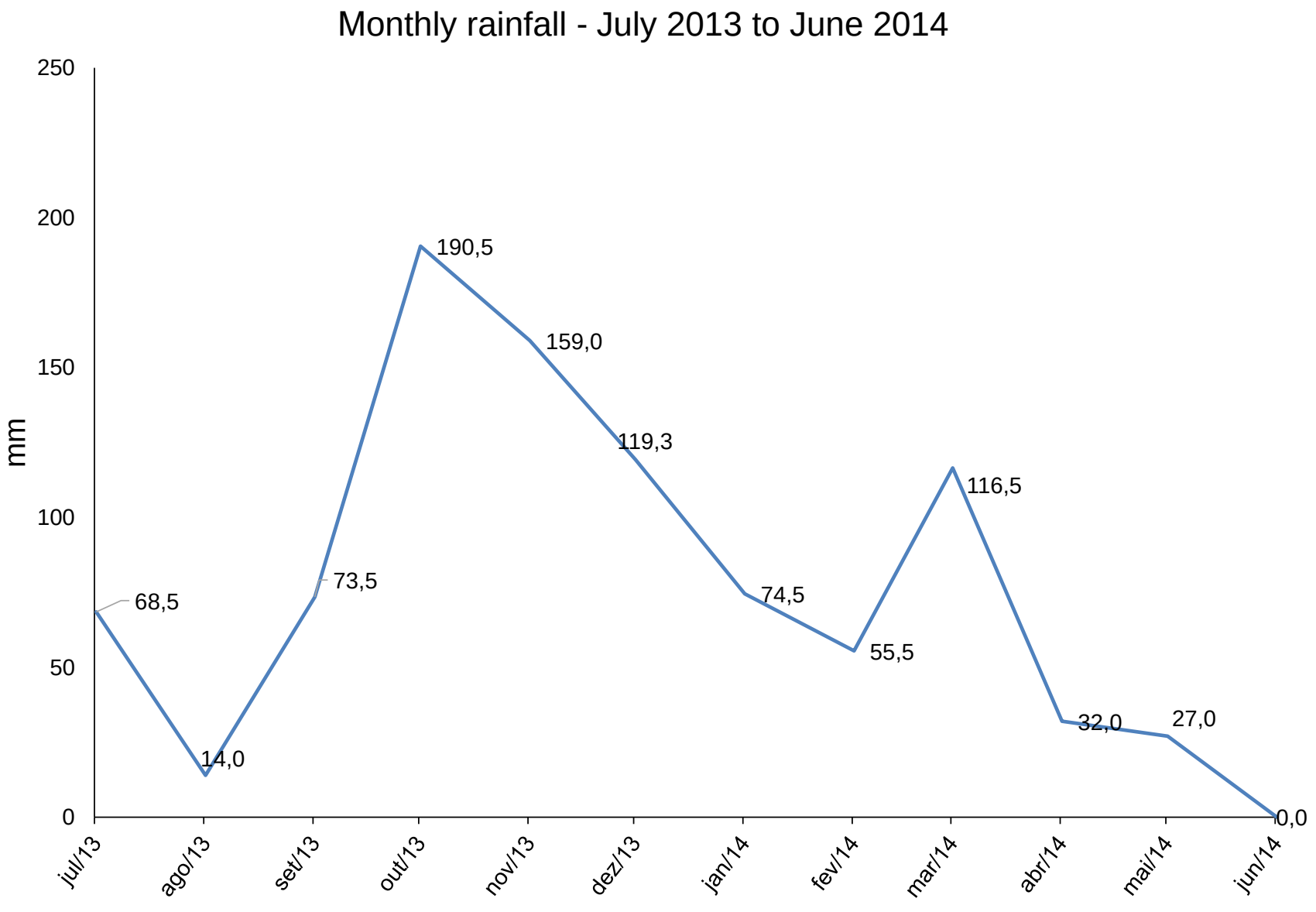
Solubor®

Solubor® Application

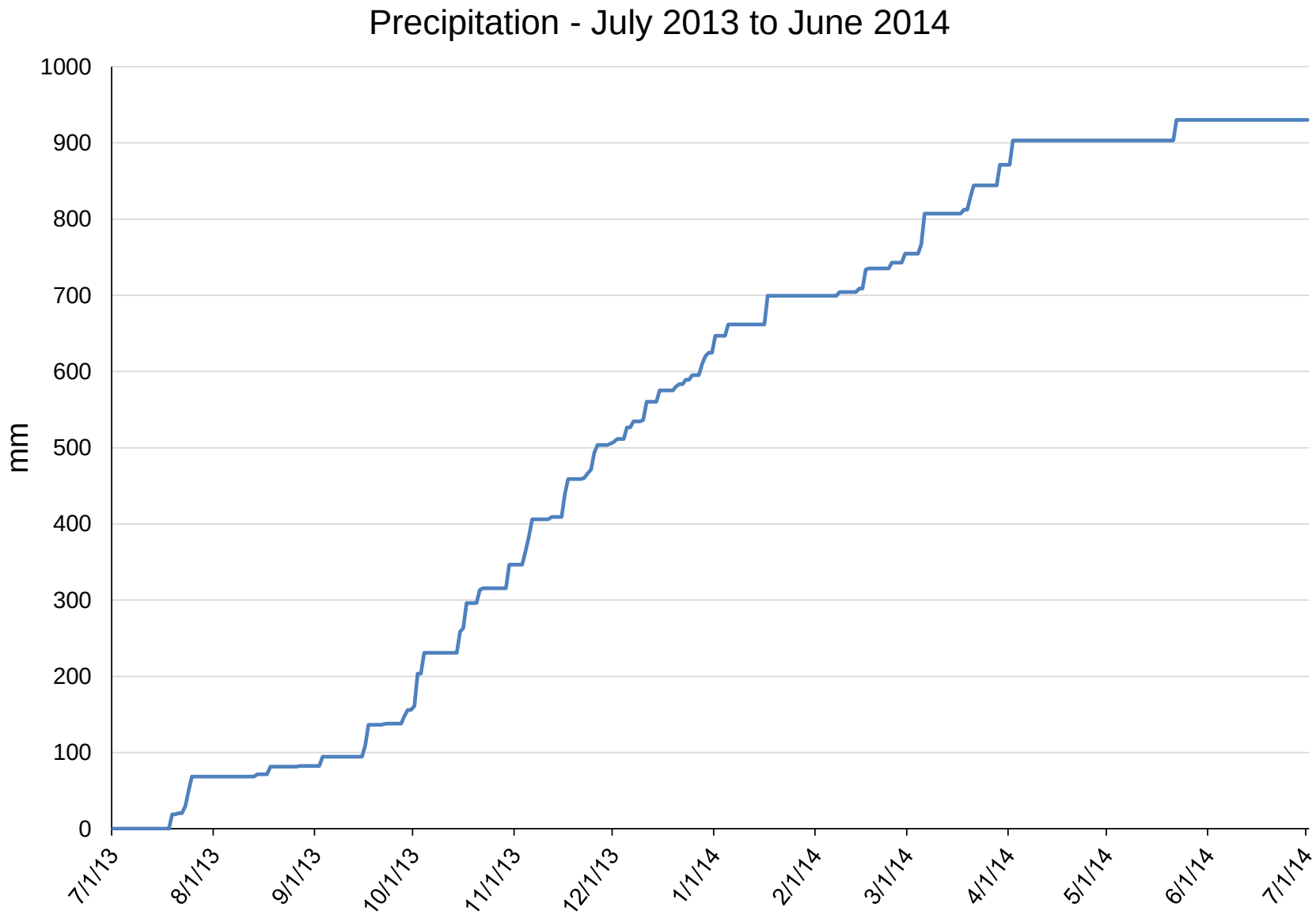
Rainfall


Daily rainfall - July 2013 to June 2014
mm
45
40
35
30
25
20
15
10
5
0
07/01/13
08/01/13
09/01/13
10/01/13
11/01/13
12/01/13
01/01/14
02/01/14
03/01/14
04/01/14
05/01/14
06/01/14
07/01/14

Rainfall


Monthly rainfall - July 2013 to June 2014
mm
250
200
150
100
50
0
68,5
14,0
73,5
190,5
159,0
119,3
74,5
55,5
116,5
32,0
27,0
0,0
jul/13
ago/13
set/13
out/13
nov/13
dez/13
jan/14
fev/14
mar/14
abr/14
mai/14
jun/14

Rainfall


Precipitation - July 2013 to June 2014
mm
1000
900
800
700
600
500
400
300
200
100
0
7/1/13
8/1/13
9/1/13
10/1/13
11/1/13
12/1/13
1/1/14
2/1/14
3/1/14
4/1/14
5/1/14
6/1/14
7/1/14

Rainfall

- Total rainfall during the experiment was 930 mm, which is lower than normal years
- Amount below normal between January and April, the period of greatest development of culture
- There was a decline in yield in the major production areas in coffee region
- Problem in fruits with malformed seeds

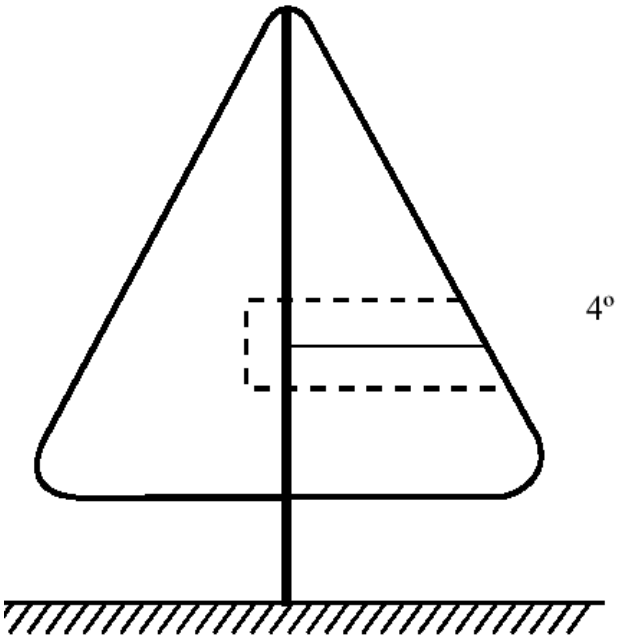
Evaluations to Be Made

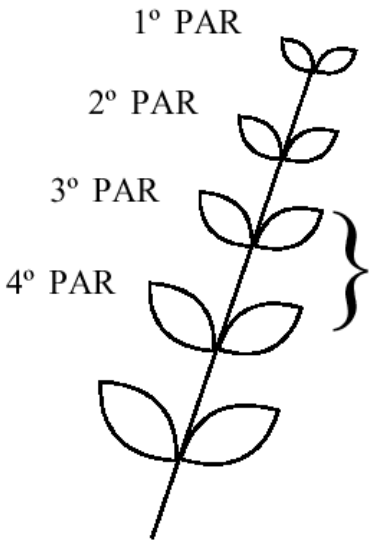
- Leaf analysis – in the beginning of February (2014 and 2015)
- Yield in June 2014
- Coffee quality in July 2014
- Soil tests per plot to evaluate B content in October 2014

90 Days After Fertilization (02/05/14)

Taking Leaves Samples (02/05/14)

Methodology

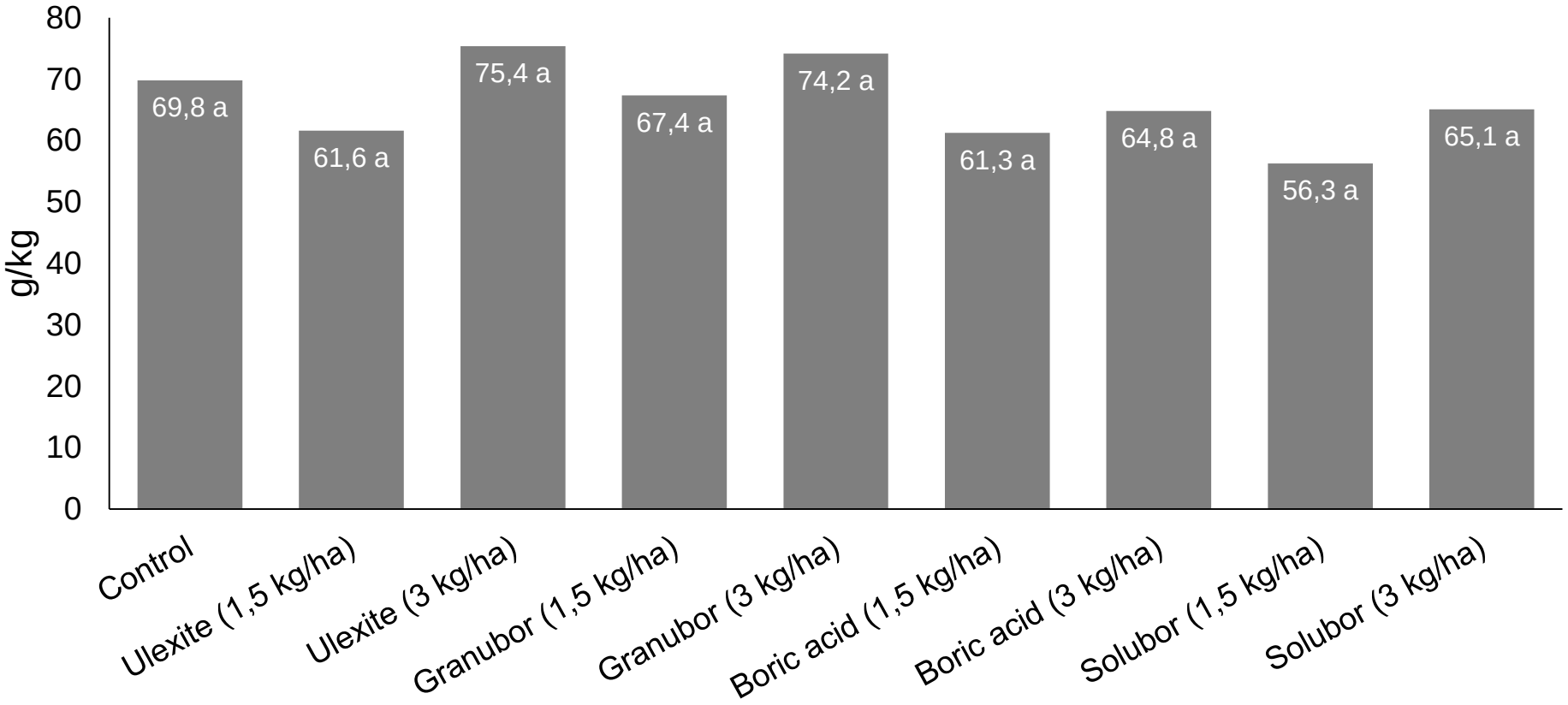




❶ 3rd and 4th pairs of leaves

❷Two side of the plants

Tissue Test



Average = 66,20 mg/kg VC = 12,64%

- Values are the average of 4 replicates
- Means followed by the same letter do not differ statistically by the Scott-Knott test at 5% probability
- No significative differences in B in leaves in function of sources and rates of B

Harvest

June, 6th

Plants Before Harvest

Plants Before Harvest

Harvested Six Plants per Plot

Removal of Impurities

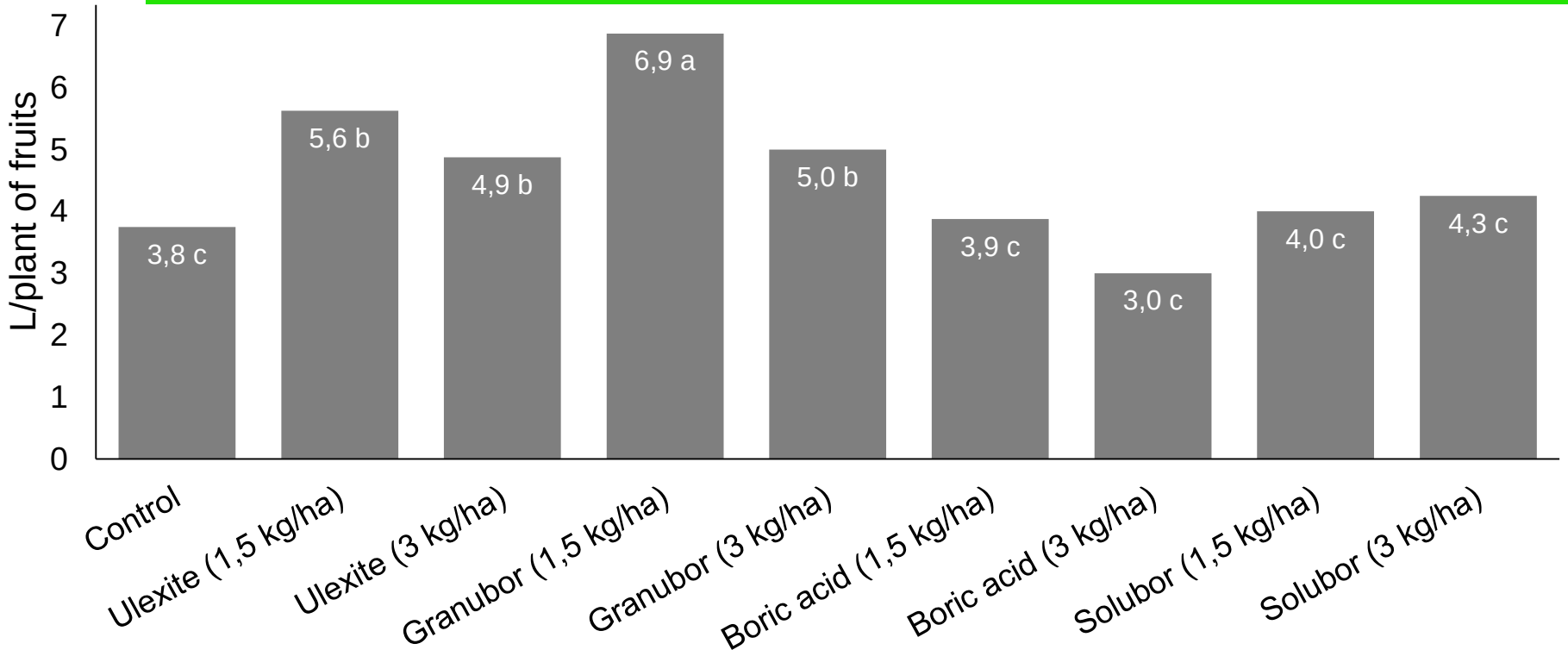
Coffee Fruits from Six Plants

Steps After Harvest

- Measuring the amount of liters of coffee fruits generated per plot.
- Selection of a sample per plot by separating a liter of coffee fruits harvested
- Sample placed in a container with water
- Selection of floating fruits, that were to surface water
  - ✓ Fruits with malformed seeds
- No floating fruits were separated in green and mature

Measuring the amount of liters of coffee fruits generated

Fruits per Plants (L/plant)



Average = 4,58 L/ha VC = 19,67%

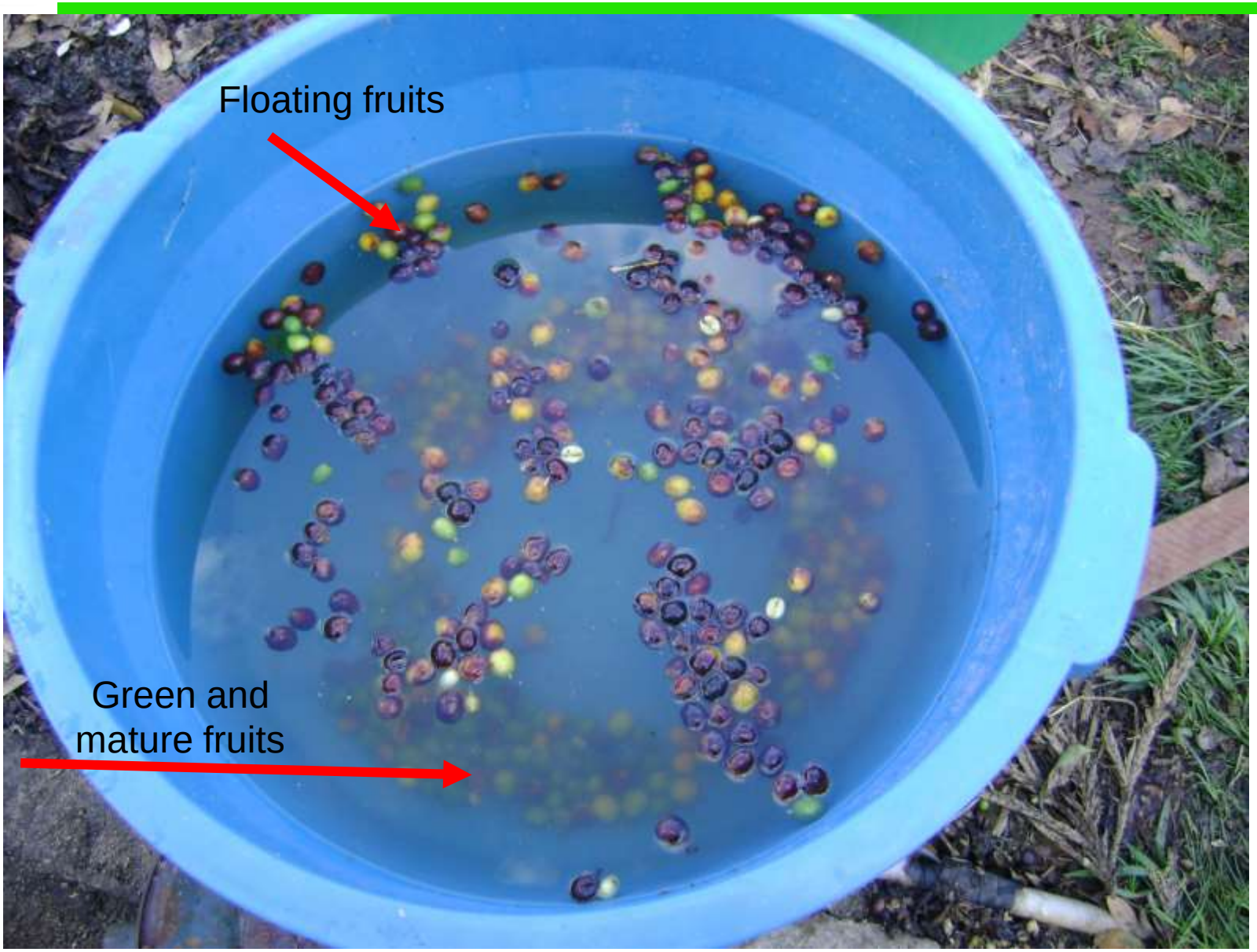
- Values are the average of 4 replicates
- Means followed by the same letter do not differ statistically by the Scott-Knott test at 5% probability

Fruits per Plants (L/plant)

- *Granubor*® in rate 1.5 kg/ha was the best treatment
- *Granubor* > Ulexite
- Lower rate > Bigger rate, probably because of toxicity of B
- Granulated sources > Soluble sources = Control

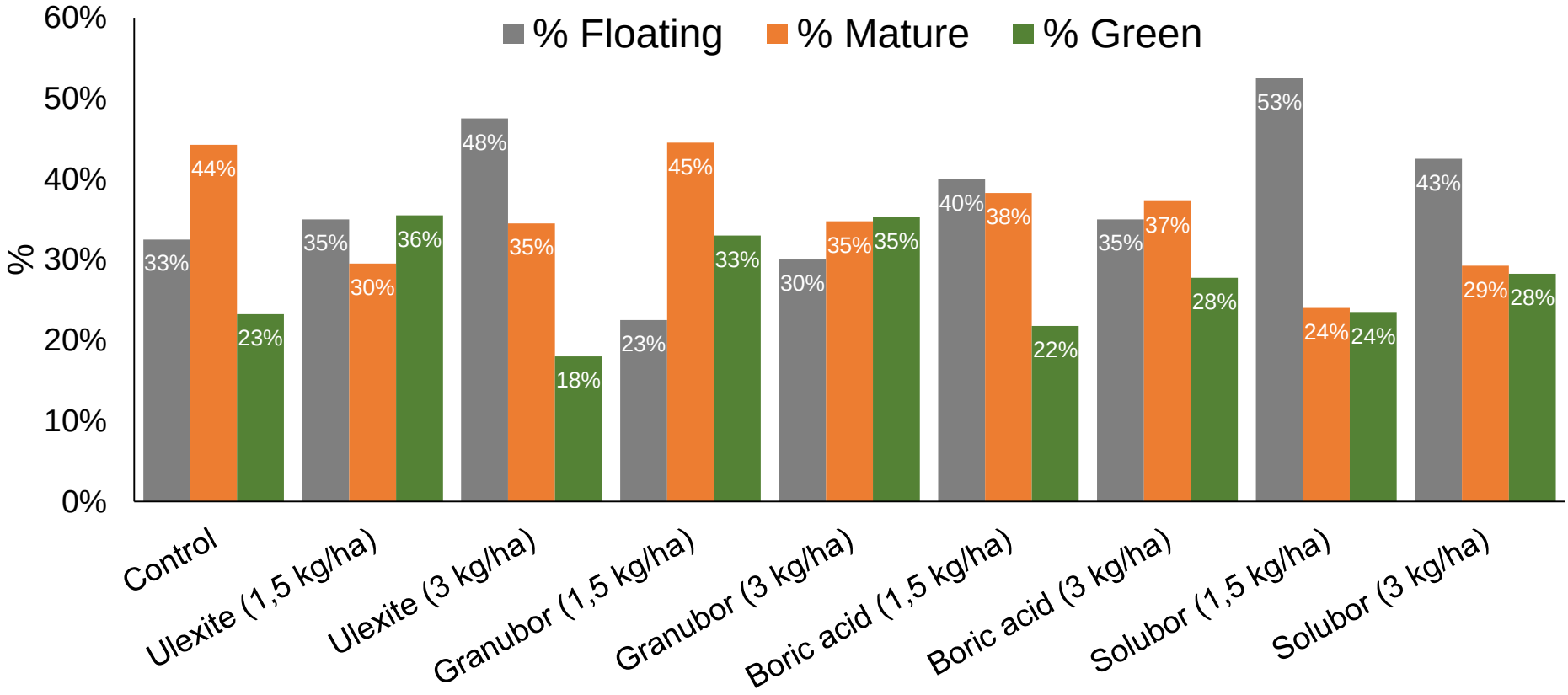
Selection of a sample per plot by separating a liter of coffee fruits harvested

Sample in a Container



Drying Samples in the Sun

Selection of Fruits



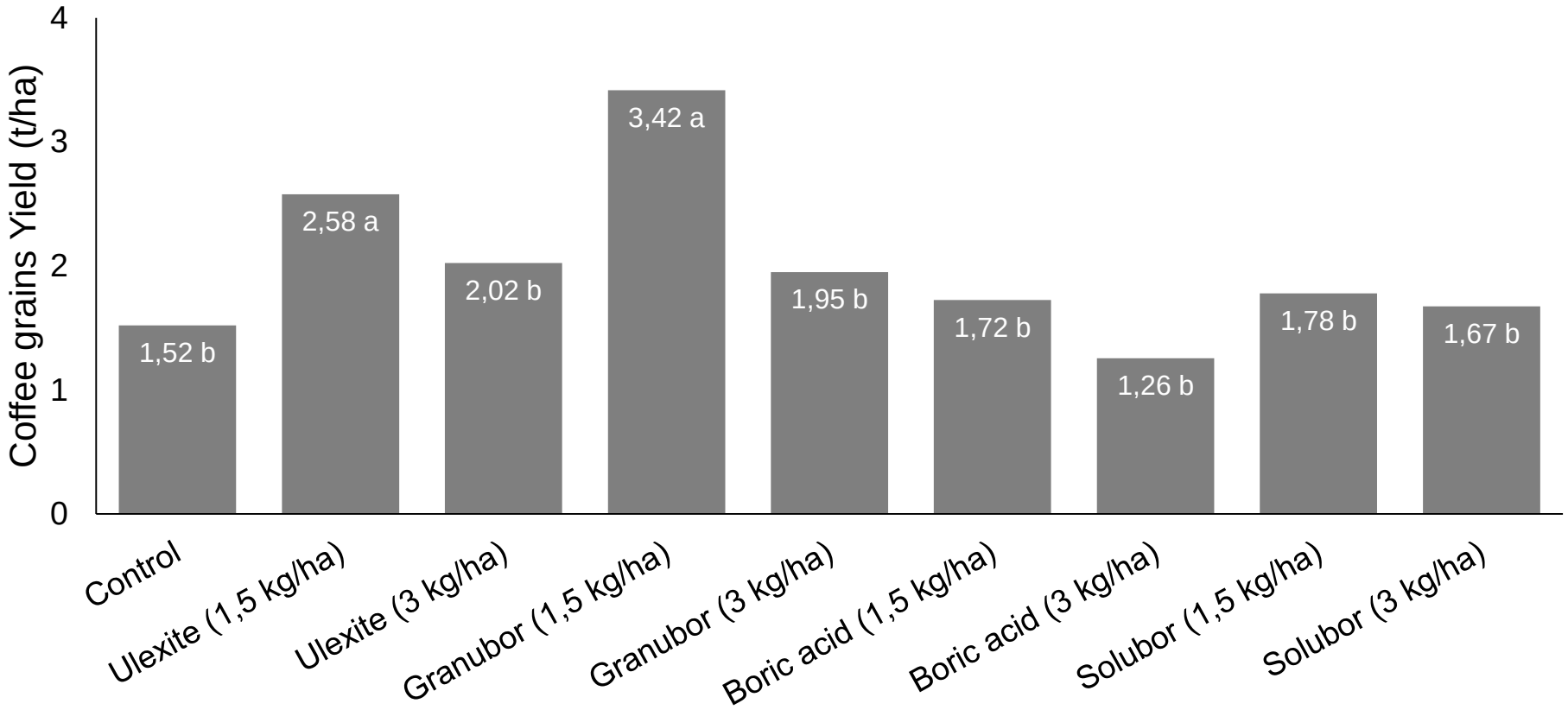
Selection of Fruits

- High variability among treatments
- Floating fruits – worst characteristic
  - ✓ Ulexite and *Solubor*® had more floating fruits
  - ✓ *Granubor*® had less floating fruits
- Mature fruits – Best characteristic
  - ✓ *Granubor* and Control had best results

Steps After Drying

- The grains were mixed (float, ripe and green) and then weighed.
  - ✓ Weight of coffee beans
- Grains were benefited, took up the bark. Then weighed
  - ✓ Weight of coffee grains
- Calculated the relationship between weight of grains and weight of beans = “Renda”

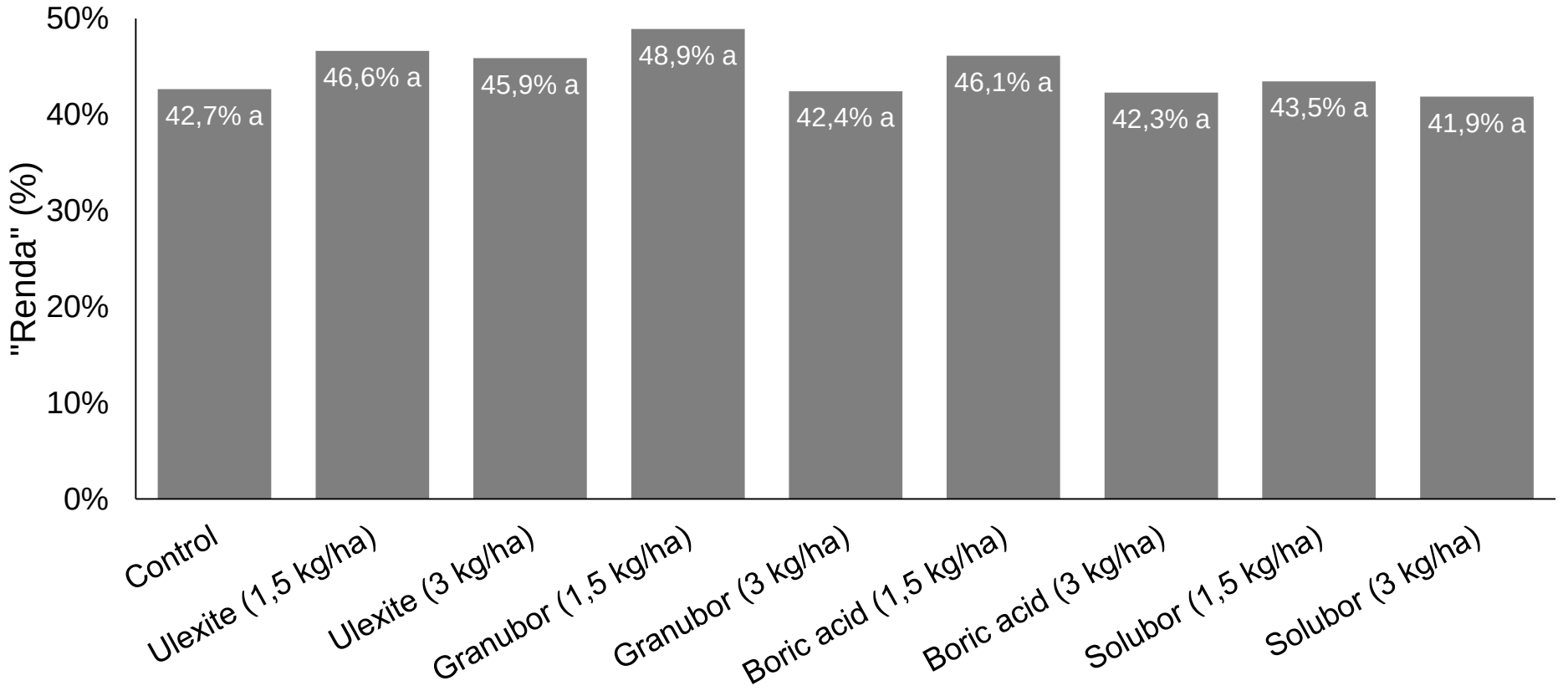
Yield Coffee Grains (t/ha)



Average = 1,99 t/ha VC = 32.89%

- Values are the average of 4 replicates
- Means followed by the same letter do not differ statistically by the Scott-Knott test at 5% probability

Revenue (%)



Average = 44,5% VC = 12,43%

- Values are the average of 4 replicates
- Means followed by the same letter do not differ statistically by the Scott-Knott test at 5% probability

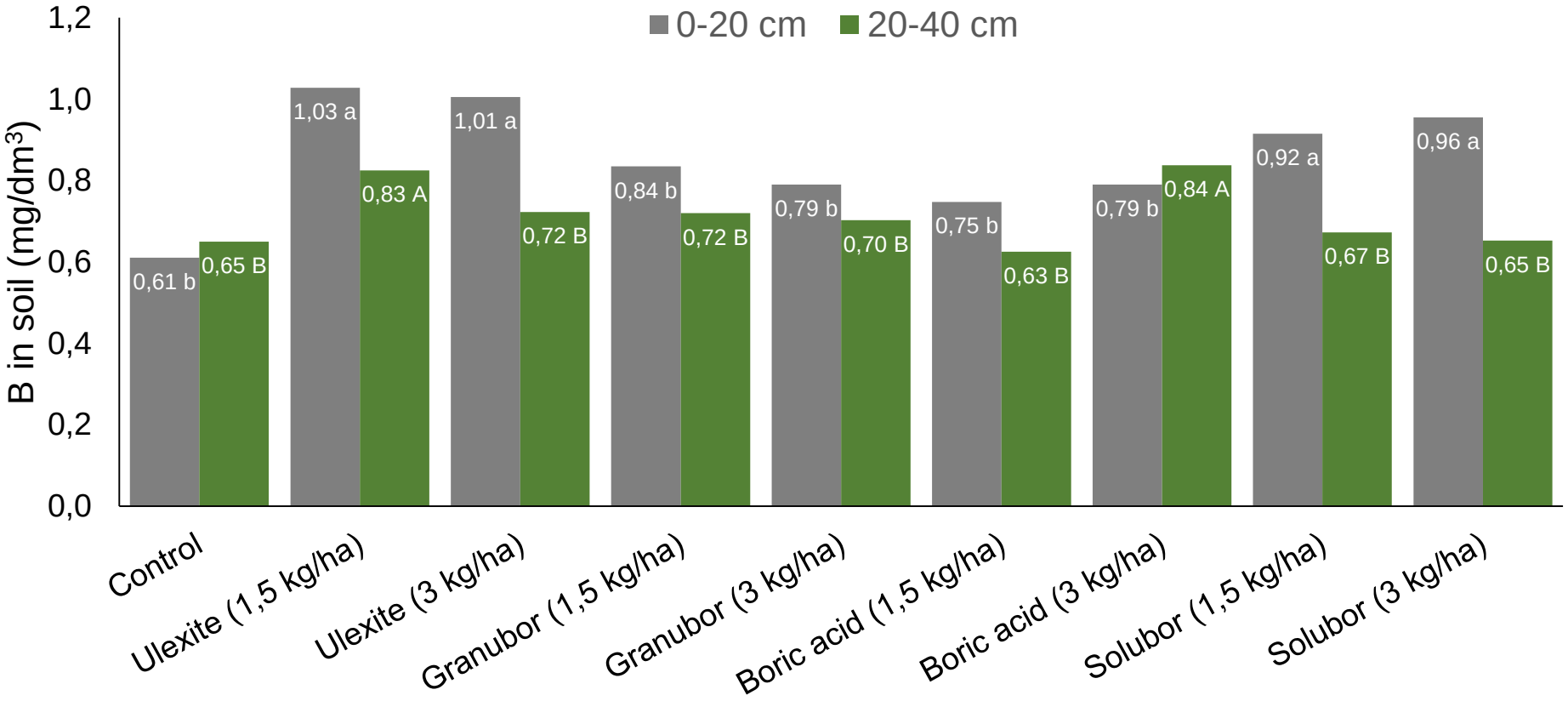
Yield

- Significant responses to the application of granular sources Ulexite and *Granubor*® compared to Control and Soluble Sources (Boric Acid and *Solubor*®)
- The explanation may be due to gradual solubility relative to the more soluble sources, which may have higher losses caused by leaching of B.
- Even without significant differences, the source *Granubor* showed superior results
- The rate of 1.5 kg/ha of B was sufficient to increase yield, and the rate of 3 kg/ha may be caused depreciation by possible toxicity
- The boric acid source in the highest rate caused a reduction in yield
- There was no effect on “Renda”

Soil Sampling

Soil Sampling, 0-20- e 20 40 cm depth

B in Soil, 0-20- e 20 40 cm depth



0-20 cm: Average = 0,85 mg/dm³ VC = 18,59%

20-40 cm: Average = 0,71 mg/dm³ VC = 13,58%

- Values are the average of 4 replicates
- Means followed by the same letter do not differ statistically by the Scott-Knott test at 5% probability
- Only even comparisons of the same depth

B in Soil, 0-20- e 20 40 cm depth

- Even one year after the implementation of the sources, the B continues in higher concentration in the surface layer, except for boric acid.
- Significantly greater amount of residual B 0-20 cm in depth when using Ulexite and *Solubor*®, regardless of the dose applied.
- B from boric acid source was leached in greater amount than when applied *Solubor*.
- *Granubor*® treatments had lower amount of residual B in the soil than the source Ulexite. However, the yield was higher for the use of *Granubor*. This may indicate that the source *Granubor* had a solubility of more adjusted to the needs of the culture.

Conclusions for First Year

- Despite the adverse weather conditions, coffee plants were influenced by the application of boron in the soil
- Application of granular sources Ulexite and *Granubor*® showed significant results when compared to Control and Soluble Sources (Boric Acid and *Solubor*®)
- Even without significant differences, the source *Granubor* showed superior results
- The second crop which starts from now it will be important to the final conclusion of this experiment.

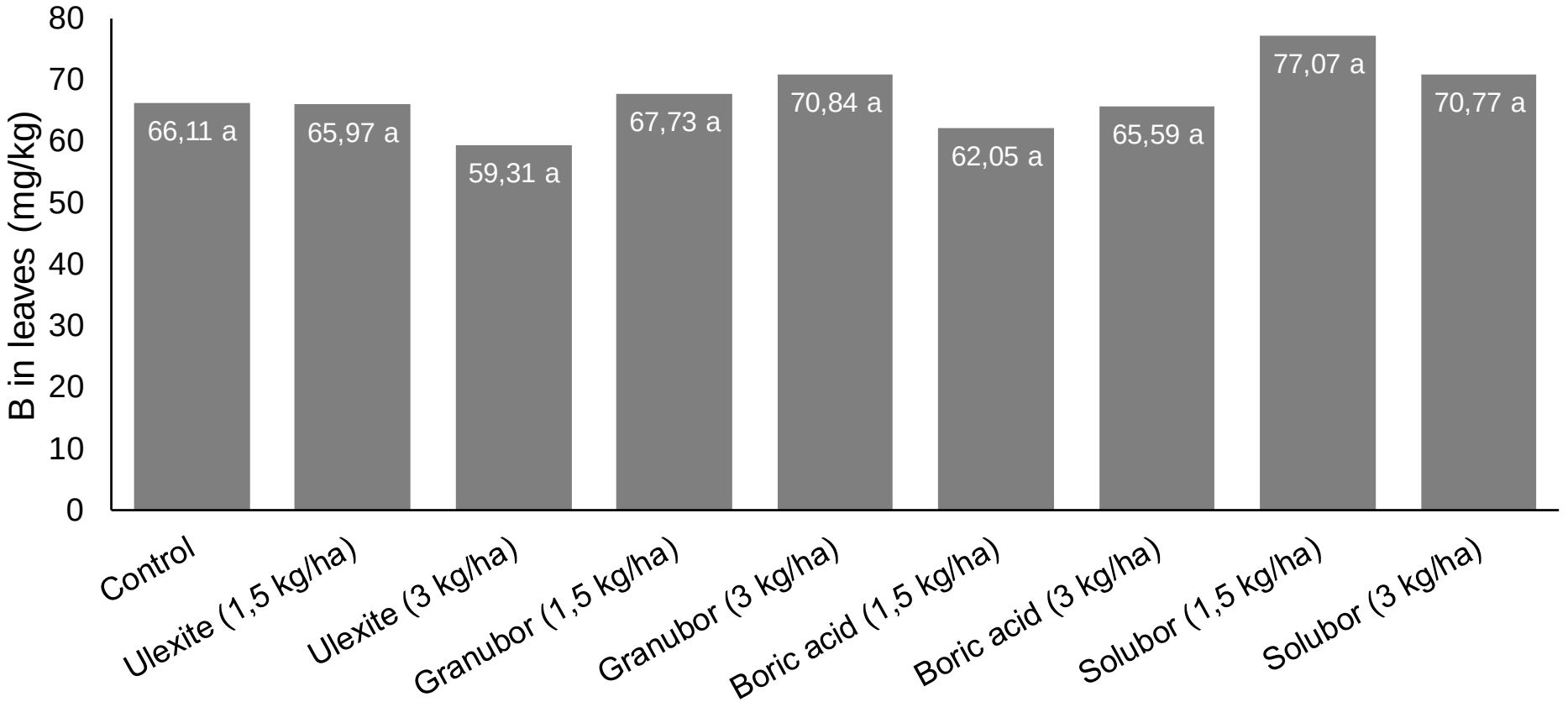
Second Year

Treatments application – November, 15th, 2014

Evaluations

- Leaf analysis – in the beginning of February 2015)
- Yield in June 2015
- Coffee quality in July 2015
- Soil tests per plot to evaluate B content in October 2015

Tissue Test



Average = 66,20 mg/kg VC = 15,43%

- Values are the average of 4 replicates
- Means followed by the same letter do not differ statistically by the Scott-Knott test at 5% probability
- No significative differences in B in leaves in function of sources and rates of B

Harvest

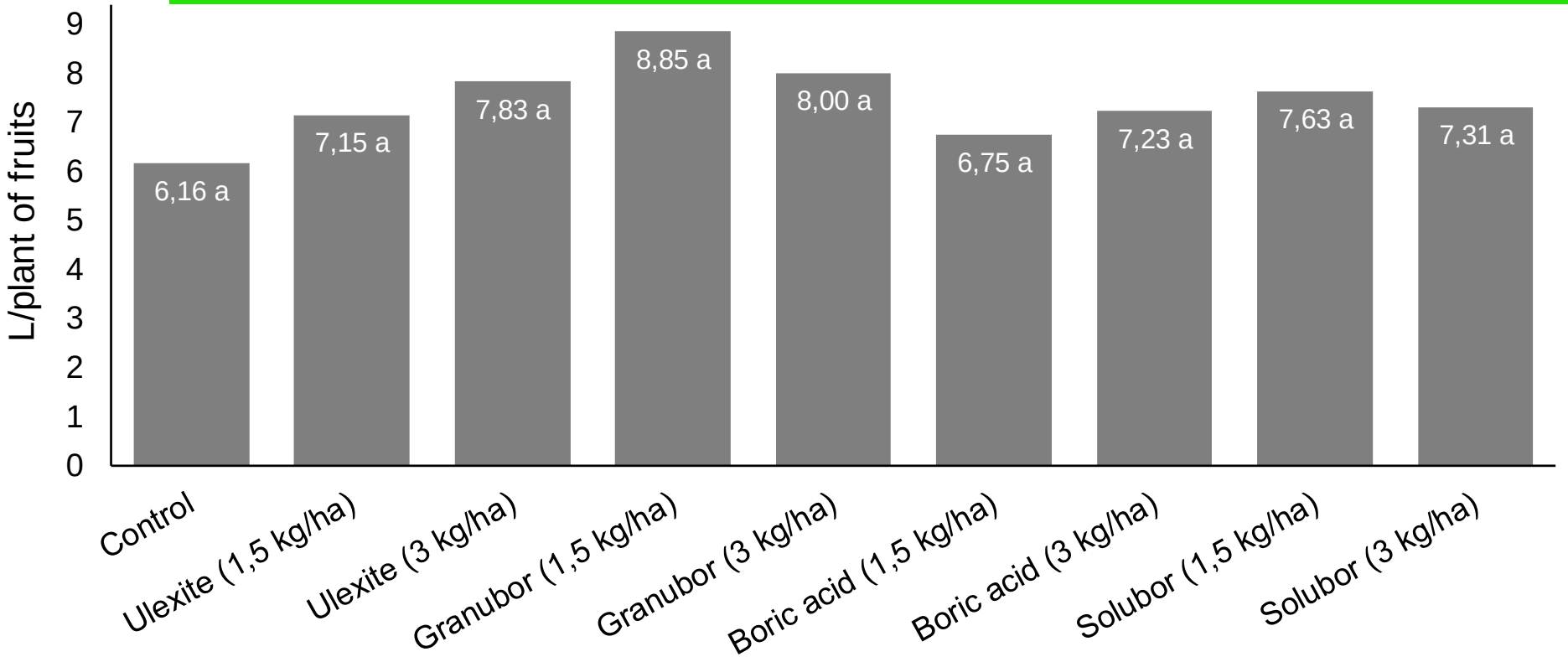
June, 26th, 2015

Harvest





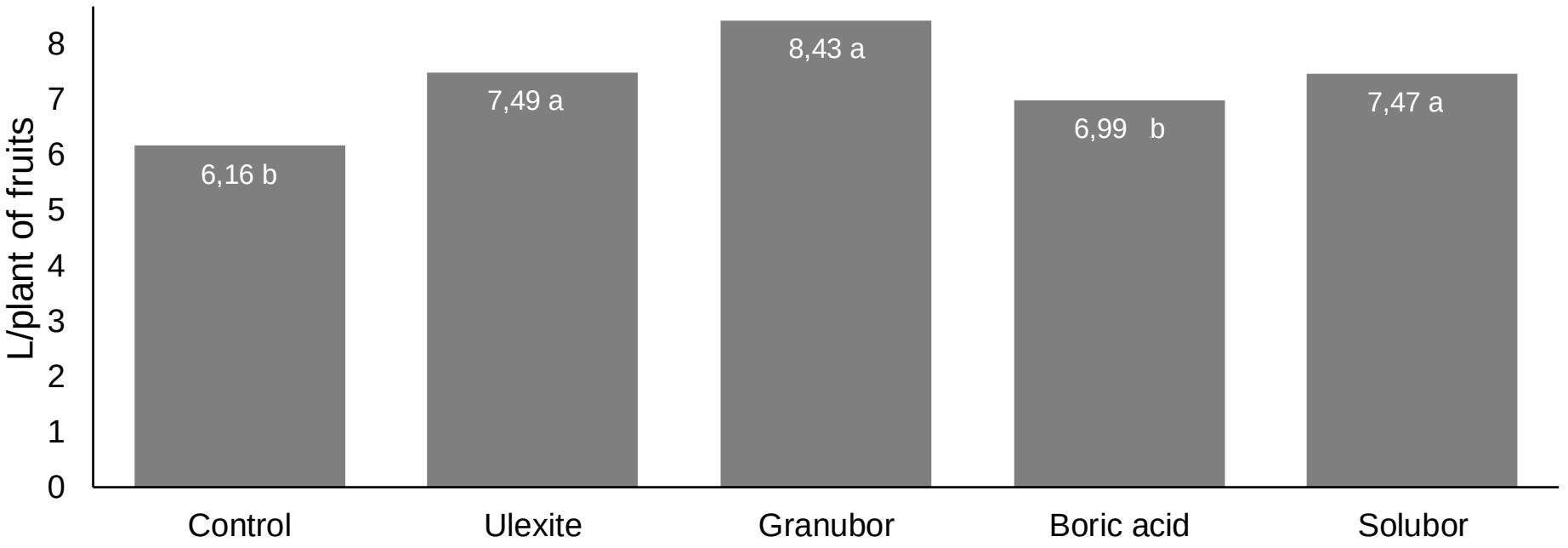

Fruits per Plants (L/plant) – Sources and Rates



Average = 7,43 L/ha VC = 15,39%

- Values are the average of 4 replicates
- Means followed by the same letter do not differ statistically by the Scott-Knott test at 5% probability

Fruits per Plants (L/plant) – Sources



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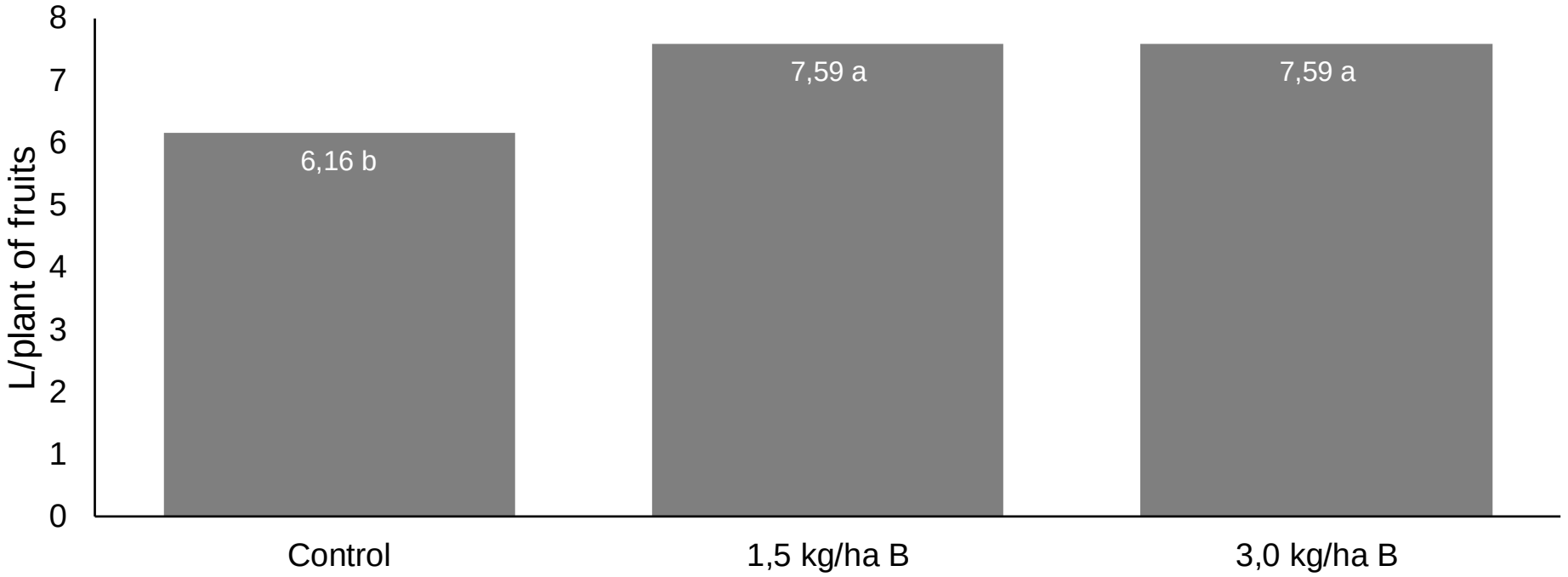
Fruits per Plants (L/plant) – Rates



Average = 7,43 L/ha VC = 15,39%

- Values are the average of 4 replicates
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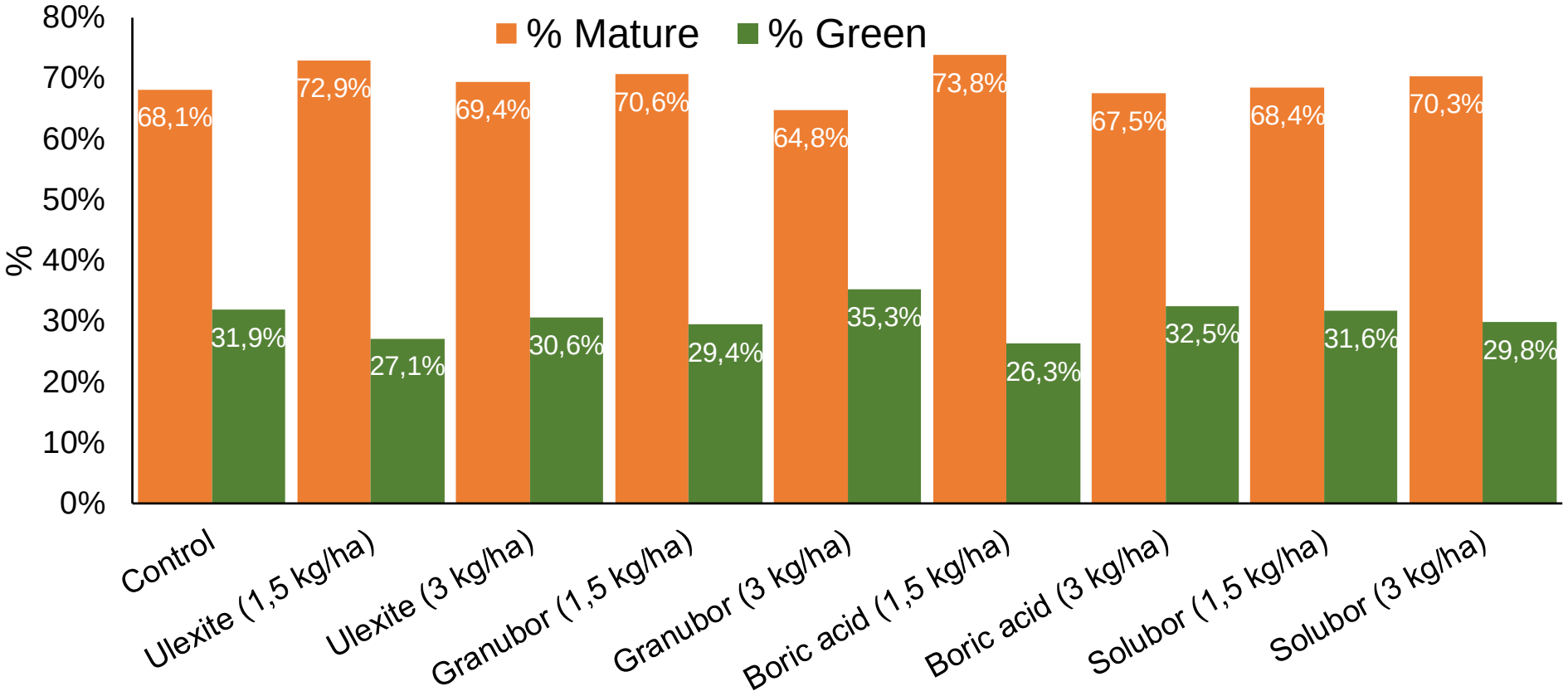
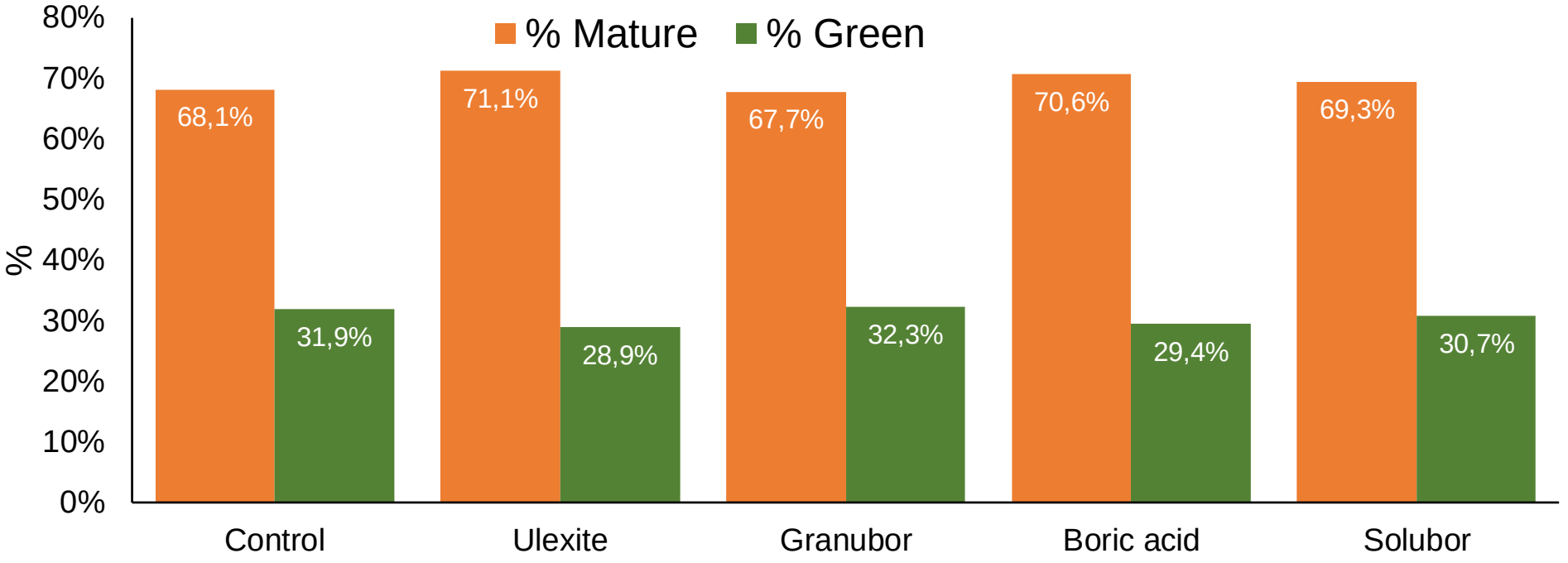
Fruits per Plants (L/plant)

- *Granubor*® in rate 1.5 kg/ha was the best treatment
- *Granubor* = Ulexite = *Solubor*® > Boric acid
- There was effects of boron application, rates have same results

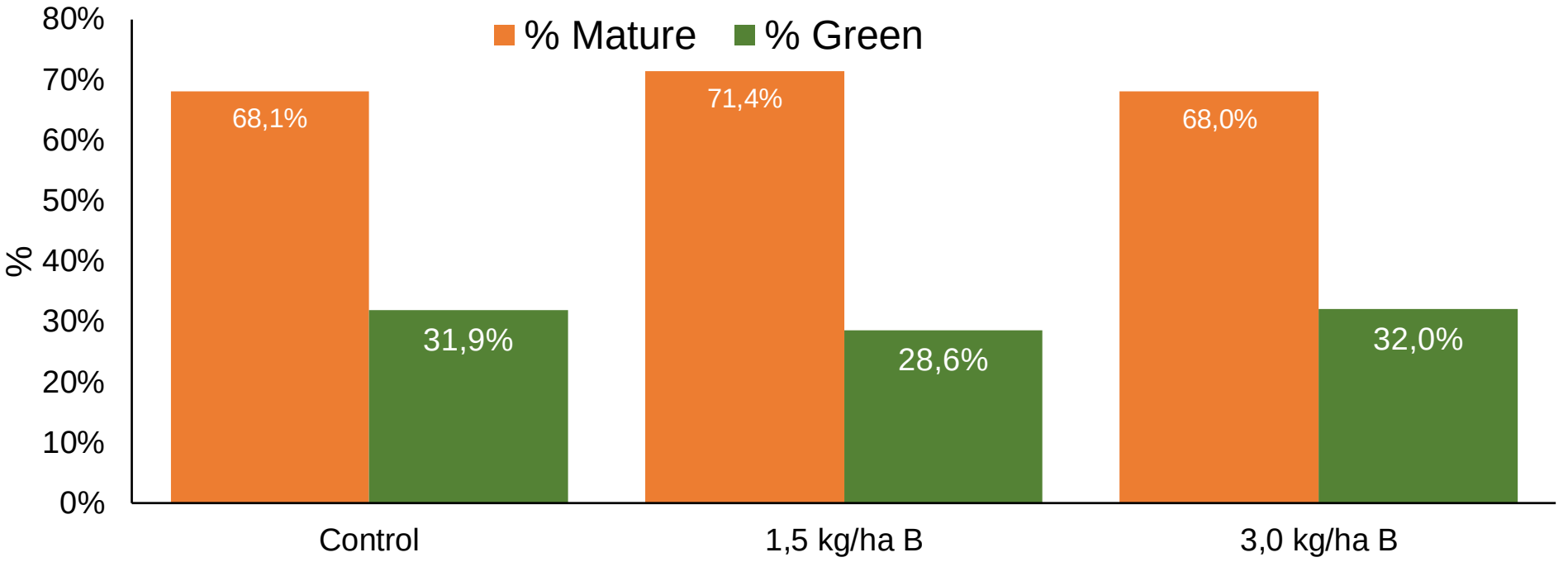
Selection of Fruits – Sources and Rates



Selection of Fruits – Sources



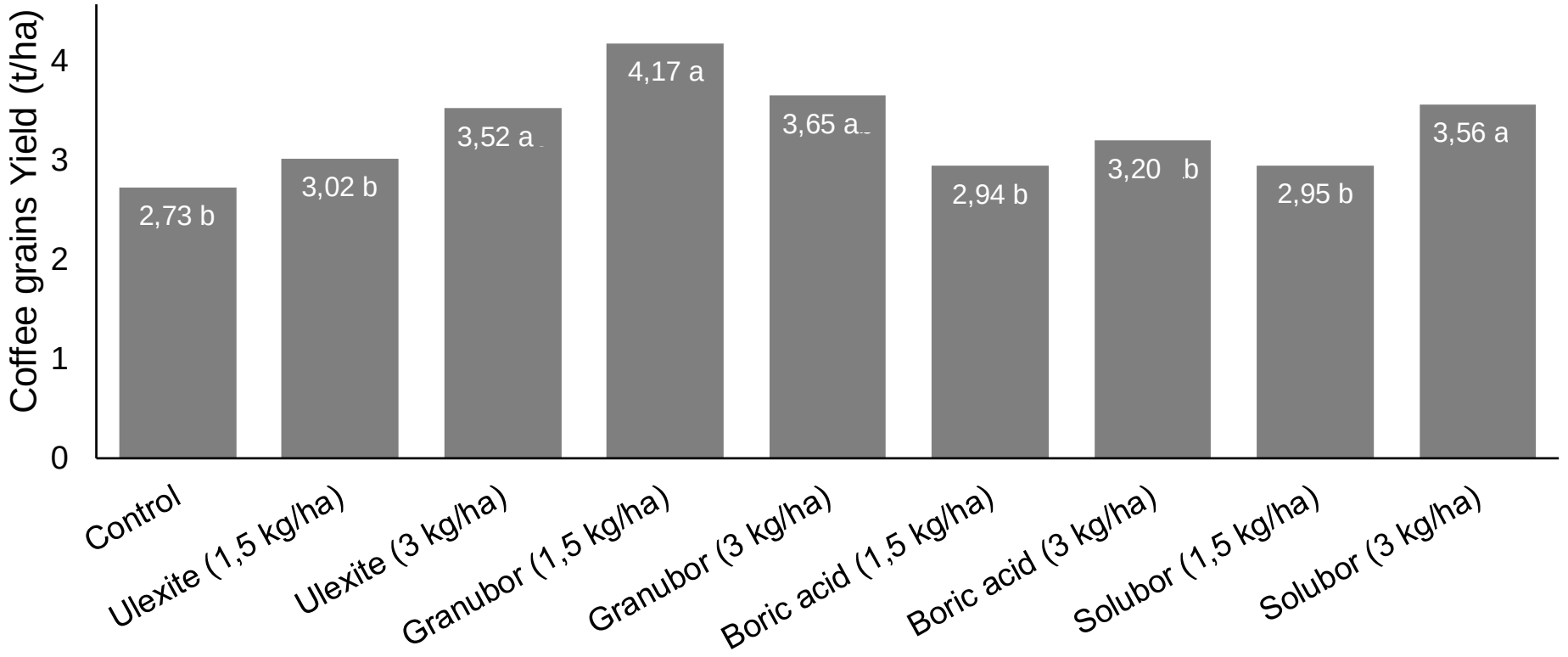
Selection of Fruits – Rates



Selection of Fruits

- No effects between sources and rates of Boron in the maturation of coffee grains

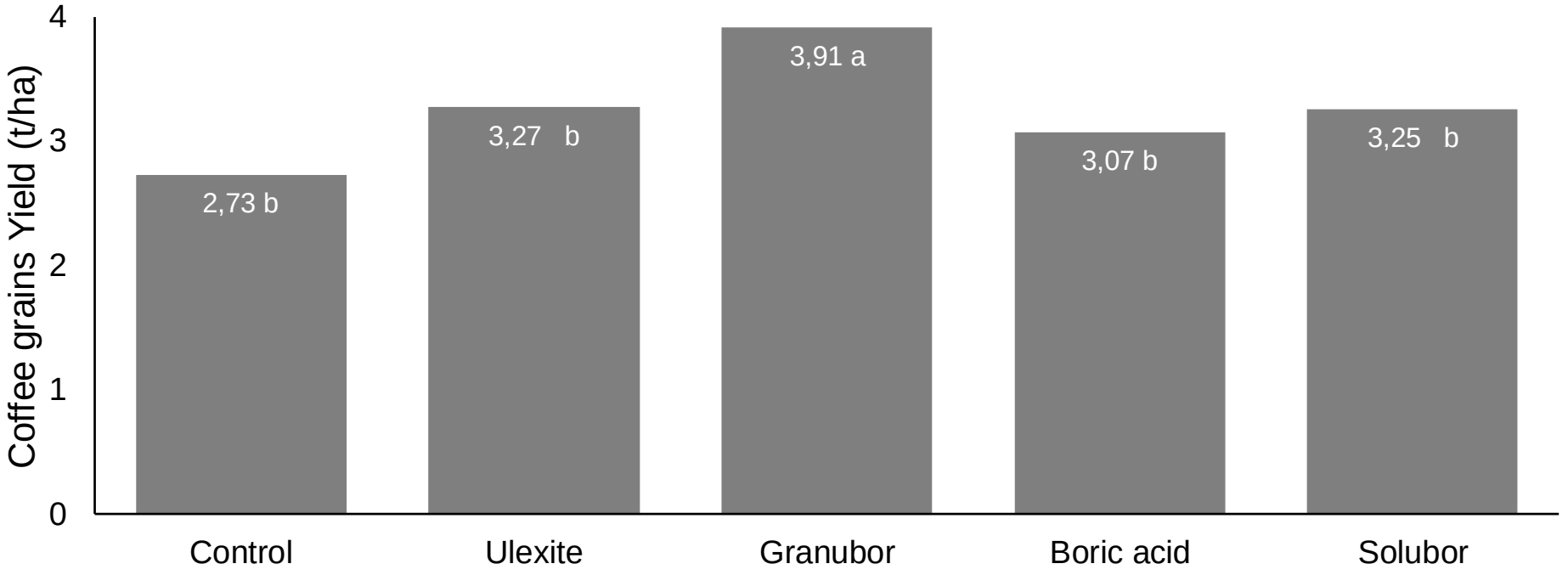
Yield Coffee Grains (t/ha) – Sources and Rates



Average = 3,30 t/ha VC = 14,27%

- Values are the average of 4 replicates
- Means followed by the same letter do not differ statistically by the Scott-Knott test at 5% probability

Yield Coffee Grains (t/ha) – Sources



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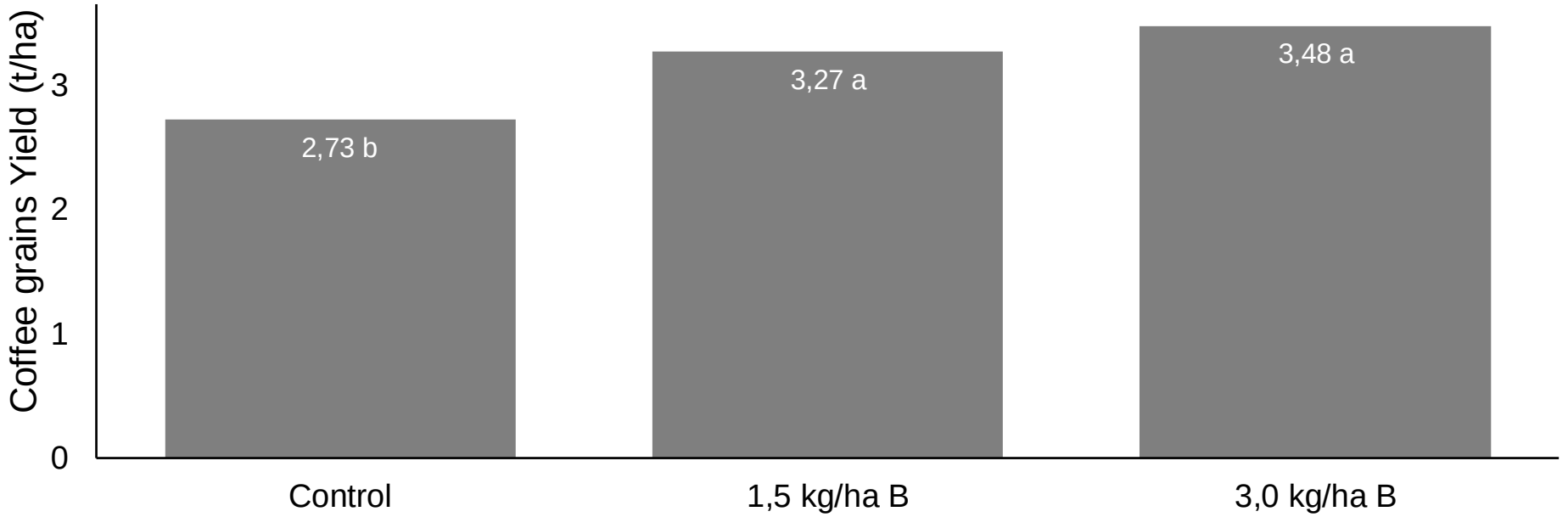
Yield Coffee Grains (t/ha) – Rates



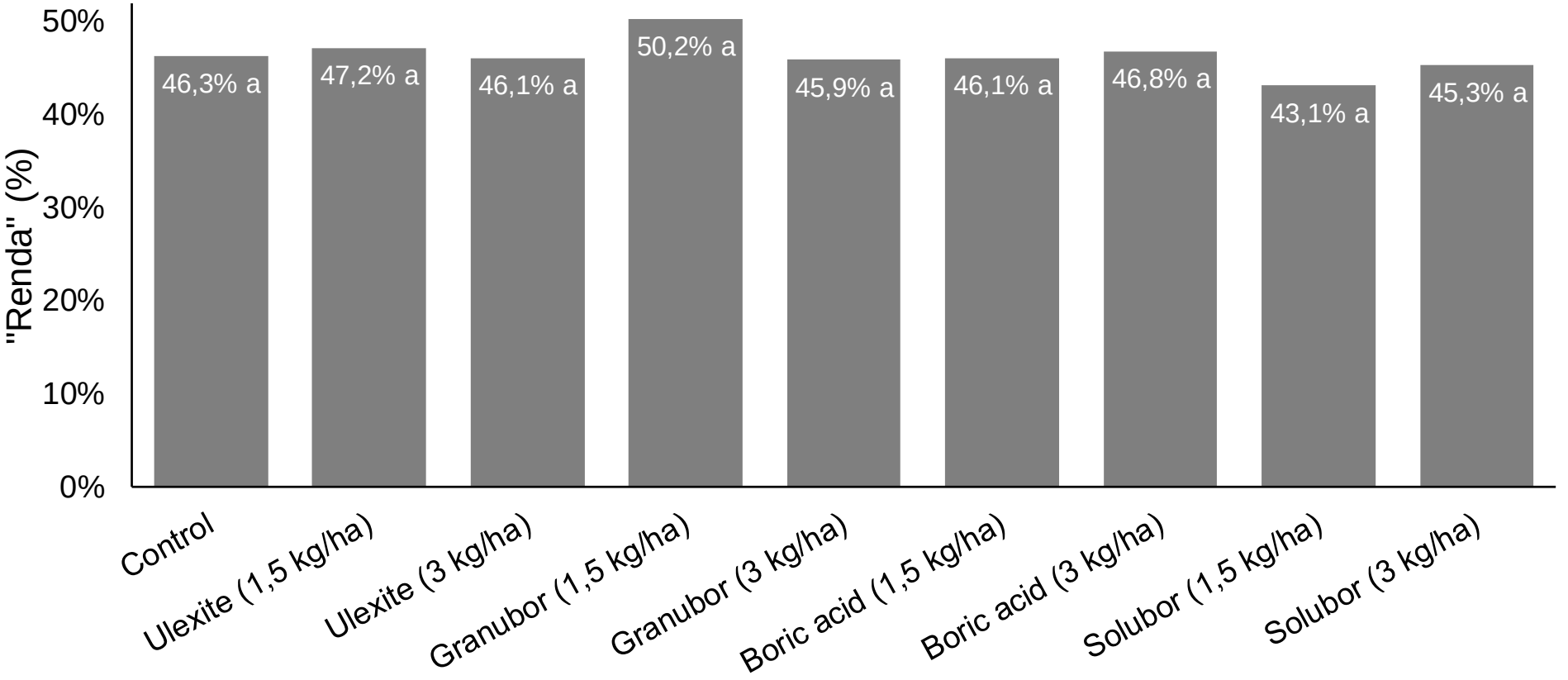
Average = 3,30 t/ha VC = 14,27%

- Values are the average of 4 replicates
- Means followed by the same letter do not differ statistically by the Scott-Knott test at 5% probability

Yield Coffee Grains

- Significative effects between sources and rates of Boron in the yield of coffee grains
- *Granubor*® > Ulexite = *Solubor*® = Boric Acid = Control
- *Granubor* in the lower rate is the best treatment
- Trends to rate 3 kg/ha B better then 1.5 kg/ha, except to *Granubor*

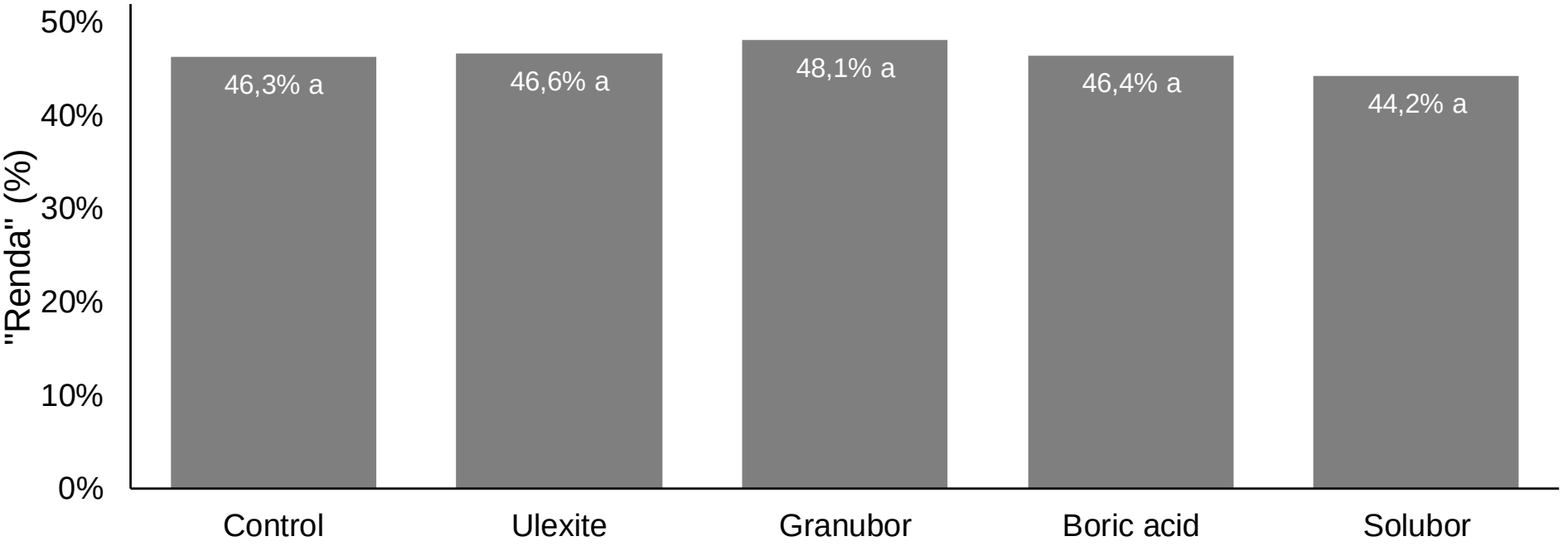
Revenue (%) - Sources and Rates



Average = 46,3% VC = 7,78%

- Values are the average of 4 replicates
- Means followed by the same letter do not differ statistically by the Scott-Knott test at 5% probability

Revenue (%) - Sources



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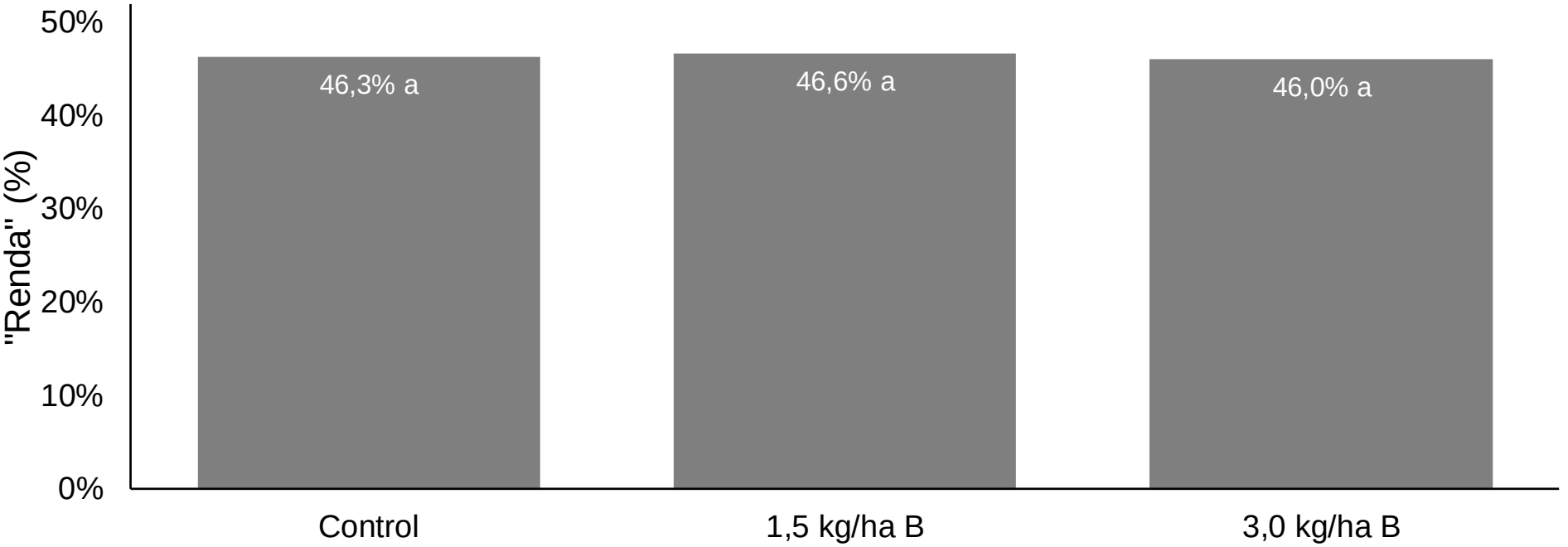
Revenue (%) - Rates



Average = 46,3% VC = 7,78%

- Values are the average of 4 replicates
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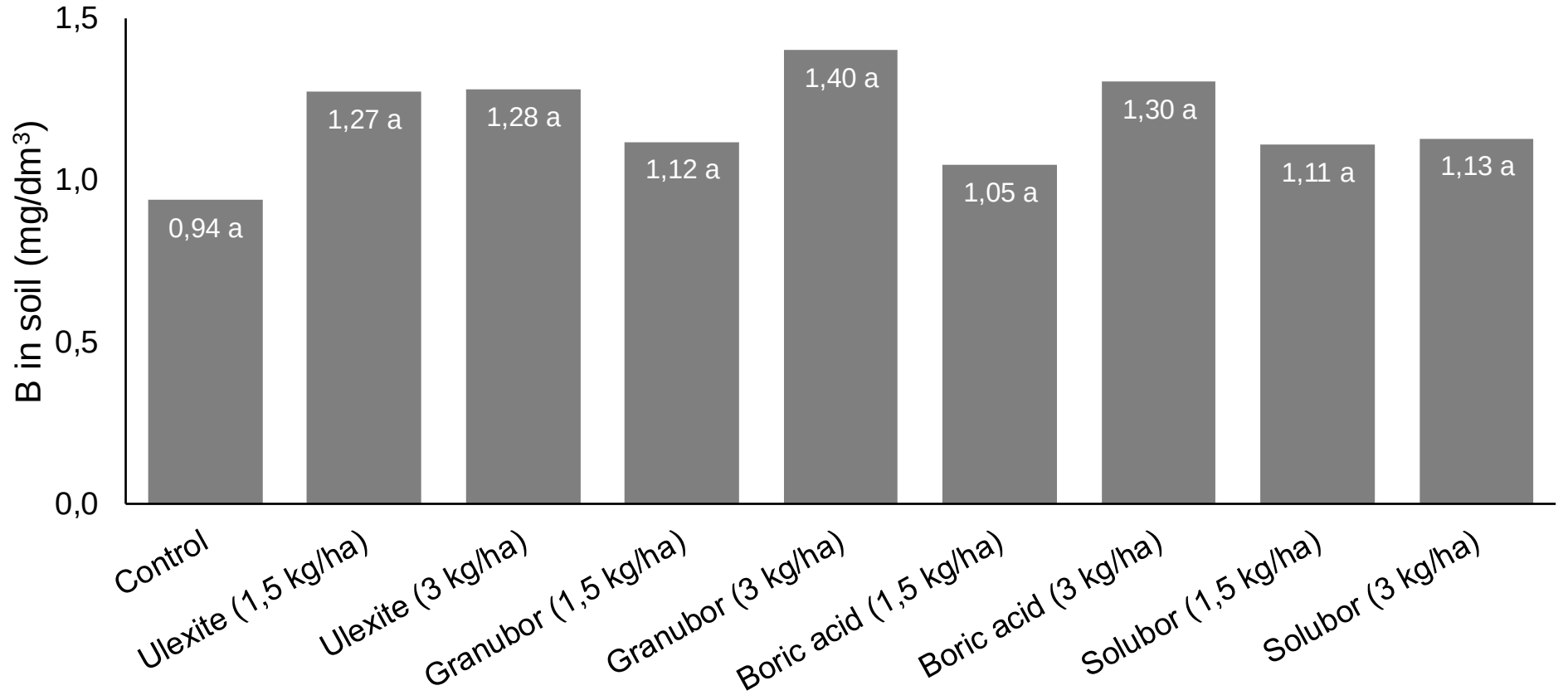
Revenue

- There was no significant effect in sources and rates of boron on revenue of grains coffee

Soil Sampling

B in Soil, 0-20 cm depth – Sources and Rates



0-20 cm: Average = 1,18 mg/dm³ VC = 24,33%

- Values are the average of 4 replicates
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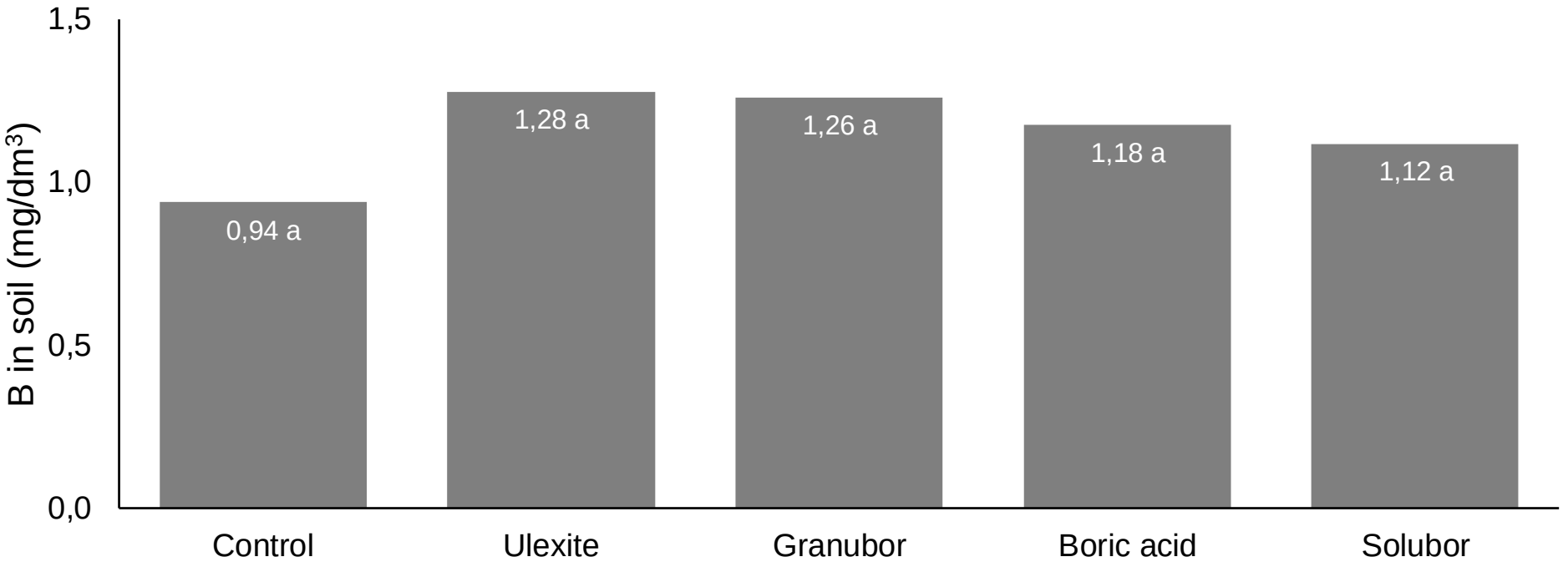
B in Soil, 0-20 cm depth – Sources



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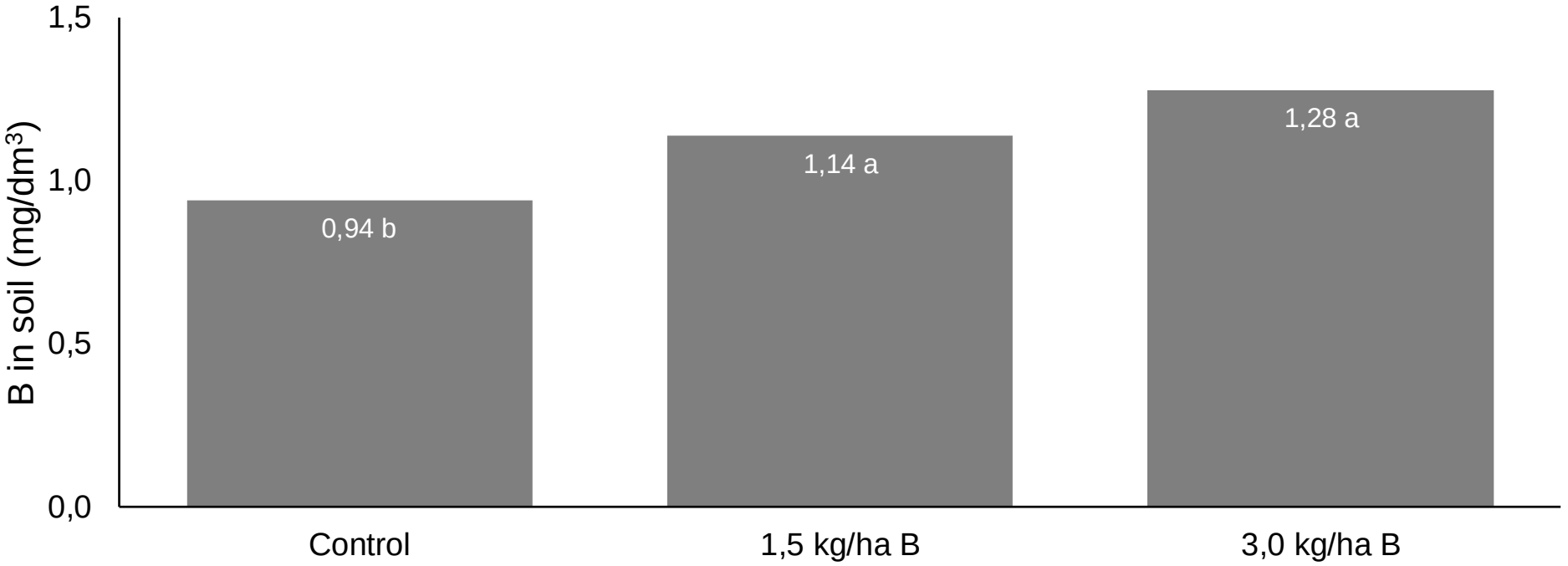
B in Soil, 0-20 cm depth – Rates



0-20 cm: Average = 1,18 mg/dm^3 VC = 24,33%

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B in Soil, 0-20- e 20 40 cm depth

- There was significant effects of rates of boron in the increment of boron in soil
- Despite the no significant effects, is possible to consider the effects of sources and granulated sources increase more amount of B in soil

Conclusions for First Year

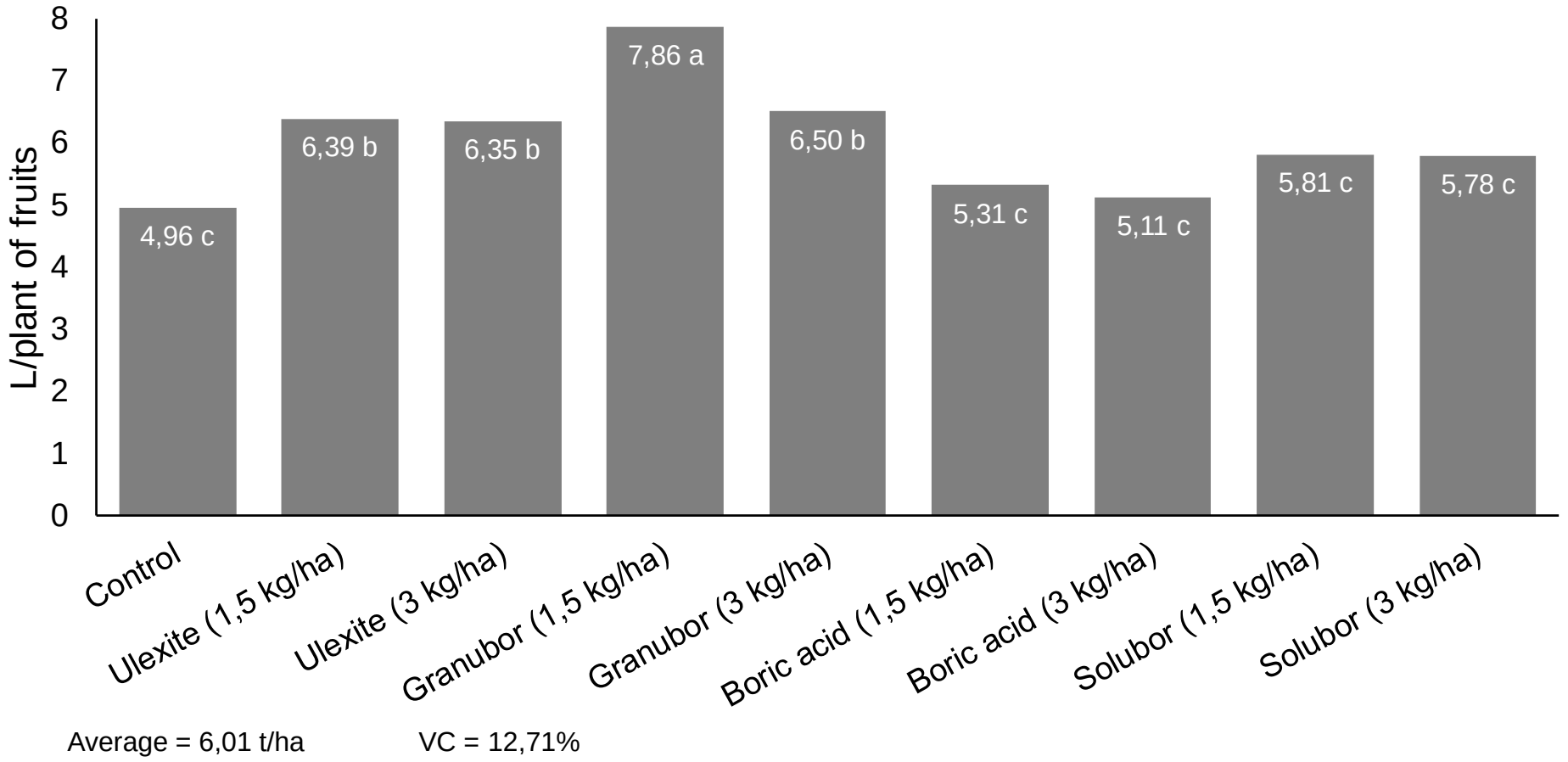
- Coffee plants were influenced by the application of boron in the soil
- *Granubor*® showed superior results

Two Years Average Yield

Two Years Average Yield

- Very important consider two years average because this is how farmers consider yield
- Coffee has a important characteristic of one year with low yield and other with higher. It is a physiologic characteristic of the crop.

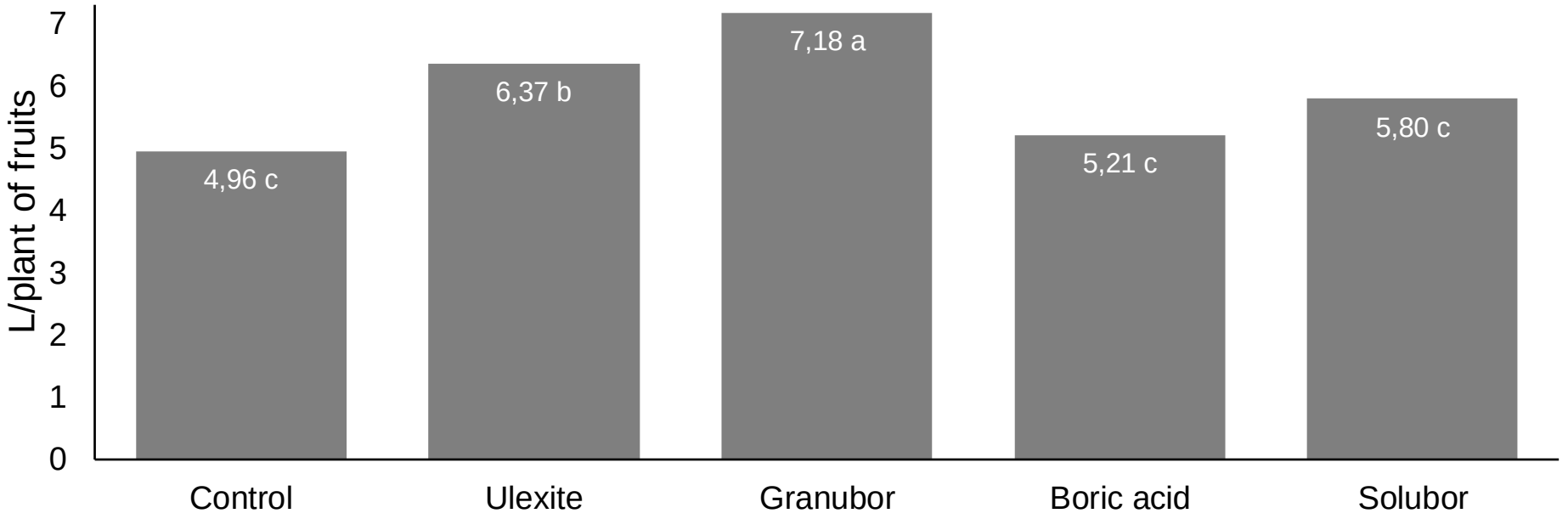
Fruits per Plants (L/plant) – Sources and Rates



Average = 6,01 t/ha VC = 12,71%

- Values are the average of 4 replicates
- Means followed by the same letter do not differ statistically by the Scott-Knott test at 5% probability

Fruits per Plants (L/plant) – Sources



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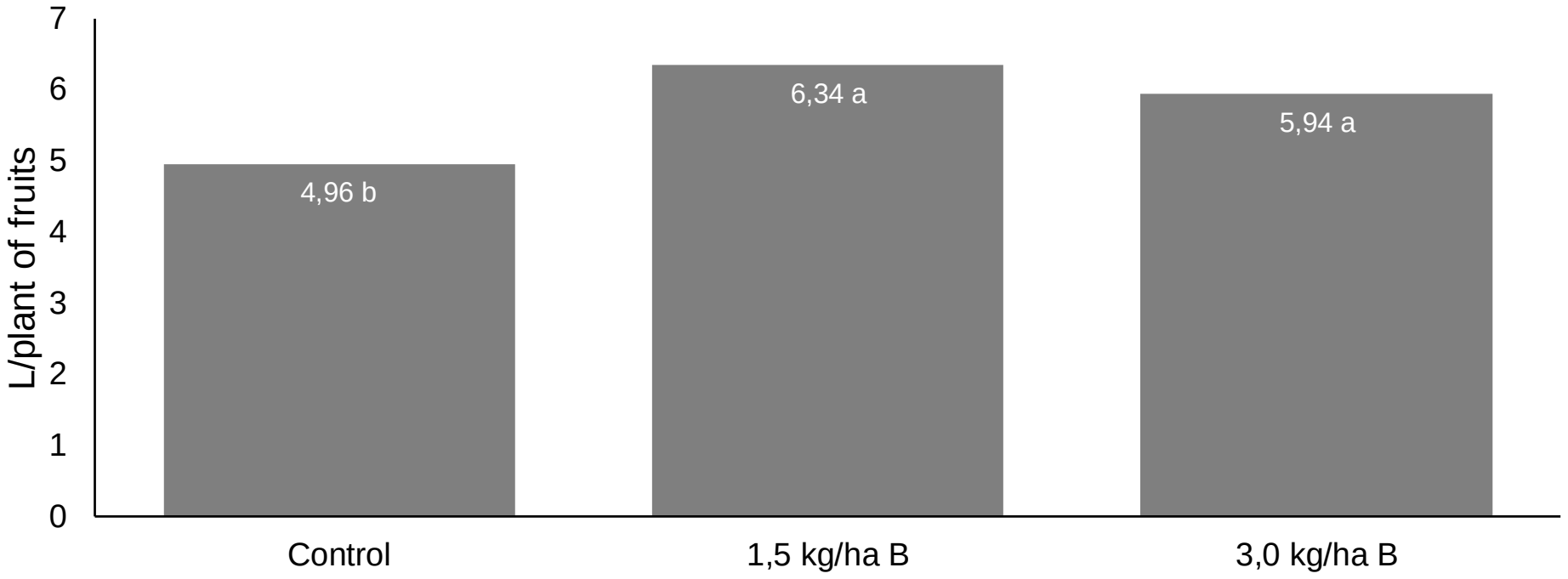

Average = 6,01 t/ha VC = 12,71%

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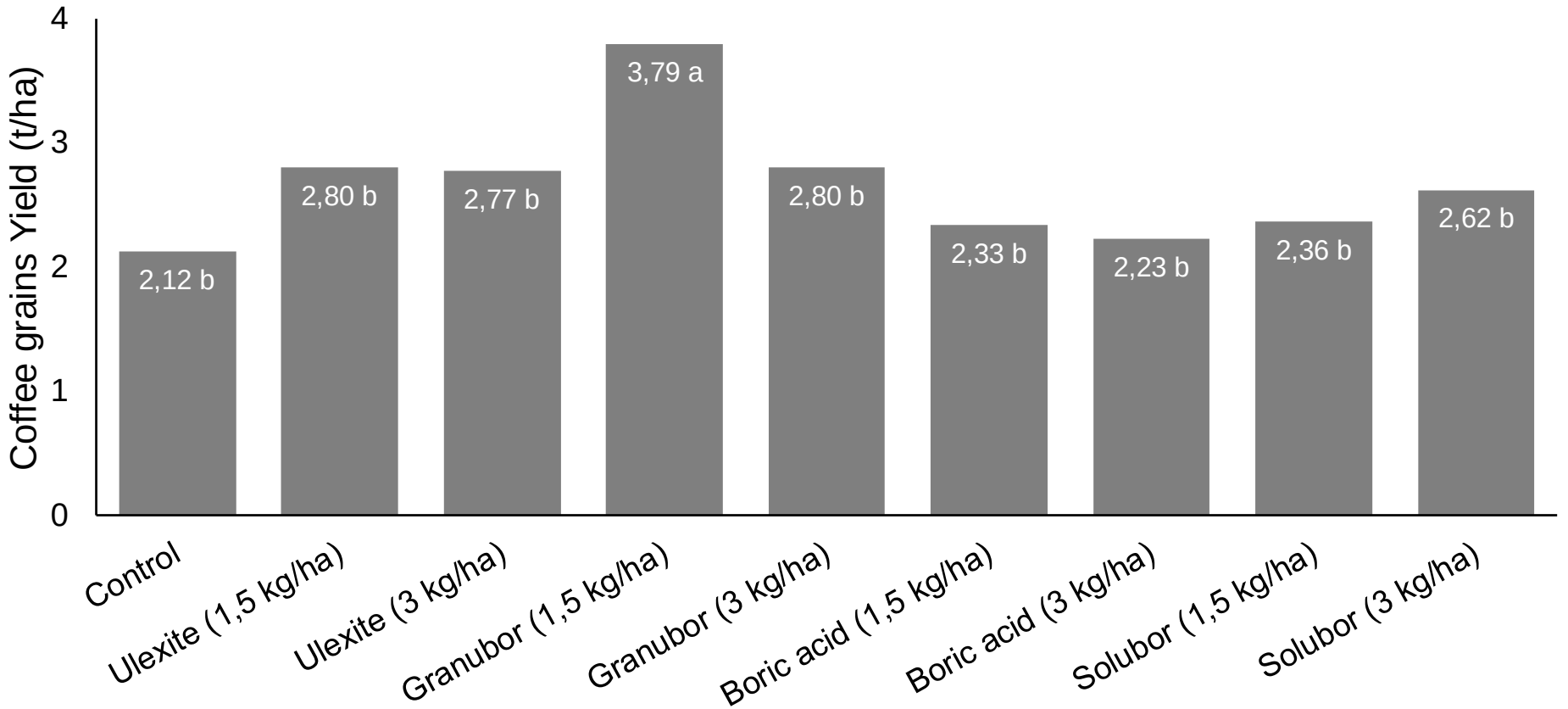
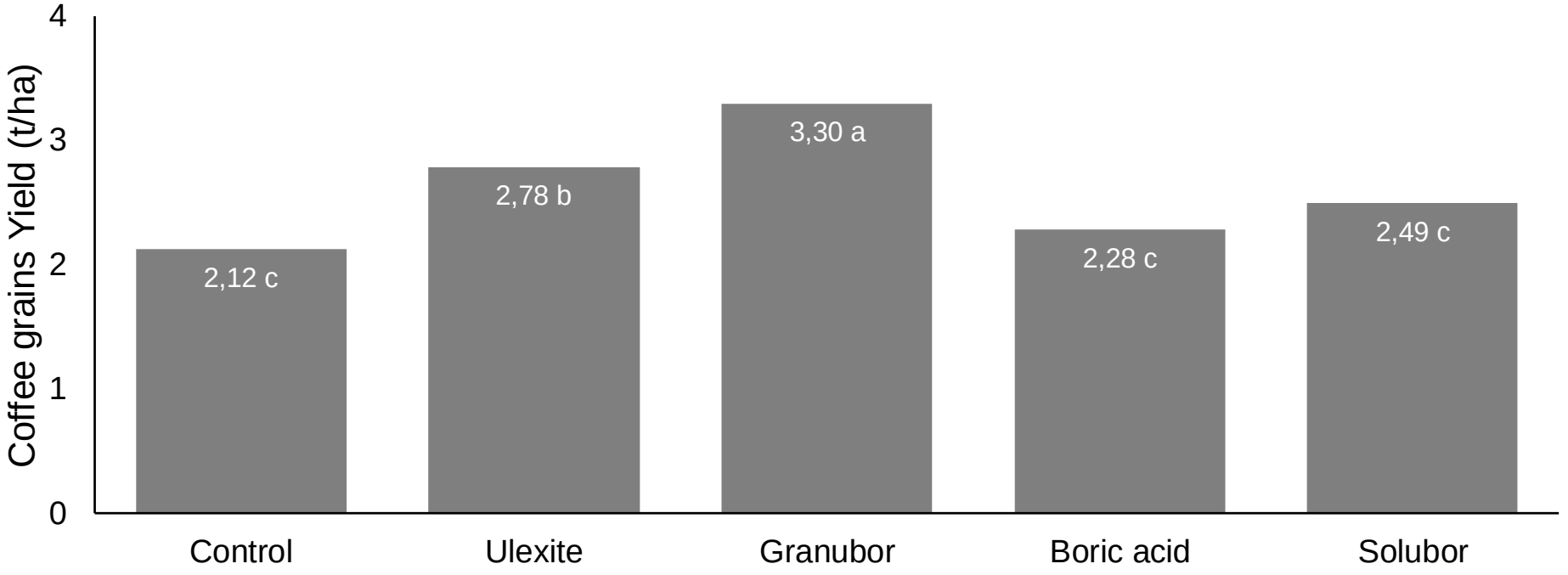
Yield Coffee Grains (t/ha) – Sources and Rates



Average = 2,65 t/ha VC = 16,69%

- Values are the average of 4 replicates
- Means followed by the same letter do not differ statistically by the Scott-Knott test at 5% probability

Yield Coffee Grains (t/ha) – Sources



Average = 2,65 t/ha VC = 16,69%

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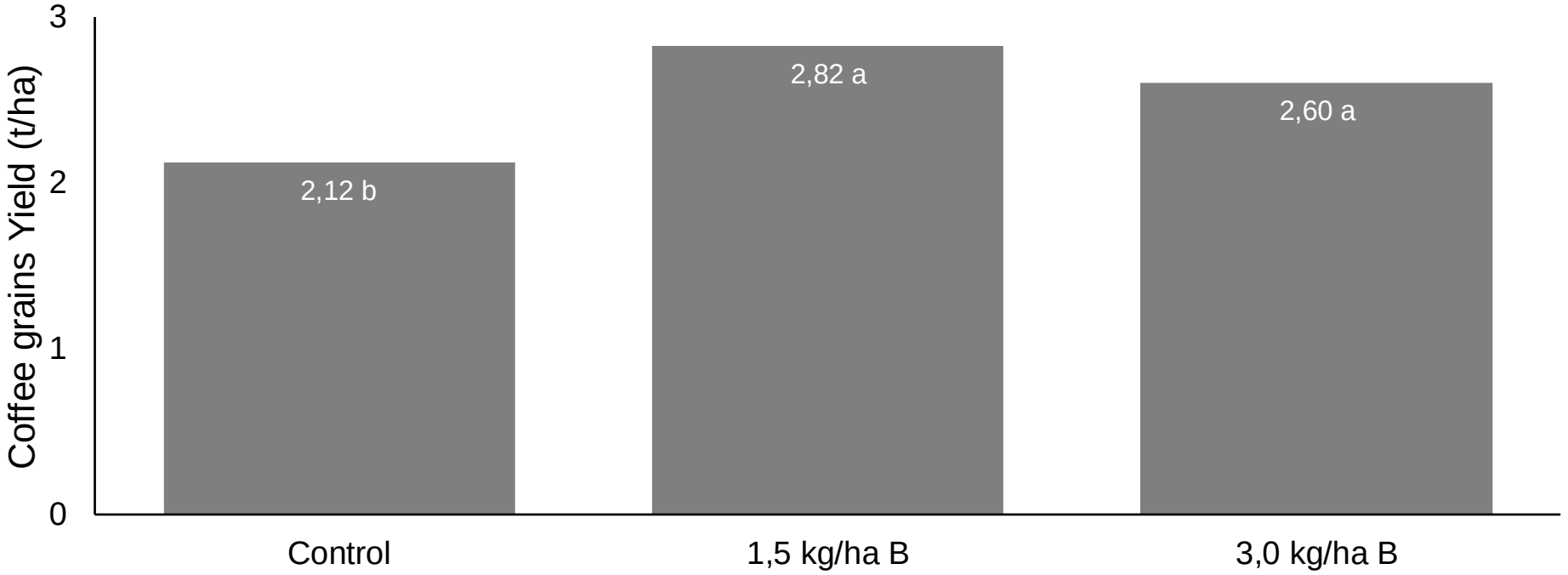
Yield Coffee Grains (t/ha) – Rates



Average = 2,65 t/ha VC = 16,69%

- Values are the average of 4 replicates
- Means followed by the same letter do not differ statistically by the Scott-Knott test at 5% probability

Conclusions and Recommendation

- Boron showed as an important micronutrient to coffee production
- Application is soil has a good response, and the suggestion is the rate 1.5 kg/ha per year, in the beginning of fertilization time (September to October)
- Granulated sources was more effective than soluble
- *Granubor*® was the best source, because it have a good solubility, more adjusted to the needs of the crop.
- Boron application wasn't involved in quality characteristics in this trial (influence in maturation and revenue).
- More trials are important to consolidate the results