Can stable isotopes separate organic from conventional bananas?

Philippe Tixier, Denis Lœillet, Mathieu Coulis,
Thierry Lescot, Luc de Lapeyre de Bellaire

GECO
Agroecology ★ Banana ★ Plantain ★ Pineapple

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AGRICULTURAL RESEARCH
FOR DEVELOPMENT

IHC 2022
31ST INTERNATIONAL HORTICULTURAL CONGRESS
14-20 AUGUST 2022
CONGRESS CENTRE ANGERS-FRANCE

MIUM QUALITY
BANANAS
QUALITÀ
BIO
5
Banane
bio
Noircit au contact du froid
Crue ou cuite
BANANE
CAVENDISH
1,50 € /kilo
N° Touche : 3
Le kg
1 €50
Variété CAVENDISH
Catégorie I
Produit traité
2920 210517 1895600 1.000 kg
2819657000000
COTE D'IVOIRE
BANANE
CAVENDISH BIO 5 FRUITS
0,40 € /pièce
La pièce
1 €99
Variété CAVENDISH
Calibre P14
Catégorie 2
210603 6134471 5.000 UC
3347761000915
REPUBLIQUE DOMINICAINE

Conventional

Organic

vs

Residues

vs

?

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Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** Hydrogen 1.008																	2 **He** Helium 4.00260
2	3 **Li** Lithium 6.940	4 **Be** Beryllium 9.01218											5 **B** Boron 10.810	6 **C** Carbon 12.011	7 **N** Nitrogen 14.007	8 **O** Oxygen 15.999	9 **F** Fluorine 18.99840	10 **Ne** Neon 20.1797
3	11 **Na** Sodium 22.98977	12 **Mg** Magnesium 24.305											13 **Al** Aluminum 26.98154	14 **Si** Silicon 28.085	15 **P** Phosphorus 30.97376	16 **S** Sulfur 32.060	17 **Cl** Chlorine 35.450	18 **Ar** Argon 39.948
4	19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.95591	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.93804	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.93319	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.38	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.630	33 **As** Arsenic 74.92159	34 **Se** Selenium 78.971	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.798
5	37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90584	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90637	42 **Mo** Molybdenum 95.95	43 **Tc** Technetium [97.90721]	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.414	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.293
6	55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	71 **Lu** Lutetium 174.9668	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.94788	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.084	79 **Au** Gold 196.96657	80 **Hg** Mercury 200.592	81 **Tl** Thallium 204.380	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98040	84 **Po** Polonium [209]	85 **At** Astatine [210]	86 **Rn** Radon [222]
7	87 **Fr** Francium [223]	88 **Ra** Radium [226]	103 **Lr** Lawrencium [262]	104 **Rf** Rutherfordium [267]	105 **Db** Dubnium [268]	106 **Sg** Seaborgium [271]	107 **Bh** Bohrium [274]	108 **Hs** Hassium [269]	109 **Mt** Meitnerium [276]	110 **Ds** Darmstadtium [281]	111 **Rg** Roentgenium [281]	112 **Cn** Copernicium [285]	113 **Nh** Nihonium [286]	114 **Fl** Flerovium [289]	115 **Mc** Moscovium [288]	116 **Lv** Livermorium [293]	117 **Ts** Tennessine [294]	118 **Og** Oganesson [294]
			57 **La** Lanthanum 138.90547	58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.90766	60 **Nd** Neodymium 144.242	61 **Pm** Promethium [144.91276]	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.92535	66 **Dy** Dysprosium 162.500	67 **Ho** Holmium 164.93033	68 **Er** Erbium 167.259	69 **Tm** Thulium 168.93422	70 **Yb** Ytterbium 173.04		
			89 **Ac** Actinium [227]	90 **Th** Thorium 232.0377	91 **Pa** Protactinium 231.03588	92 **U** Uranium 238.02891	93 **Np** Neptunium [237]	94 **Pu** Plutonium [244]	95 **Am** Americium [243]	96 **Cm** Curium [247]	97 **Bk** Berkelium [247]	98 **Cf** Californium [251]	99 **Es** Einsteinium [252]	100 **Fm** Fermium [257]	101 **Md** Mendelevium [258]	102 **No** Nobelium [259]		

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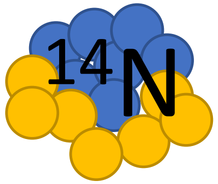
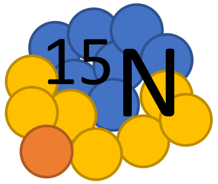
Isotopes of nitrogen

^{14}N = 7 protons + 7 neutrons



99.636 %

^{15}N = 7 protons + 8 neutrons



0.364 %

Isotopic ratio:

$$R = {}^{15}N \;/\; {}^{14}N$$

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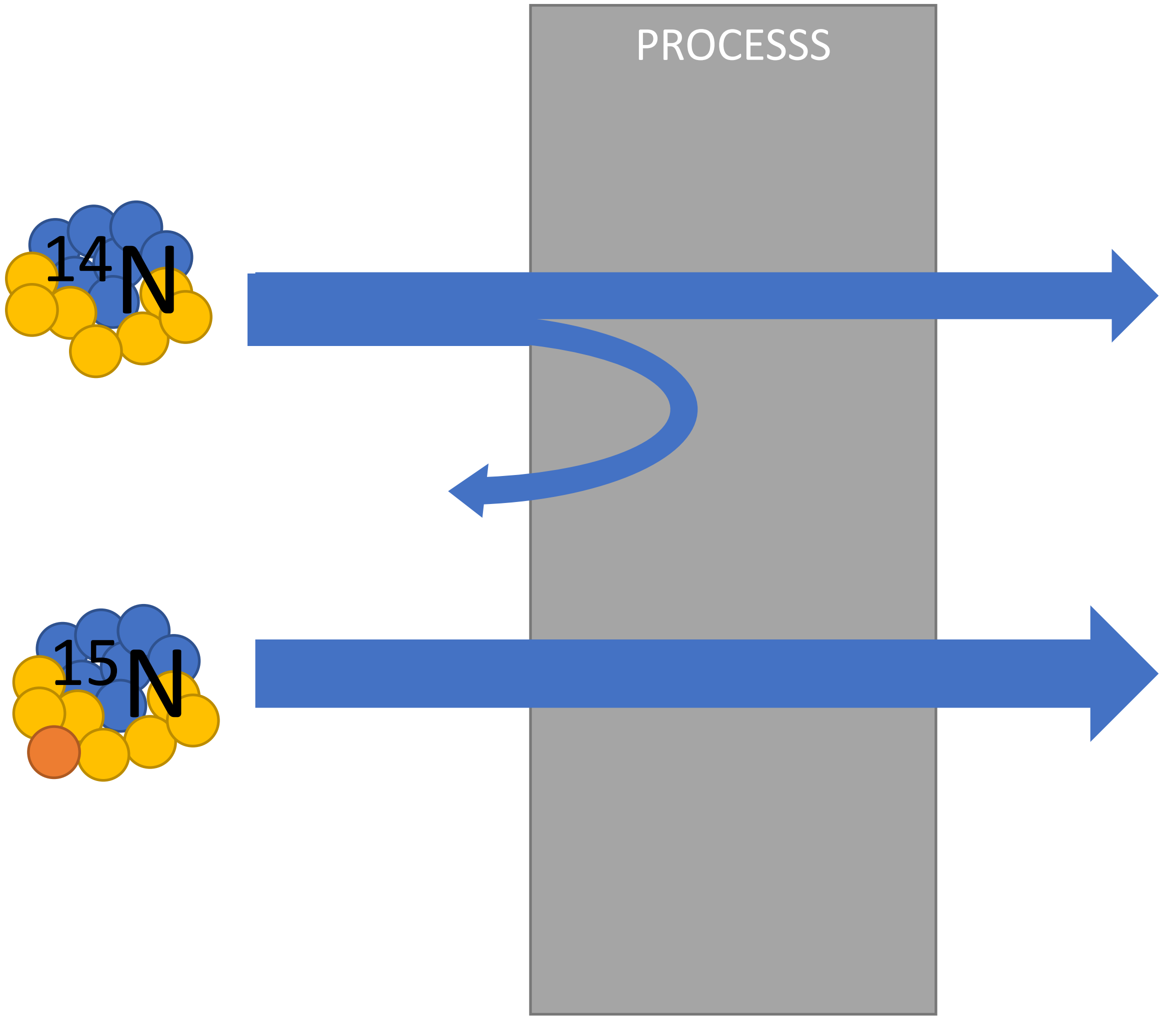
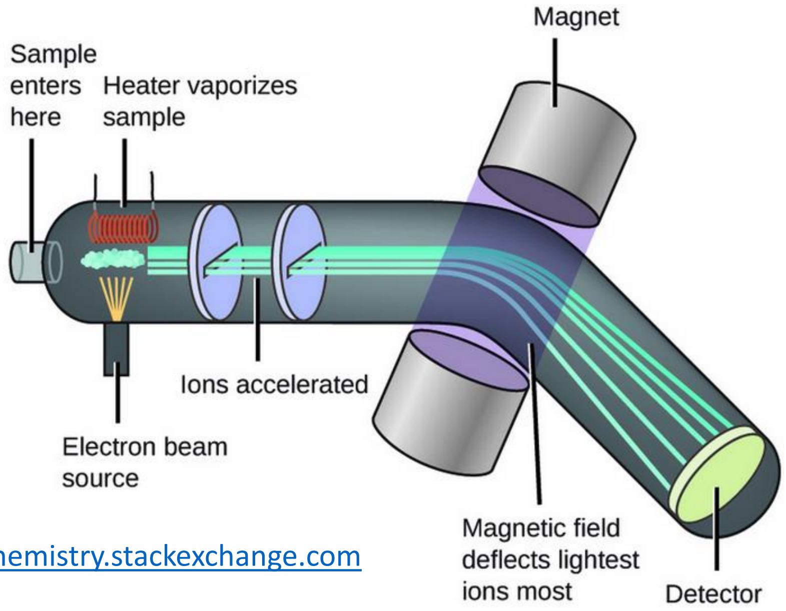
Isotopic fractionation



Isotopic Ratio Mass Spectrometer



chemistry.stackexchange.com

Isotopic values $$\delta\ (‰) = \frac{R_s - R_{ref}}{R_{ref}} \times 1000$$

^{15}N reference is N from atmospheric air → δ^{15}N air = 0 ‰

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Atmospheric N fixated by Haber-Bosch process
→ **LOW $\delta^{15}N$ (usually below 0 ‰)**

N from plants or animals with multiples isotopic fractionation events
→ **HIGH $\delta^{15}N$ (usually between 3 and 8 ‰)**

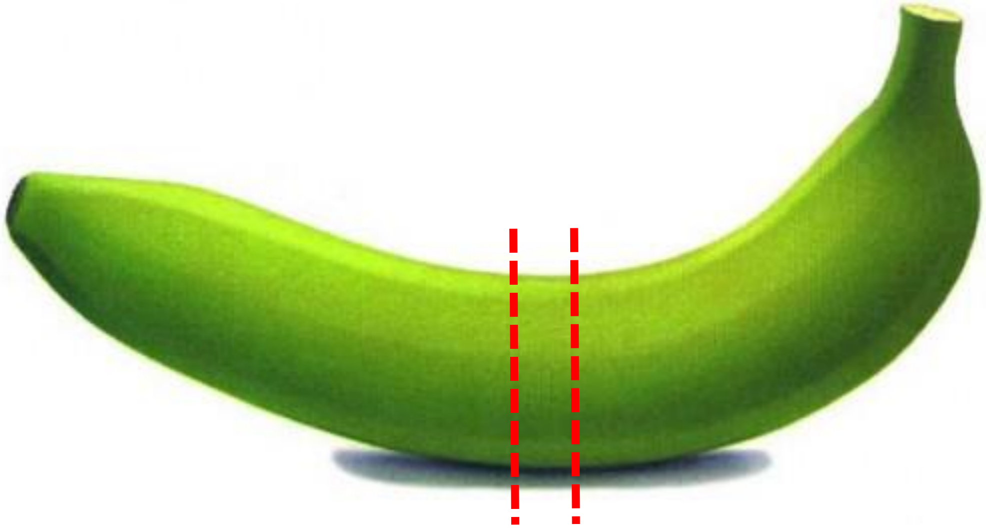
Sampling strategy

- 14 farms (7 couples organic/conventionnal)

Confidence in their
non-use of mineral fertilizer

- 20 fruits per farm

- 1 measure = 1 fruit



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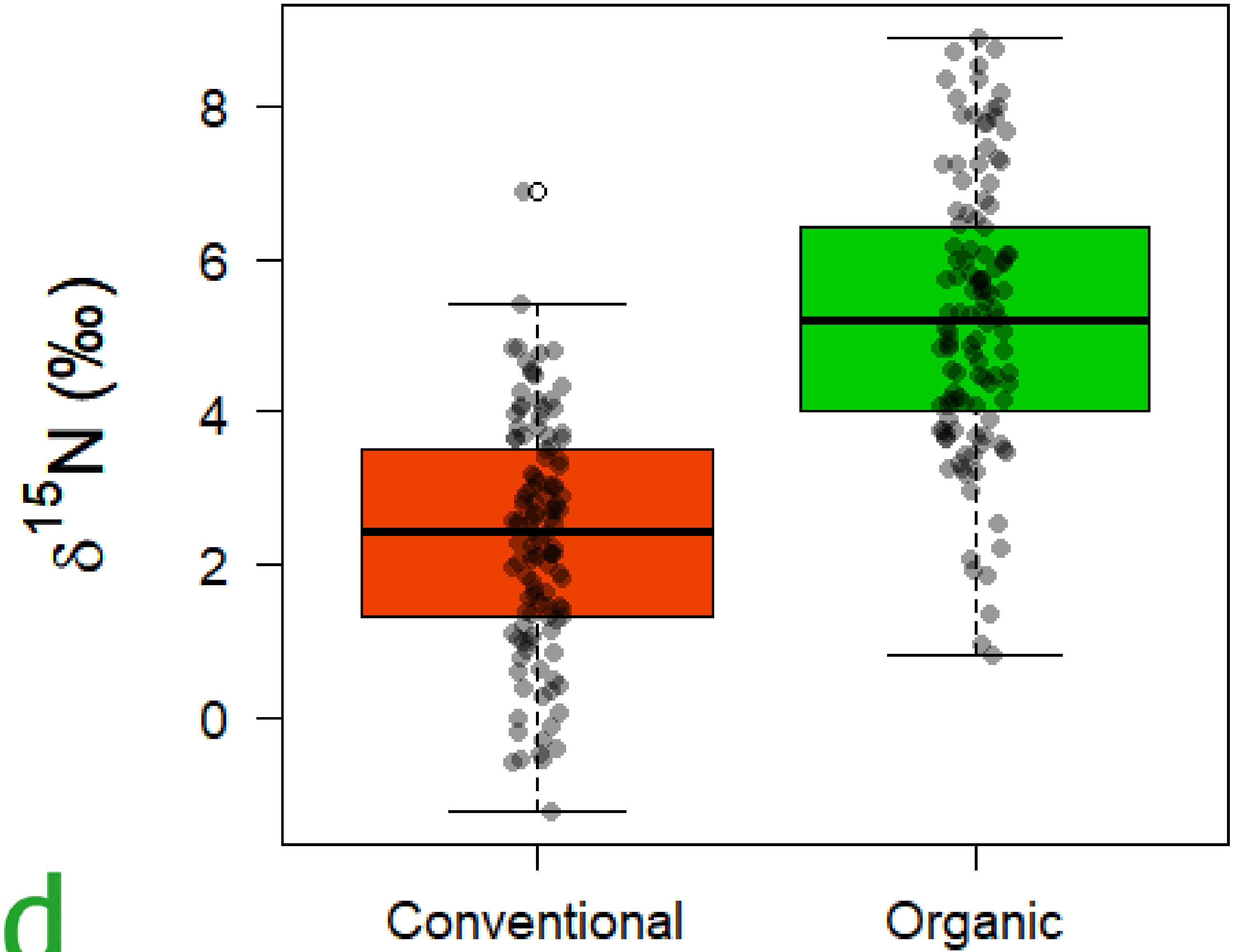
Comparison of δ^{15}N from conventional and organic



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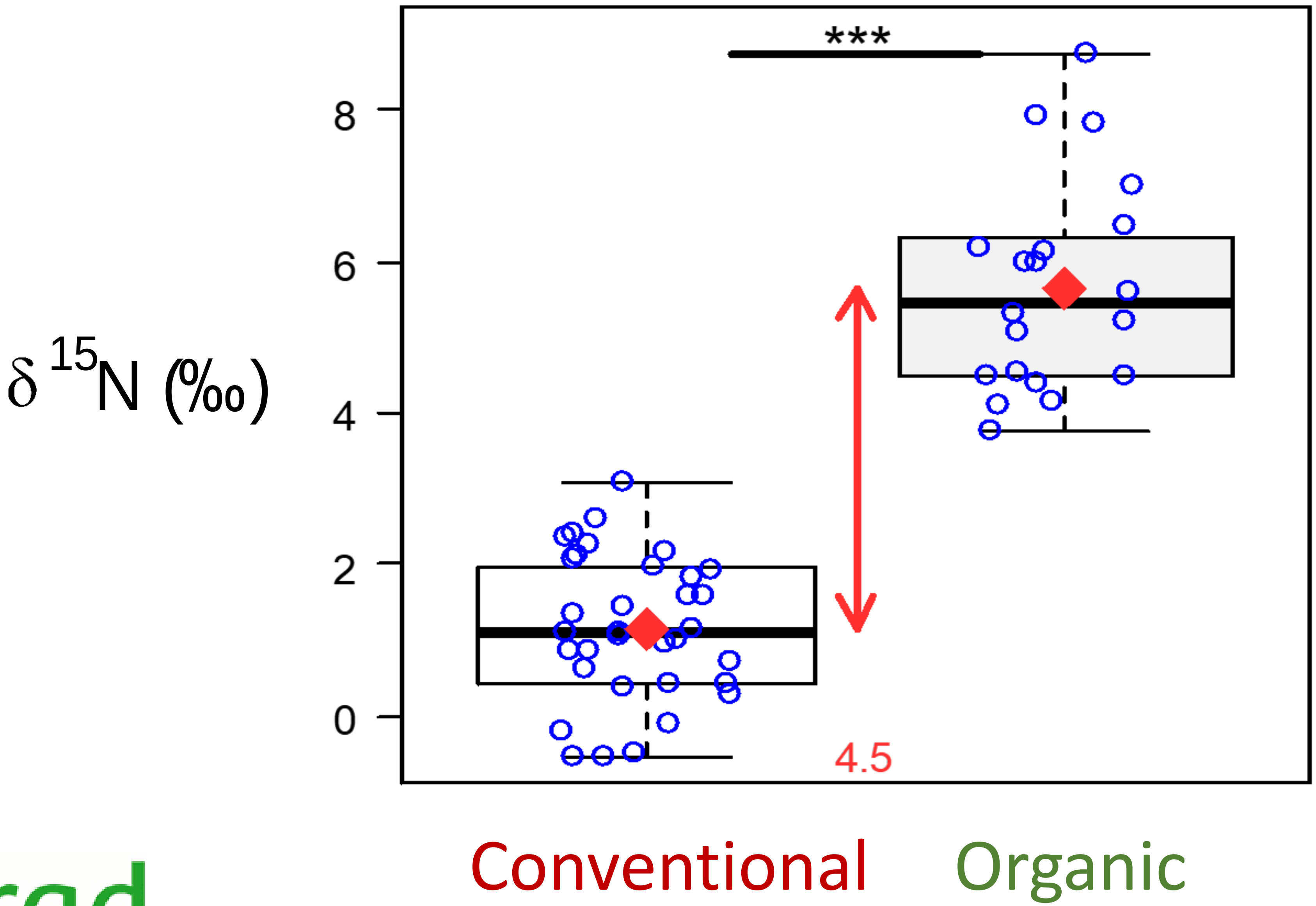
Guadeloupe



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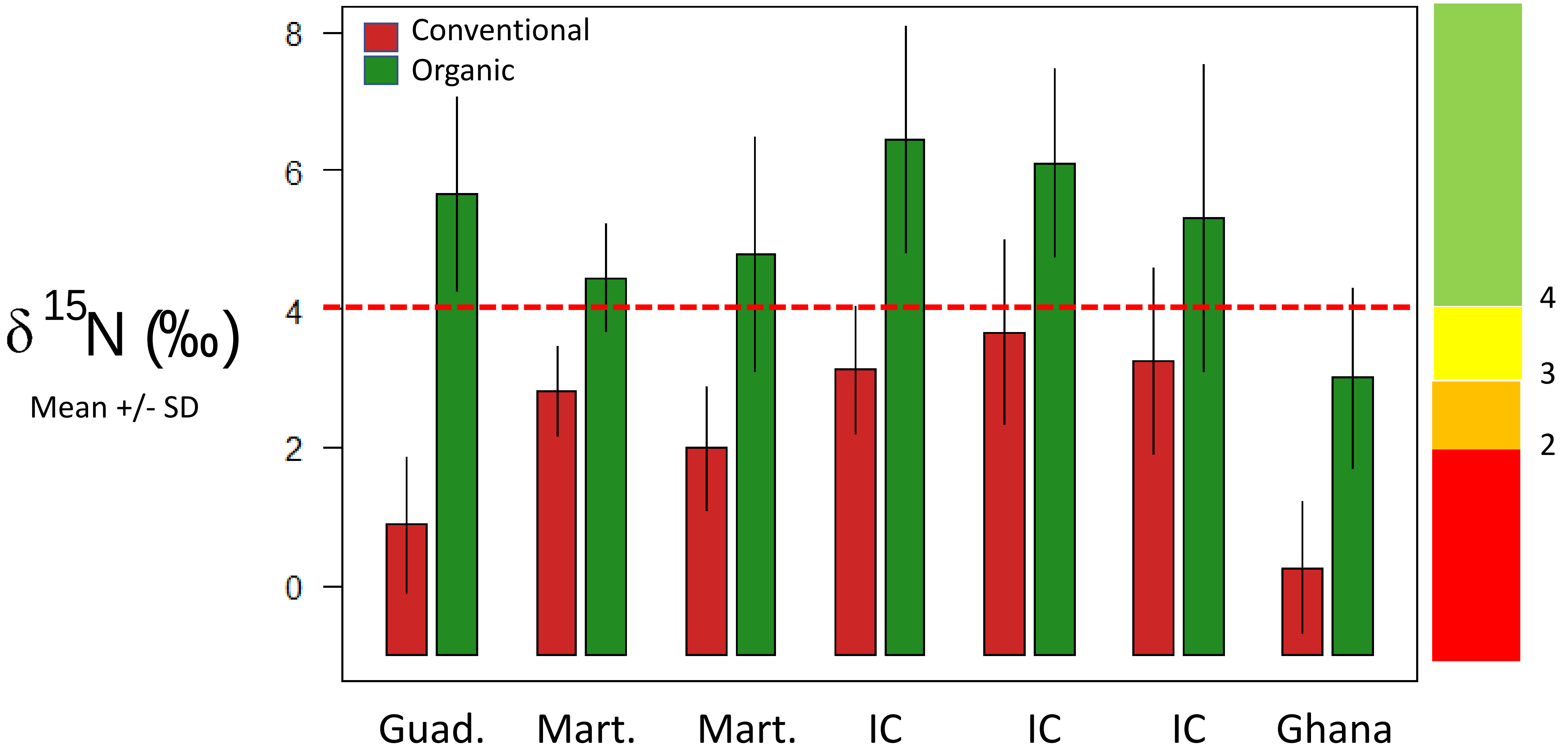

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journal homepage: www.elsevier.com/locate/foodres

Linking growing conditions to stable isotope ratios and elemer compositions of Costa Rican bananas (*Musa* spp.)

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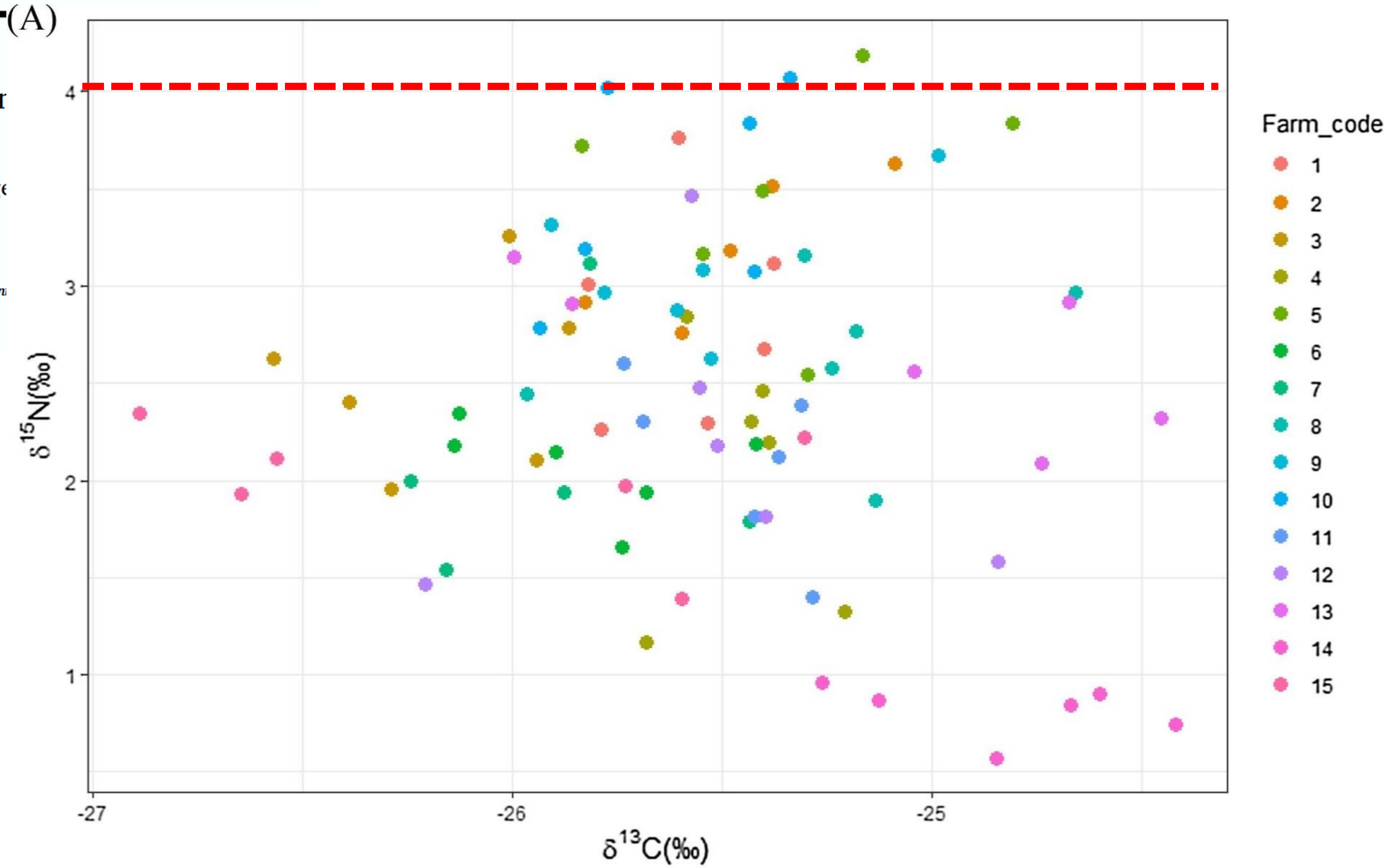

Wang *et al.* 2020 Food Research International

foods

MDPI

Article

Preliminary Study on Tracing the Origin and Exploring the Relations between Growing Conditions and Isotopic and Elemental Fingerprints of Organic and Conventional Cavendish Bananas (*Musa* spp.)

Zhijun Wang [1], Sara W. Erasmus [1] and Saskia M. van Ruth [1,2,*]

banana pulp and peel samples collected from different countries and related growing conditions.

Farm	Pulp (*n*)	Peel (*n*)	Altitude (m)	Monthly Mean Temperature (°C)	Annual Rainfall (mm/Year)	Production System
CO1	12	6	66	23.2	1837	Conventional
CR1	12	6	726	23.4	2857	Conventional
CR2	12	6	47	24.4	5014	Conventional
CR3	12	6	24	26.3	1837	Conventional
DR1	12	6	65	26.7	925	Organic
DR2	12	6	27	26.7	925	Organic
EC1	12	6	32	22.9	1511	Organic
EC2	12	6	22	26.5	843	Conventional
PA1	12	6	20	19.7	3679	Conventional
PE1	12	6	40	24.1	200	Organic

n: number of samples.

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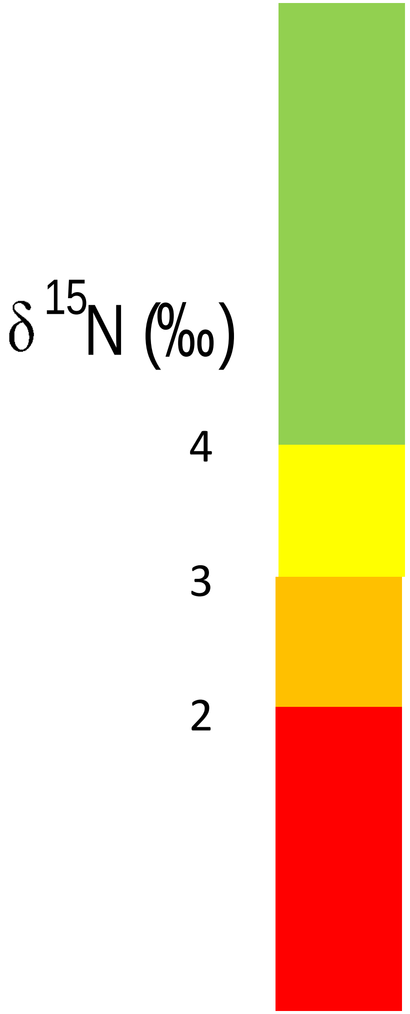

$\delta^{15}N$	Production System
2.9 [b] ± 0.8	Conventional
−0.9 [f] ± 0.9	Conventional
1.1 [cd] ± 1.5	Conventional
−0.5 [ef] ± 0.6	Conventional
1.9 [cd] ± 0.4	Organic
6.3 [a] ± 1.3	Organic
1.5 [ce] ± 0.6	Organic
−0.4 [ef] ± 0.2	Conventional
0.0 [def] ± 0.1	Conventional
1.7 [c] ± 0.3	Organic

Wang *et al.* 2021 Foods

Key results

- We can segregate organic from conventional!
- Improved if a regional reference is established
- 15 to 20 fruits are enough (may be improved with pooling fruits)

Perspectives

- Establishing a referential per producing regions

- Today, certification organizations can (shall ☺) use this measure to help focusing their control in the field

Acknowledgements

- The producers
- Benoit Lacombe from Institut-Agro Montpellier

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Isotopes Don't Lie, differentiating organic from conventional banana (*Musa* AAA, Cavendish subgroup) fruits using C and N stable isotopes

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Thank you very much !

tinyurl.com/tixier

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