# *Application of biochar to irrigated technosoils: Effects on germination and agronomic properties*

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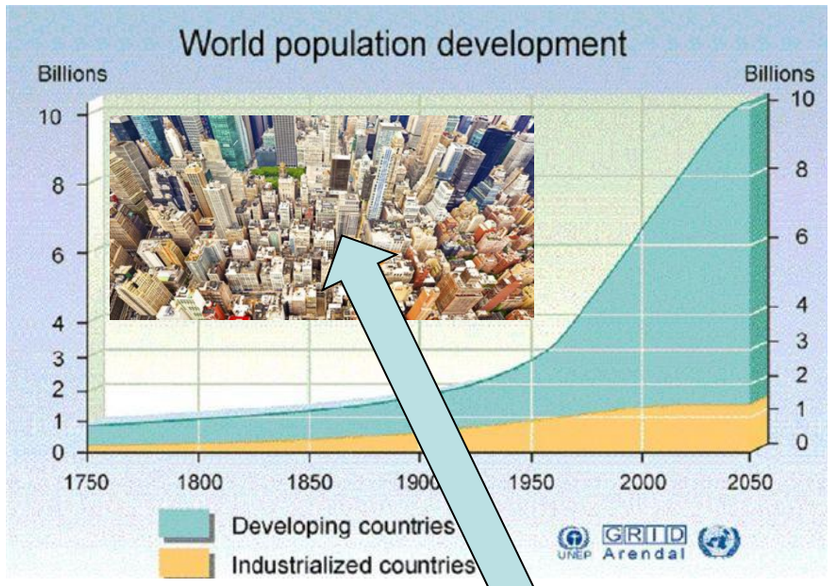
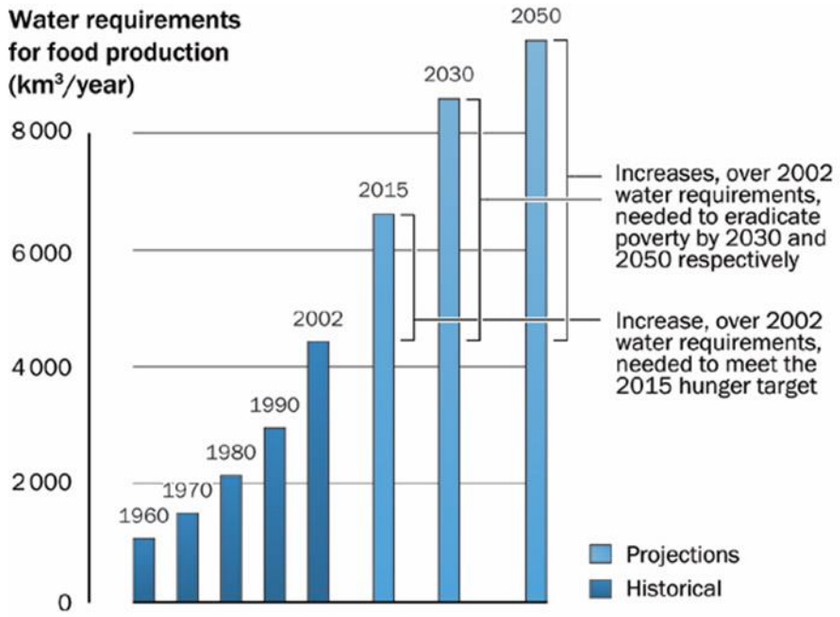
**IRNAS**

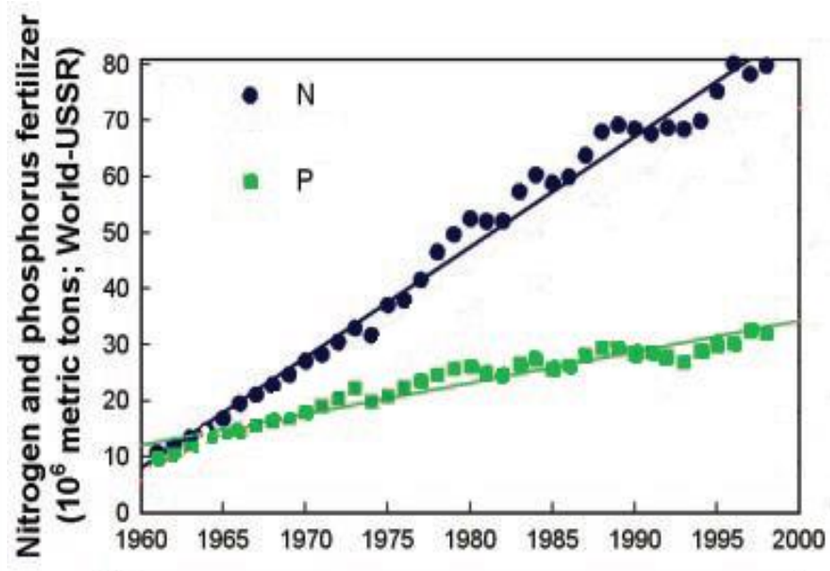
Instituto de Recursos Naturales y Agrobiología de Sevilla

25th May, 2022

# Today's challenges of agriculture

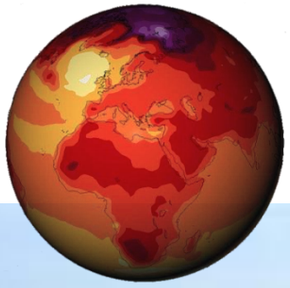


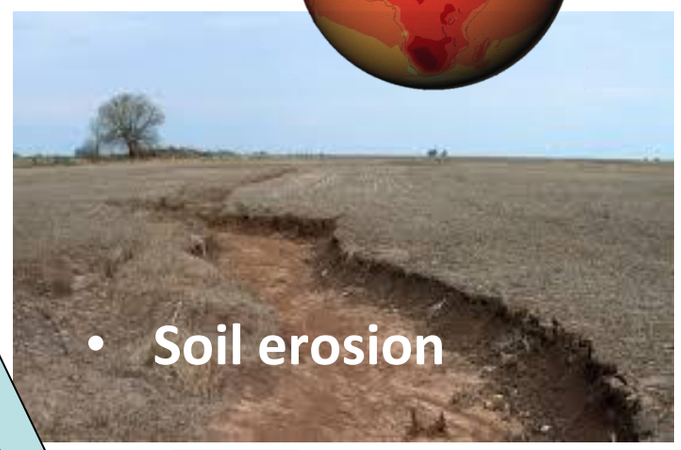




- **Population growth**

**Within a context of global warming**



- **Increase of water and mineral fertilizers requirements**



**Search for sustainable solutions:**
**Biochar for Green-roofs? Technosoils?**

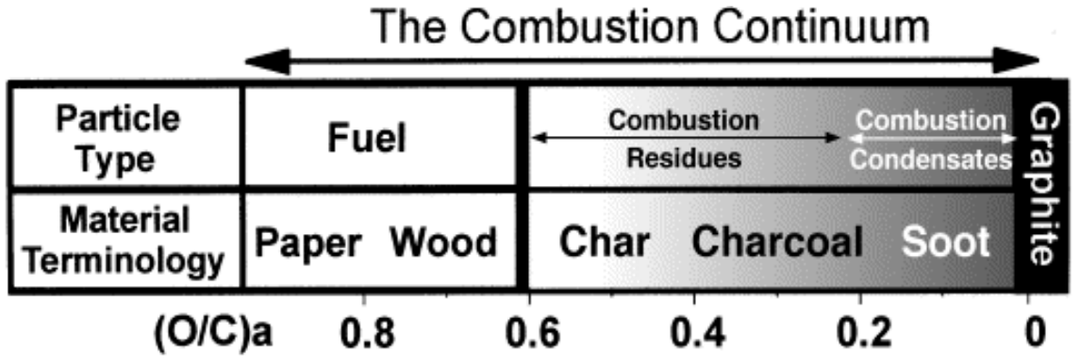
# Biochar: Pyrogenic carbon for soil amendment

**Pyrogenic C**

**Organic residues**

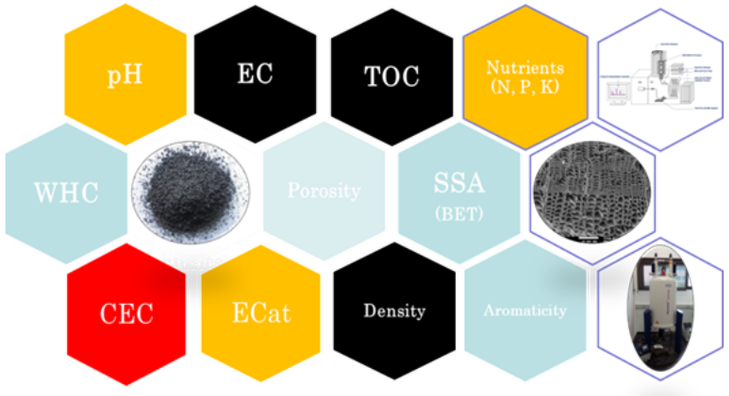
Pyrolysis


Biochar




*Masiello & Druffel, 1998*

Pyrolysis and feedstock




Different properties

# Case study 1

- Soil: *Eutric Cambisol* (pH 5.5) Campania (South Italy)
- Cultivation: Wheet Varieties: Svevo (commercial) Vs. Saragolla (old-traditional)
- Greenhouse conditions: 30% WHC
- Amendment: **2%** Wood biochar (500 ºC)

Racioppi et al., 2019, Agronomy.

# Case study 2

- Soil: *Luvisol, chromic*; (pH 7.8) Seville (SW, Spain)
- Cultivation: *Lolium perenne*
- Grenhouse conditions: 14h light $day^{-1}$; 22 ºC; 700 mm $H_2O$ $yr^{-1}$
- Amendment: **1%** $^{15}N$-enriched grass char (350 ºC)

De la Rosa & Knicker, 2011; SBB

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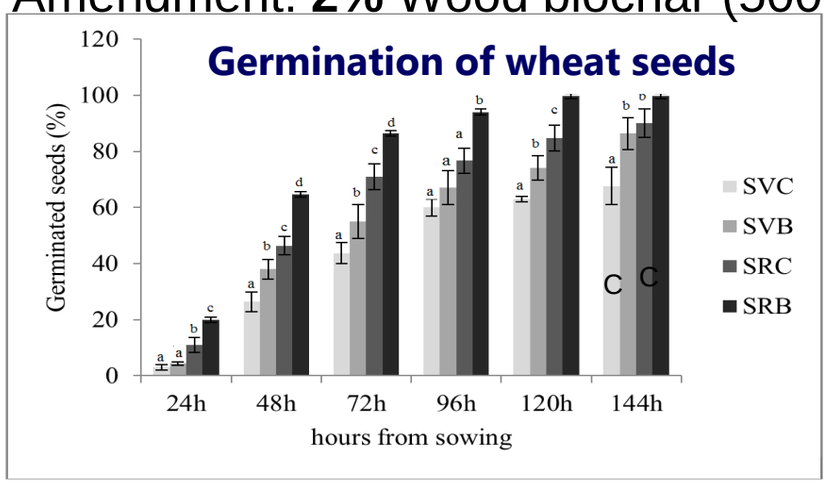


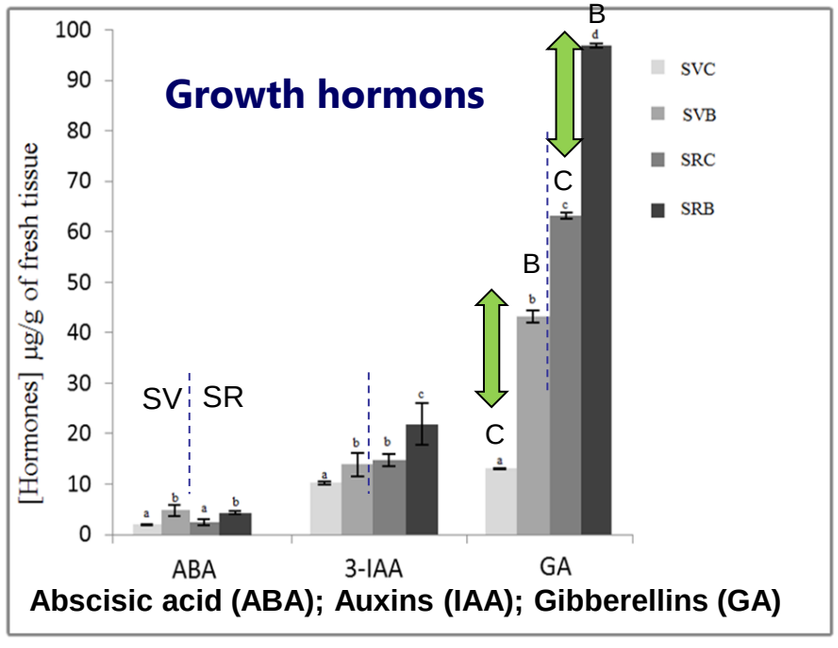


**Abscisic acid (ABA); Auxins (IAA); Gibberellins (GA)**

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- **Greater germination rates (& abundance of growth hormons) at biochar amended pots**
- **Traditional wheet variety showed better results than (new) commercial variety**

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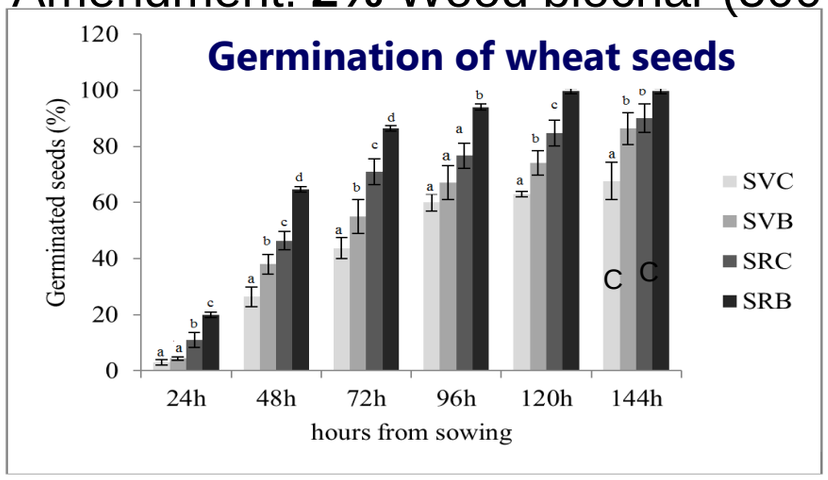


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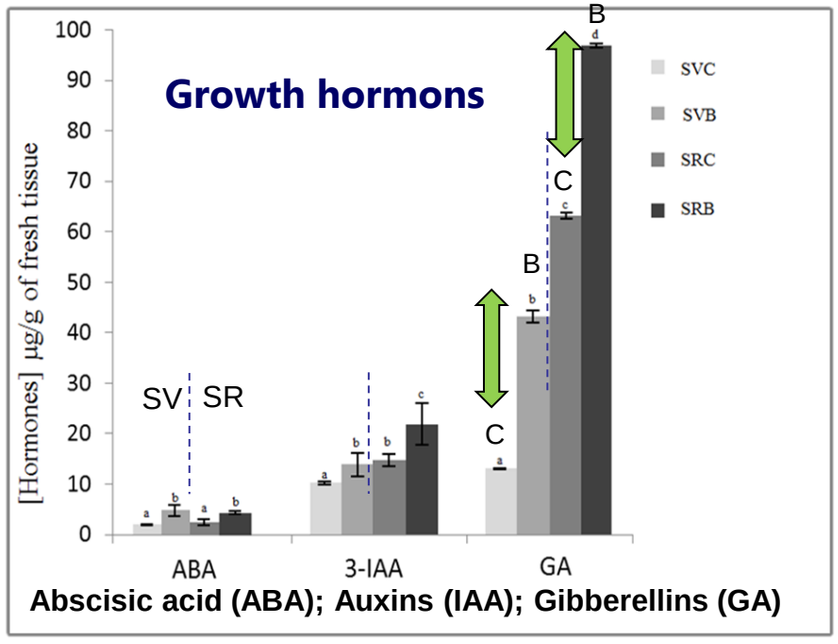


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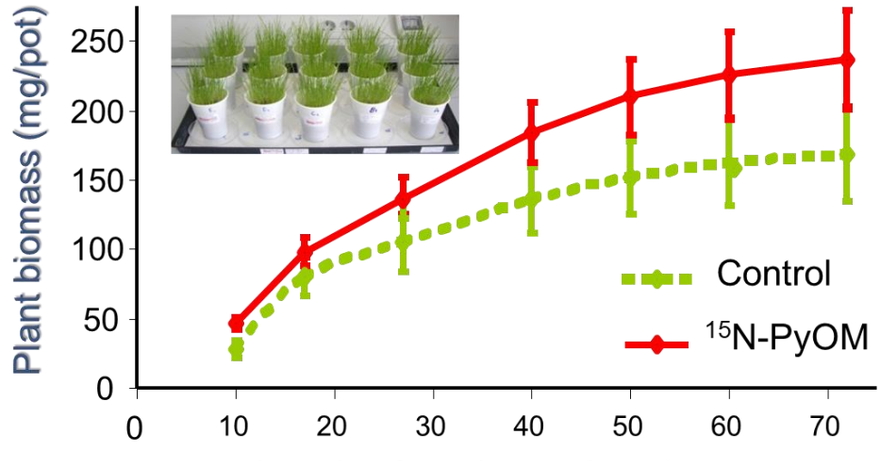
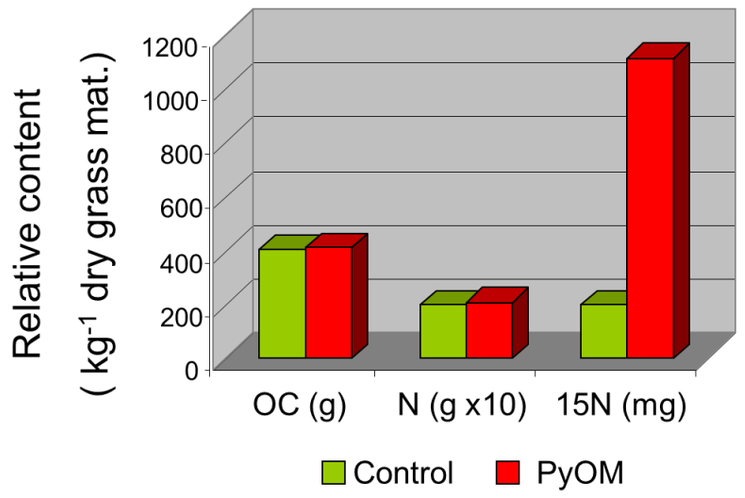


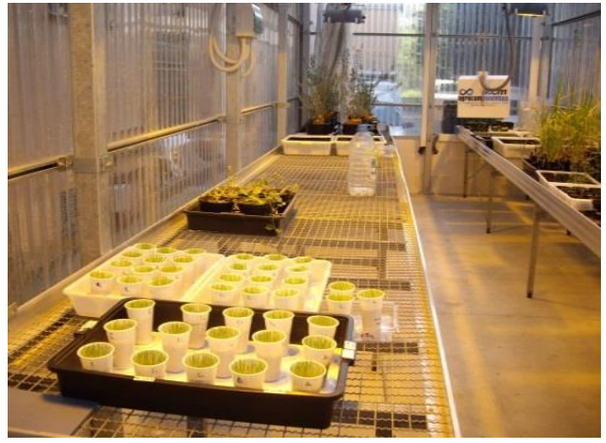

**Biochar effect on plant shoots**




- **Increase of plant yields due to biochar addition**
- **N available from $^{15}$N-enriched biochar for plant growth**

**Increases of plant yields and plant growth! But no effect on water retention**

# Case study 3



- Soil: *Luvisol, chromic*; (pH 7.8) Seville (SW, Spain)
- Cultivation: *Lolium perenne*
- Grenhouse conditions: 14h light day$^{-1}$; 22 ºC; 700 mm $H_2O$ yr$^{-1}$
- Amendments:

| | Biochar 1 | Biochar 2 | Biochar 3 | Biochar 4 |
|---|---|---|---|---|
| **Producer (location)** | Swiss Biochar, Laussane | Sonnenerde, Austria | Pyreg, Germany | Bodegas Torres, Spain |
| **Feedstock** | **Mixed wood** | **Paper sludge & wheat husks** | **Sewage sludge** | **Vineyard wood (kiln method)** |
| **C content (g kg$^{-1}$)** | 757 | 509 | 179 | 764 |
| **pH ($H_20$)** | 10.4 | 10.4 | 6.7 | 10.3 |
| **WHC[a] (%)** | 266± 16 | 233± 14 | 27± 5 | 178± 17 |
| **$SSA_{BET}$[b] ($m^2$ $g^{-1}$)** | **407.2± 5.2** | **116.9± 2.0** | 67.3± 1.3 | **≤ 5** |

a)WHC: Water holding capacity; b) SSA: Specific Surface Area according to Brunaüer-Emmett-Teller (BET) equation

# Case study 3

- Soil: *Luvisol,* chromic; (pH 7.8) Seville (SW, Spain)
- Cultivation: *Lolium perenne* (ray grass)
- Grenhouse conditions: 14h light day$^{-1}$; 22 ºC; 700 mm $H_2O$ yr$^{-1}$
- Amendments:

| | Biochar 1 | Biochar 2 | Biochar 3 | Biochar 4 |
|---|---|---|---|---|
| **Producer (location)** | Swiss Biochar, Laussane | Sonnenerde, Austria | Pyreg, Germany | Bodegas Torres, Spain |
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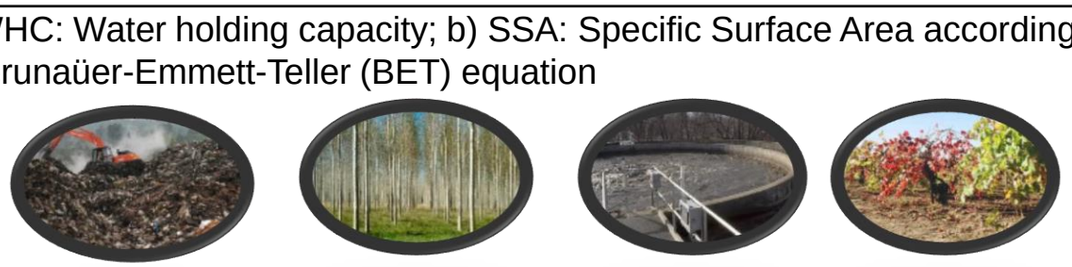
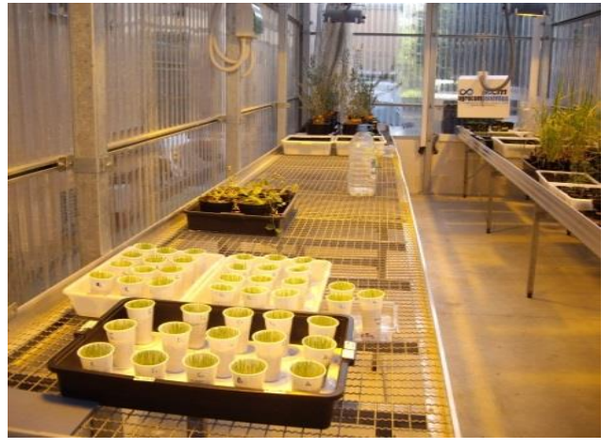
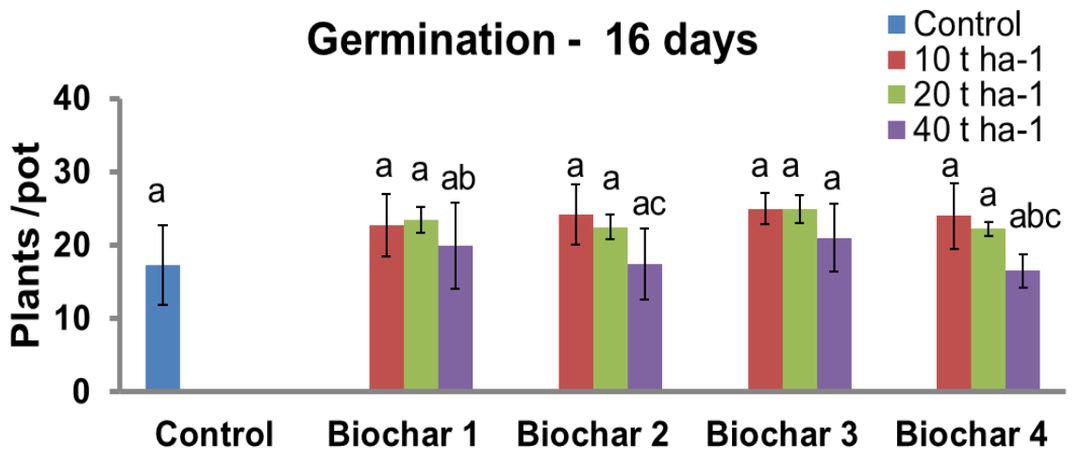
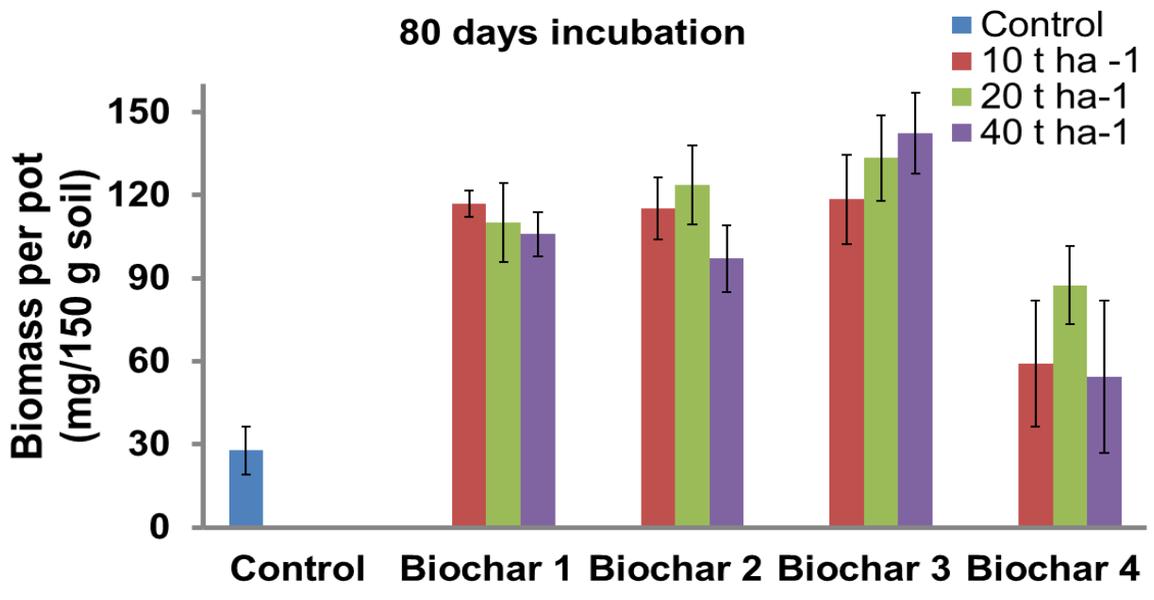






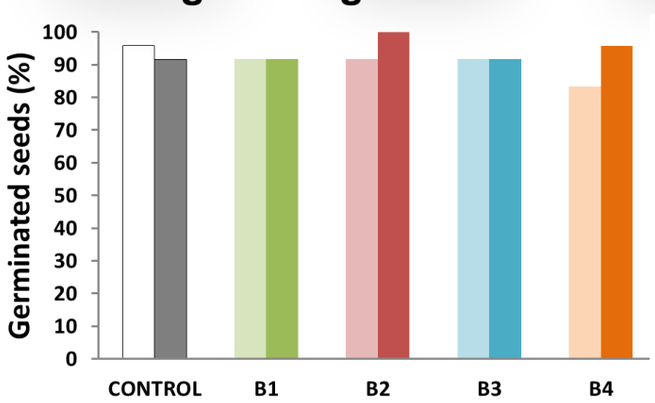



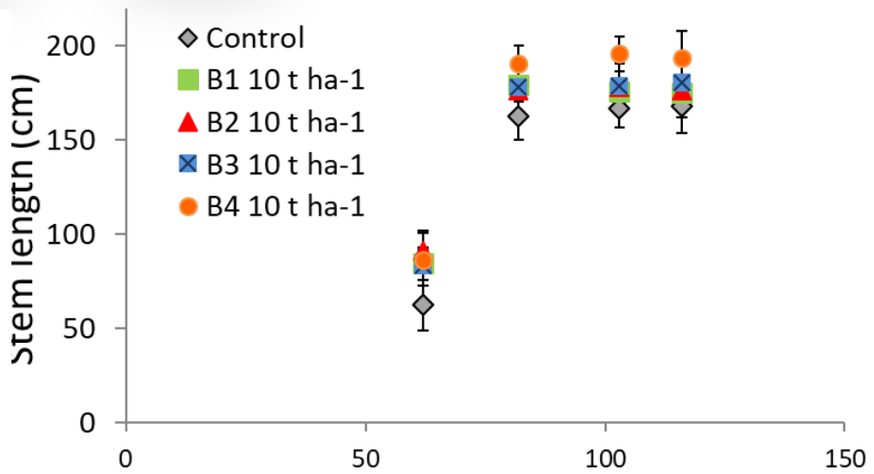

- **No effect of biochar on germination rates**
- **Increase of biomass production due to biochar addition (B1, B2 and B3 better than B4)**
- **Greater biochar doses did not result on greater plant yields**

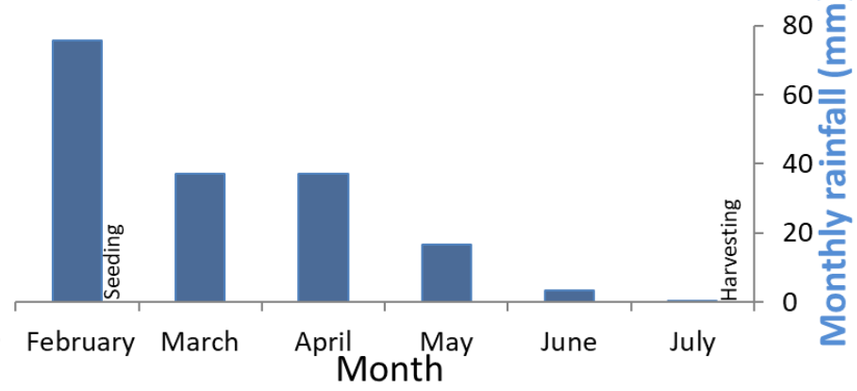
De la Rosa et al., 2014. STOTEN

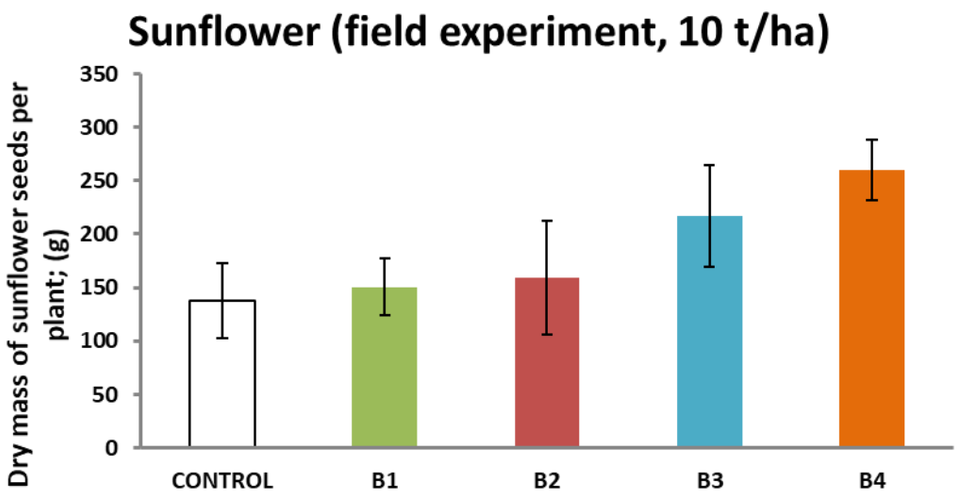
# Case study 4

- Soil: *Cambisol,* calcic; (pH 8.2) Coria del Río (SW, Spain)
- Cultivation: *Helianthus annuus*
- Field conditions: Mediterranean climate ; 540 mm $H_2O$ $yr^{-1}$
- Amendments: Doses eq.  to 1.5 and 15 t/ha
- **No additional water irrigation or fertilizer**




- **No effect of biochar on germination rates**
- **Increase of biomass production due to biochar addition B3 and especially  B4**

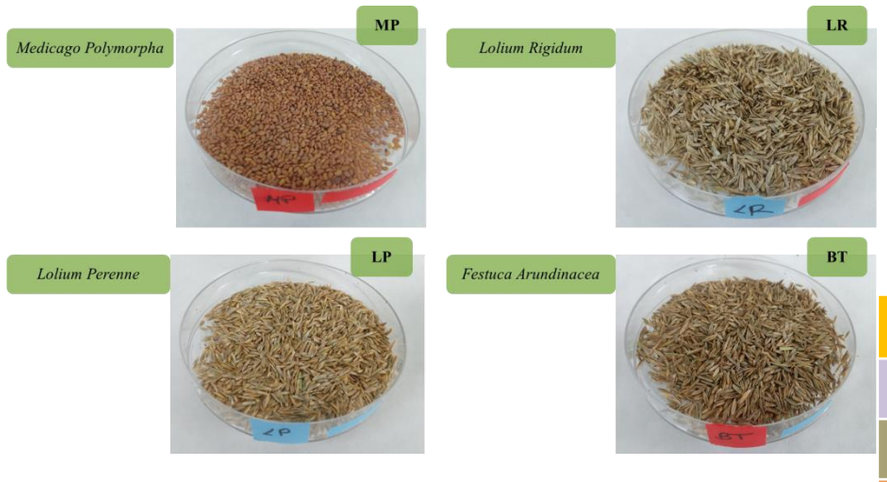
**The worst biochar under greenhouse conditions turned out to be the best at field (non-irrigated) conditions**

# Case study 5

- Pot experiment: Olive pomace biochar (saline), wood biochar and Green-waste compost as **alternative growing media to peat**
- Greenhouse conditions: 24ºC, 11h light/day
- Amendments: Doses eq. to 0, 10 and 20% of biochars and green compost
- Water added regularly equivalent to 700 mm $yr^{-1}$
- 3 diferente amendments (11 treatments)

| B1 (Olive pomace; 500 ºC) | B2 (Wood; 500ºC) | CM (Green compost) | Peat |
|---|---|---|---|

- 4 diferente seeds



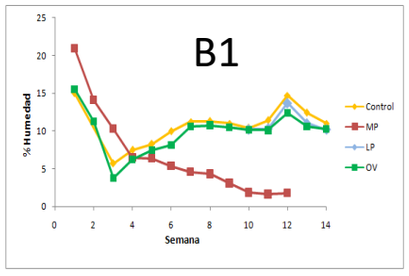

- **Significant differences between biochars: B1 (saline-olive pomace biochar) impeded germination**
- **Adequate response with B2 and green compost and its mixture**

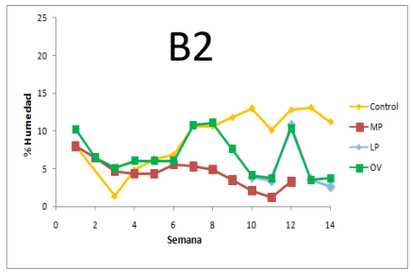
## Germination effects

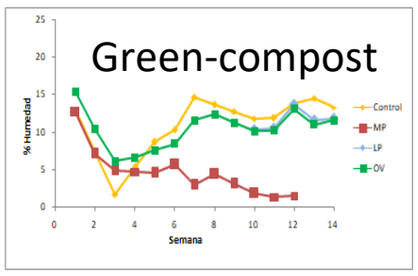
| | Treatment | Germination rates (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Lolium Rigidum* | | *Medicago Polymorpha* | | *Lolium Perenne* | | *Festuca Arundinacea* | |
| | | 8 d | 16 d | 8 d | 16 d | 8 d | 16 d | 8 d | 16 d |
| 1 | B1 - 10% | 0,0 | 0,0 | 0,0 | 0,0 | 5,6 | 5,6 | 0,0 | 5,6 |
| 2 | B2 - 10% | 16,7 | 16,7 | 38,9 | 38,9 | 38,9 | 38,9 | 55,6 | 61,1 |
| 3 | CM - 10% | 16,7 | 22,2 | 22,2 | 22,2 | 72,2 | 72,2 | 50,0 | 50,0 |
| 4 | B1 - 5% + CM - 5% | 5,6 | 5,6 | 5,6 | 5,6 | 72,2 | 72,2 | 44,4 | 44,4 |
| 5 | B2 - 5% + CM - 5% | 0,0 | 0,0 | 5,6 | 5,6 | 83,3 | 88,9 | 77,8 | 77,8 |
| 6 | Control | 5,6 | 5,6 | 38,9 | 44,4 | 22,2 | 22,2 | 33,3 | 38,9 |
| 7 | B1 - 20% | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 5,6 | 0,0 | 0,0 |
| 8 | B2 - 20% | 0,0 | 0,0 | 22,2 | 22,2 | 66,7 | 66,7 | 66,7 | 66,7 |
| 9 | CM - 20% | 0,0 | 0,0 | 11,1 | 11,1 | 55,6 | 55,6 | 44,4 | 44,4 |
| 10 | B1 - 10% + CM - 10% | 0,0 | 0,0 | 0,0 | 0,0 | 33,3 | 33,3 | 16,7 | 16,7 |
| 11 | B2 - 10% + CM - 10% | 0,0 | 0,0 | 0,0 | 0,0 | 50,0 | 55,6 | 44,4 | 44,4 |

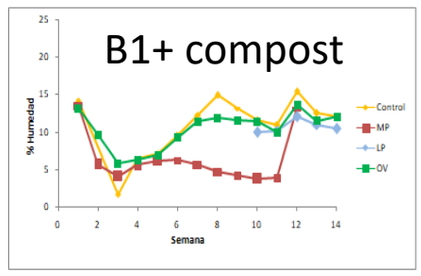
# Case study 5

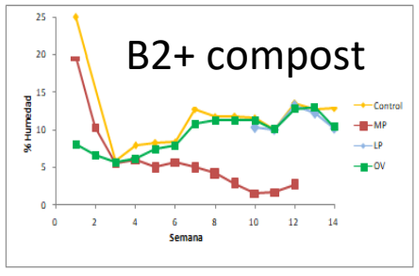
## Soil moisture

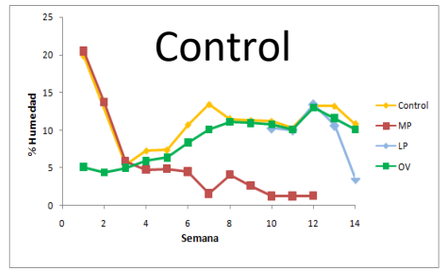


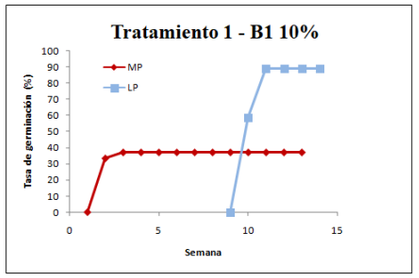




- The moisture of the technosols was driven by climatic conditions and vegetation type (evapotranspiration).
- Medicago *polymorpha* showed the greatest waster loss by transpiration
- B2 and compost retained more water than B1.

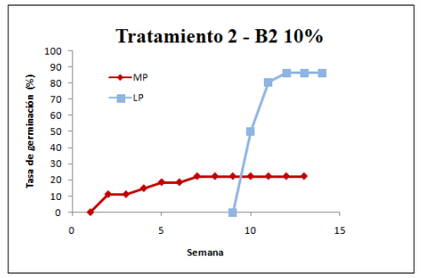
- Only B2(Wood biochar) and 20 % Green compost increased the water holding capacity of the pots

| | | WHC (%) |
|---|---|---|
| 1 | B1 - 10% | 362 |
| 2 | B2 - 10% | 407 |
| 3 | CM - 10% | 400 |
| 4 | B1 - 5% + CM - 5% | 399 |
| 5 | B2 - 5% + CM - 5% | 394 |
| 6 | Control | 394 |
| 7 | B1 - 20% | 368 |
| 8 | B2 - 20% | 424 |
| 9 | CM - 20% | 415 |
| 10 | B1 - 10% + CM - 10% | 308 |
| 11 | B2 - 10% + CM - 10% | 387 |

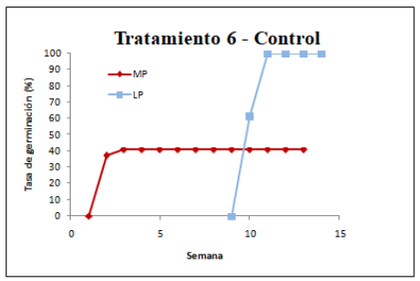
B1




B2




Control




- Contrasting germination rate and germination speed between species

# Take-home messages

- ✓ In general, adding biochar as amendment does not affect germination and improves the physical properties of soils, so that primary productivity can be increased

but….

- ✓ Not all biochars have the same properties (they are very diverse)
- ✓ It is necessary to adapt the properties of the amendments to the crop needs and climatic conditions (characterization and selection) to prevent adverse effects

*Application of biochar to irrigated technosoils:*

*Effects on germination and agronomic properties*

# Thanks for your attention

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