

Intercrop management as a tool to increase soil microbial diversity on
rainfed almond cultivations

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DIVERFARMING



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Field case studies

Pedoclimatic regions

- Mediterranean south
- Mediterranean north
- Atlantic
- Continental
- Boreal
- Pannonian
- Mediterranean Mountains
- Lusitanian
- Alpine
- Nemoral

Consortium

- Research centre
- Agrarian association (SME)
- Agrarian SME (with agri-industry)
- Logistics SME
- Manufacturer SME
- Large cooperative
- Agro-industry SME

CASE STUDIES

- Cereals
- Horticulture
- Permanent woody crops
- Grass
- Rotations
- Multiple cropping
- Intercropping
- Machinery testing





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LABORATORIO DE MICROBIOLOGÍA DE SUELOS

Centro de Investigación en Agrosistemas Intensivos Mediterráneos y
Biotecnología Agroalimentaria (CIAMBITAL)
Universidad de Almería (UAL)



ANÁLISIS DE
PROPIEDADES
MICROBIOLÓGICAS
(METAGENÓMICA)



ANÁLISIS DE
PROPIEDADES
FÍSICAS Y
QUÍMICAS



MICROSCOPIA
ÓPTICA Y
ELECTRÓNICA



MIEMBROS DEL LABORATORIO

RNM-934: Agronomía y Medio Ambiente (AGROMA)

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Introduction

The European Research project “Crop diversification and low-input farming cross Europe” (Diverfarming) aims to develop and test different diversified cropping systems under low-input practices to increase land productivity and crops quality.



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Agricultural
intensification



Monocropping
Intense tillage
Excessive fertilizers
and pesticides

- Soil organic matter loss
- Soil erosion
- Biodiversity reduction
- Greenhouse gas emissions
- Soil and groundwater pollution
- Salinization
- Economic risks and uncertainties
- ...

Low efficient use of
resources and low
term sustainability
in risk



Introduction



DIVERFARMING



Adoption of new agronomic models based on

Diversified cropping systems



Intercropping



Crop rotations



Multiple cropping



Perennial crops

Low-input management practices



Reduce tillage/no tillage



Integrated pest control



Optimised fertilization



Mulching



Regulated deficit irrigation



Precision farming



Introduction



DIVERFARMING



Adoption of new agronomic models based on

Diversified cropping systems



Intercropping



Crop rotations



Multiple cropping



Perennial crops

Low-input management practices



Reduce tillage/no tillage



Integrated pest control



Optimised fertilization



Mulching



Regulated deficit irrigation



Precision farming



Introduction

SE Spain



<http://almendraoria.blogspot.com/>

Almería



Semiarid climate
317 mm annual precipitation
ETP annual: 803 mm
15.2 °C annual mean temperature

The typical management system on the area consist on tree lines with barren soils among them

<https://commons.wikimedia.org/>



Introduction

- Low yields: 150 kg / ha vs 500 kg / ha national average
- Commercial, social and environmental marginality is derived
- This territory is defined in the geographical framework of the European Union as an environmentally and economically disadvantaged area.
- These favor abandonment of crops, which is exacerbated by the policies of the Common Agricultural Policy (CAP).
 - Different crops cannot be used to qualify for European agricultural subsidies.
 - Some cover is admitted, but not productive species.

- Erosion processes
- Loss of biodiversity



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Case study: almond monocrops, almond + vine, almond + wheat

Our objective on this work is to study the differences on the microbial diversity (fungi) of soils under an intercropping system (almond tree, vineyard and wheat) on the arid area of the Almanzora basin (northern province of Almeria, Spain).



Methodology

3 management practices

Soil Sampling (0-10 cm Depth)

9 samples x 3 crop types = 27 samples

Almond tree + vineyard



Almond tree + wheat



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Almond tree

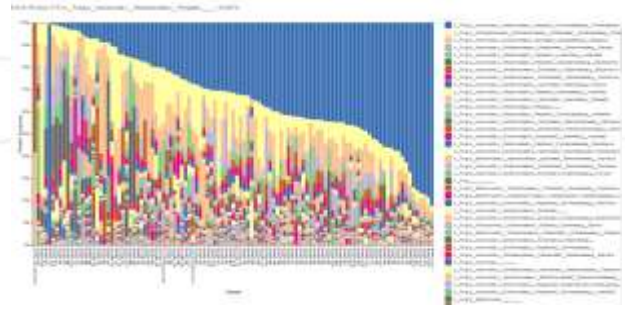


Methodology

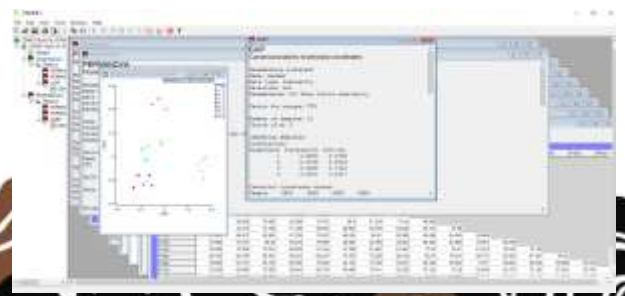
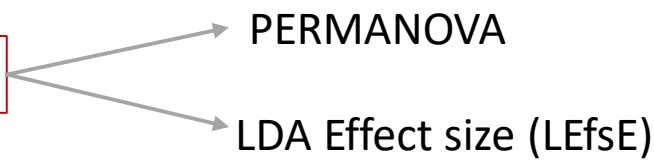
Metagenomic Analyses



Bioinformatic Analyses



Statistical Analysis



Results

One-factor permutational multivariate analysis of variance (PERMANOVA)

Source	df	SS	MS	Pseudo-F	P(perm)	perms
Crop system	2	3522.4	1761.2	3.0002	0.001	997
Res	23	13502	587.03			
Total	25	17024				

Pair-wise test PERMANOVA

Groups	t	P(perm)	perms
1, 2	1.5321	0.001	975
1, 3	1.7989	0.001	974
2, 3	1.9248	0.001	983



Results

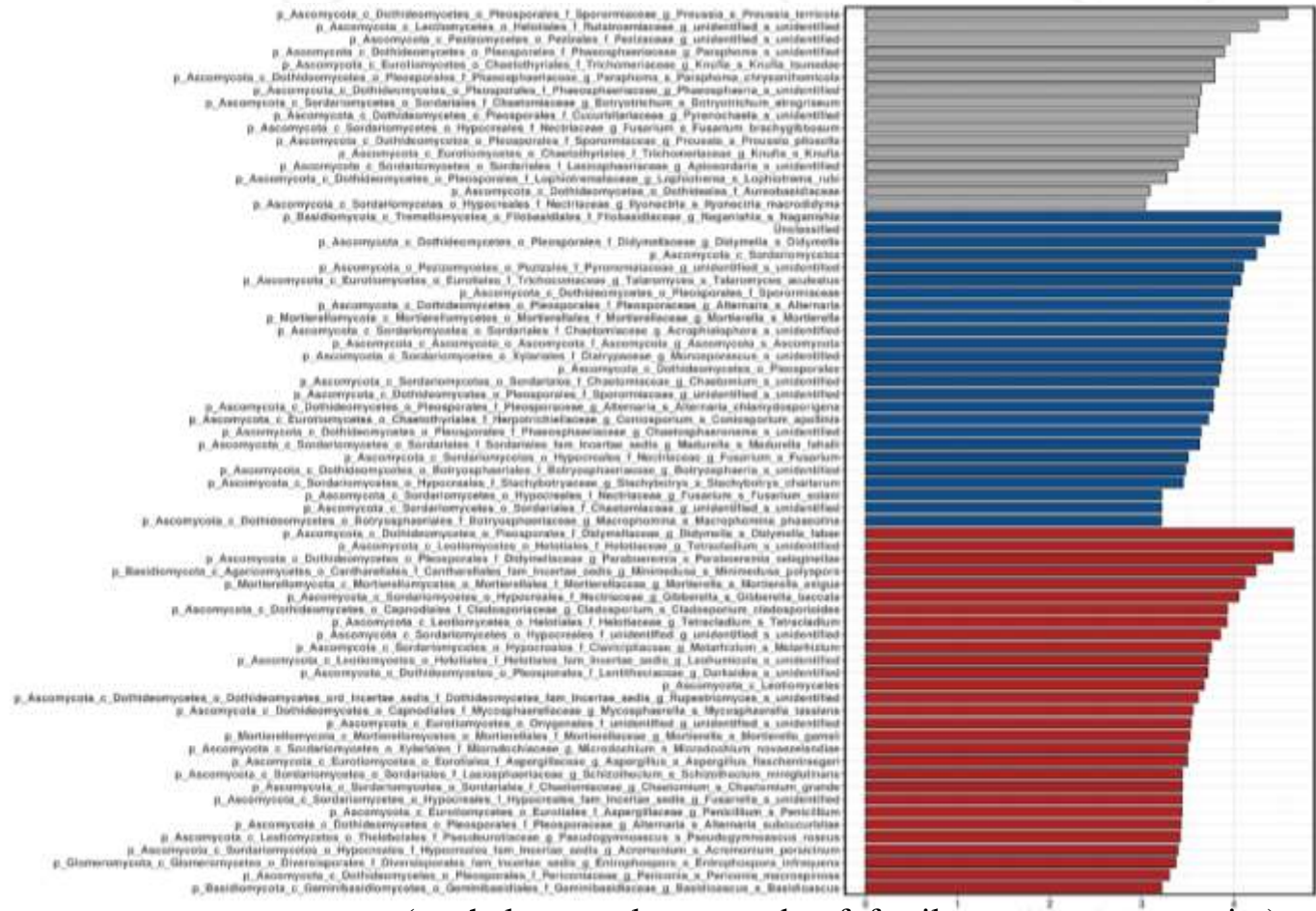
Diversity indices (mean deviation \pm standard deviation)

Crop	ASVs	Faith	Shannon	Pielou
Almond	249 \pm 39.66	44.63 \pm 5.01	5.17 \pm 1.35	0.64 \pm 0.16
Almond + vineyard	287 \pm 38.08	46.89 \pm 4.58	5.32 \pm 0.57	0.65 \pm 0.06
Almond + wheat	305 \pm 15.84	49.81 \pm 1.14	5.68 \pm 0.63	0.68 \pm 0.07



Results

Taxa more associated to different crop systems based on the LEfSe analysis.



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■ A+W ■ A ■ A+V
 A+W: Almond + Wheat
 A: Almond
 A+V: Almond + Vineyard

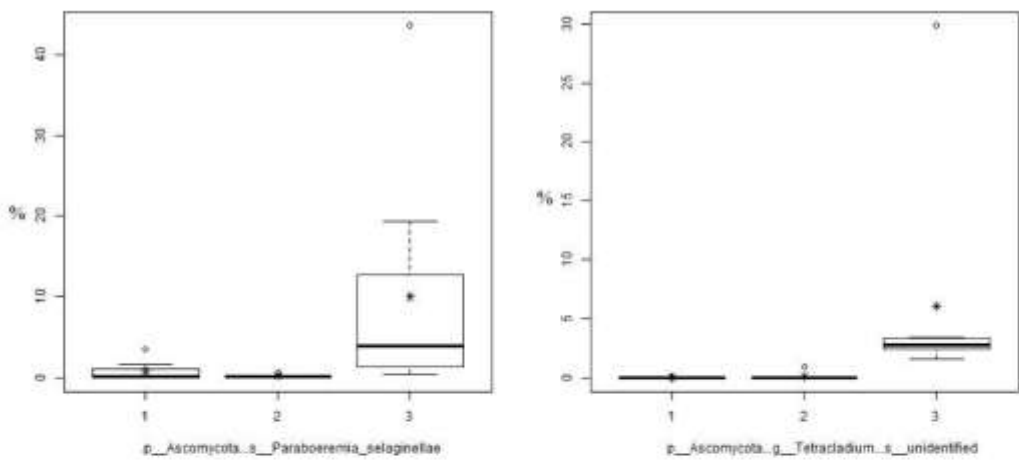


(p: phylum; c: class; o: order; f: family; g: genera, s: species)

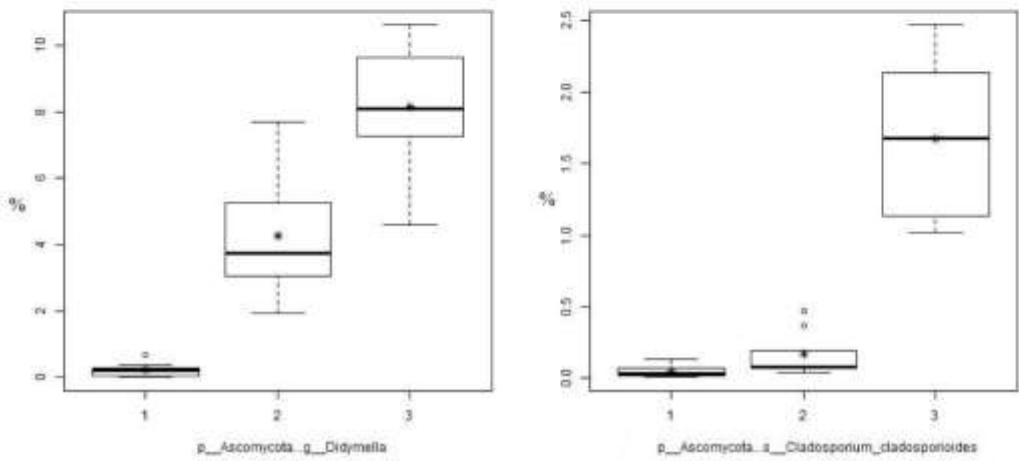


Results

Examples fungi taxa more present on the almond with wheat crop system



(p: phylum, g: genera, s: species)



1. Almond
2. Almond + vine
3. Almond + wheat

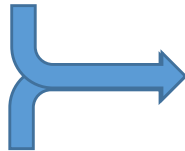


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Discussion

Lacombe et al. (2009) found a higher abundance of fungi in intercropping systems compared to monocropping systems. In addition, Bainard et al. (2012) found more diversity in intercropping systems. These findings agree with our results as we found that fungi microbial communities are significantly different when vineyards and wheat are introduced as intercrops on almond trees cultivations, being thus more diverse, showing the alpha indices a gradient

 Almond + wheat > almond + vineyard > almond.

An important number of taxa were related to the different crop systems showing the number of taxa again the same trend.

This suggests that each combination of crops can favour certain taxa which in turn can have important implications in the development of more sustainable crop systems (Bagyaraj, D. J., and Ashwin, R., 2017).



Conclusions

- The introduction of vineyard or wheat in almond tree cultivation produced differences in fungi microbial communities and an increase in the fungal diversity.
- This increase in the diversity will improve the biological soil properties and several authors suggest that can have important implications in crop productivity.
- Different taxa were more associated with the different crop systems being the system almond with wheat the one with the highest number of taxa related.
- This study can result in a start point for further research on the interactions of microorganism – plants associated to crops and the effects of intercropping in increasing the soil biodiversity.



Thank you for your attention

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References

- Anderson, M., Gorley, R.N. & Clarke, K.** 2008. *PERMANOVA+ for primer: Guide to software and statistical methods*.
- Bagyaraj, D. J. & Ashwin, R.** 2017. Soil biodiversity: role in sustainable horticulture. *Biodivers. Hortic. Crops* 5: 1–18.
- Bainard, L.D, Koch, A.M, Gordon, A.M, Newmaster, S.G, Thevathasan, N.V & Klironomos, J.N.** 2011. Influence of trees on the spatial structure of arbuscular mycorrhizal communities in a temperate tree-based intercropping system. *Agr Ecosyst Environ*, 144:13–20
- Bolyen, E., Rideout, J.R, Dillon, M., Bokulich, N., Abnet, C., Al-Ghalith, G., Alexander, H. Alm, E., Arumugam, M., Asnicar, F., Bai, Y., Bisanz, J., Bittinger, K., Brejnrod, A., Brislawn, C., Brown, C.T., Callahan, B., Caraballo-Rodríguez, A. & Chase, J.** 2019. Reproducible, interactive, scalable and extensible microbiome data science using QIIME 2. *Nature Biotechnology*. 37. 1.
- Clarke, K. & Gorley, R.** 2015. *PRIMER version 7: User manual/tutorial. PRIMER-E*. 192.
- García-Lorca, A., ed.** 1998. *Atlas comarcal de la provincial de Almería. IDEAL. Almería*.
- Lacombe, S., Bradley, RL., Hamel, C., Beaulieu, C.** 2009. Do treebased intercropping systems increase the diversity and stability of soil microbial communities? *Agr Ecosyst Environ* 131:25–31
- van der Heijden, M.G.A, Klironomos, J.N, Ursic, M., Moutoglis, P., Streitwolf-Engel, R., Boller T., Wiemken, A. & Sanders, I.R.** 1998. Mycorrhizal fungal diversity determines plant biodiversity, ecosystem variability and productivity. *Nature* 396:69–72
- Wagg, C., Jansa, J., Schmid, B. & van der Heijden, M.G.A.** 2011. Belowground biodiversity effects of plant symbionts support aboveground productivity. *Ecol Lett*. 14:1001–1009
- Zakrzewski., M, Proietti, C., Ellis, J., Hasan, S., Brion, MJ., Berger, B., Krause, L.** 2016. Calypso: A User-Friendly Web-Server for Mining and Visualizing Microbiome-Environment Interactions. *Bioinformatics*



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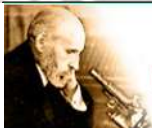


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