Cranfield
Environment
and Agrifood

COVER CROPS TO REDUCE SOIL EROSION IN MAIZE AND IMPROVE SOIL HEALTH

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8 September 2016

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Objectives & Methodology

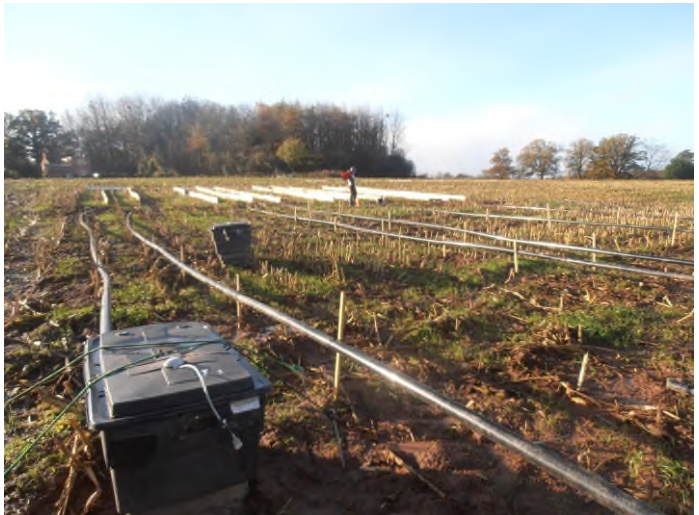
1. Quantify the role of cover cropping towards reducing surface runoff and soil loss. → Field experiment 1 (October 2014 - March 2015) and field experiment 2 (July 2015 to March 2016)

2. Quantify the cover crop/soil microbiology interactions and subsequently the role of this interaction towards improving soil health and controlling soil erosion. → Soil analysis: 2 soil sampling events November 2015 and in March 2016

3. Use information gained to critically evaluate the viability and practicability of using cover crops in maize cultivations. → Conclusion from field experiment and laboratory analysis

Field experiments

Erosion plot design



Experiment 2

Experimental layout

1. Italian ryegrass (A)
2. Italian ryegrass and hairy vetch (B)
3. Italian ryegrass and berseem clover (C)
4. Control: no cover crops (D)

Experiment 2

Timelines

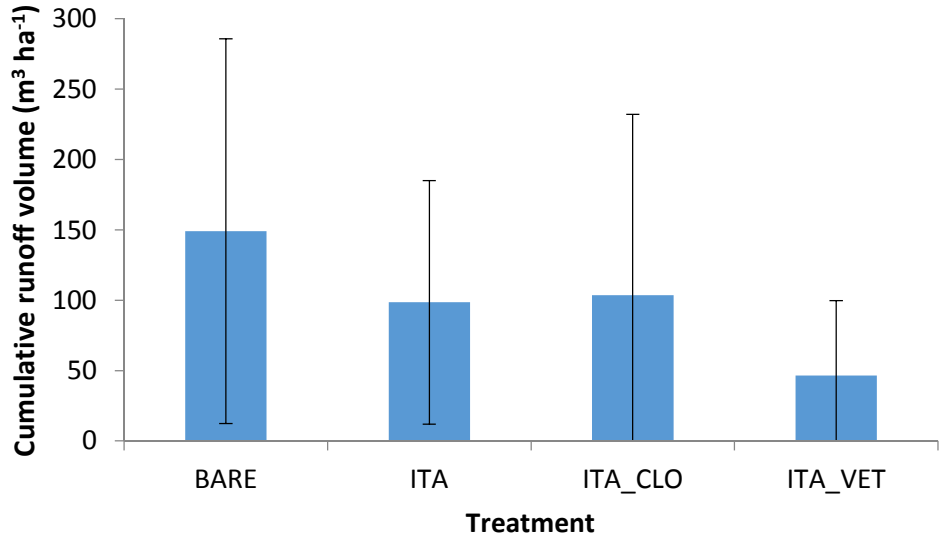
Relevant agronomic events	Runoff collection period	Sampling event number
Maize drilled in May 2015	28 July 2015 – 15 October 2015	1rst
Cover crops sown June 2015	27 November 2015 2015 - 21 December 2015	2nd
Maize harvested in October 2015 (wheelings)	21 December 2015 - 13 January 2016	3rd
Cover crops terminated in March 2016	13 January 2016 – 16 February 2016	4th
	16 February 2016 – 15 March 2016	5th

Objective 1

Field experiment 2
Runoff

Sampling event number	Runoff collection period	p values
1rst	28 July 2015 – 15 October 2015	0.36
2nd	27 November 2015 2015 - 21 December 2015	0.37
3rd	21 December 2015 - 13 January 2016	0.17
4th	13 January 2016 – 16 February 2016	0.44
5th	16 February 2016 – 15 March 2016	0.27

Cumulative runoff from July 2015 to March 2016



Vertical bars indicate 95% Confidence Intervals

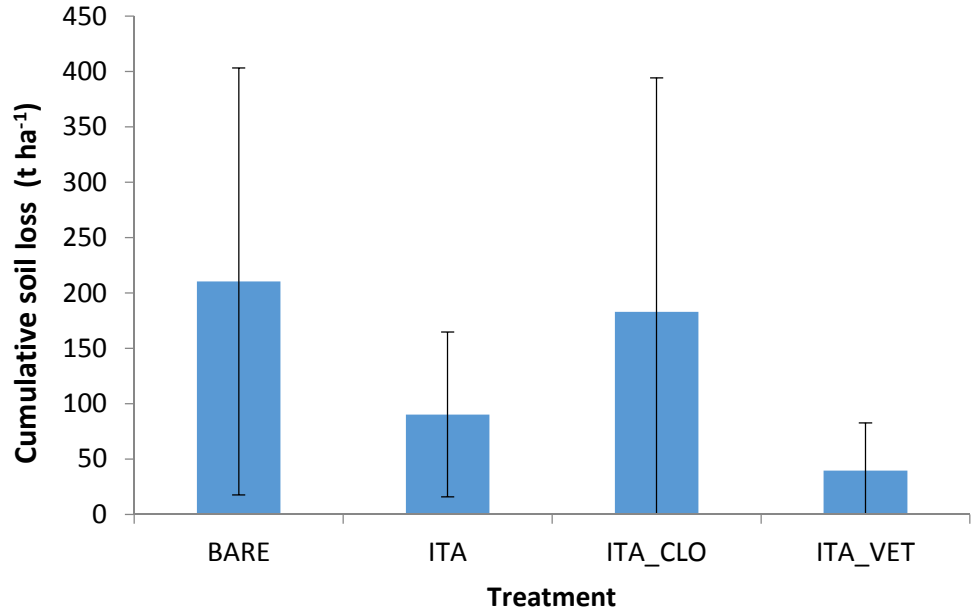
No statistical differences p< 0.05

Objective 1

Field experiment 2
Soil loss

Sampling event number	Runoff collection period	p values
1rst	28 July 2015 – 15 October 2015	0.27
2nd	27 November 2015 2015 - 21 December 2015	0.61
3rd	21 December 2015 - 13 January 2016	0.1
4th	13 January 2016 – 16 February 2016	0.51
5th	16 February 2016 – 15 March 2016	0.51

Cumulative soil loss from July 2015 to March 2016



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Objective 1

Field experiment 2
Soil loss

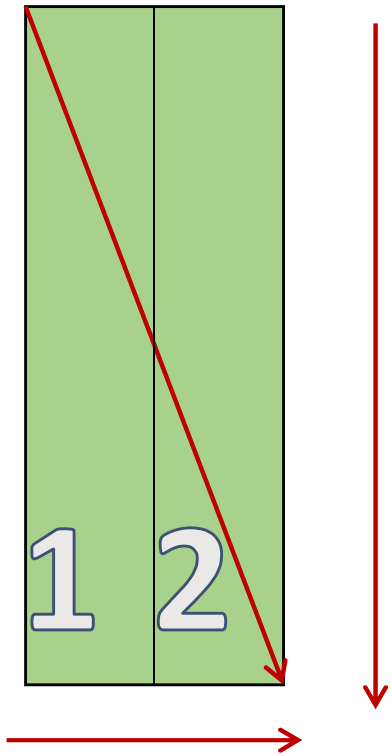
Sampling event number	Runoff collection period	p values
1rst	28 July 2015 – 15 October 2015	0.27
2nd	27 November 2015 2015 - 21 December 2015	0.61
3rd	21 December 2015 - 13 January 2016	0.1
4th	13 January 2016 – 16 February 2016	0.51
5th	16 February 2016 – 15 March 2016	0.51

	Average soil erosion rate (t ha^{-1} yr^{-1})
BARE	0.83
ITA	0.35
ITA_CLO	0.72
ITA_VET	0.15

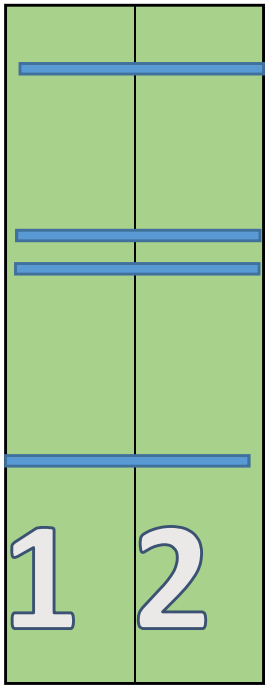
Objective 1

Linear correlations

- Soil loss and runoff production are correlated (r= 0.9)
- No correlations wheelings and soil loss or runoff
- No correlation slope characteristics soil loss or runoff



Main Slope

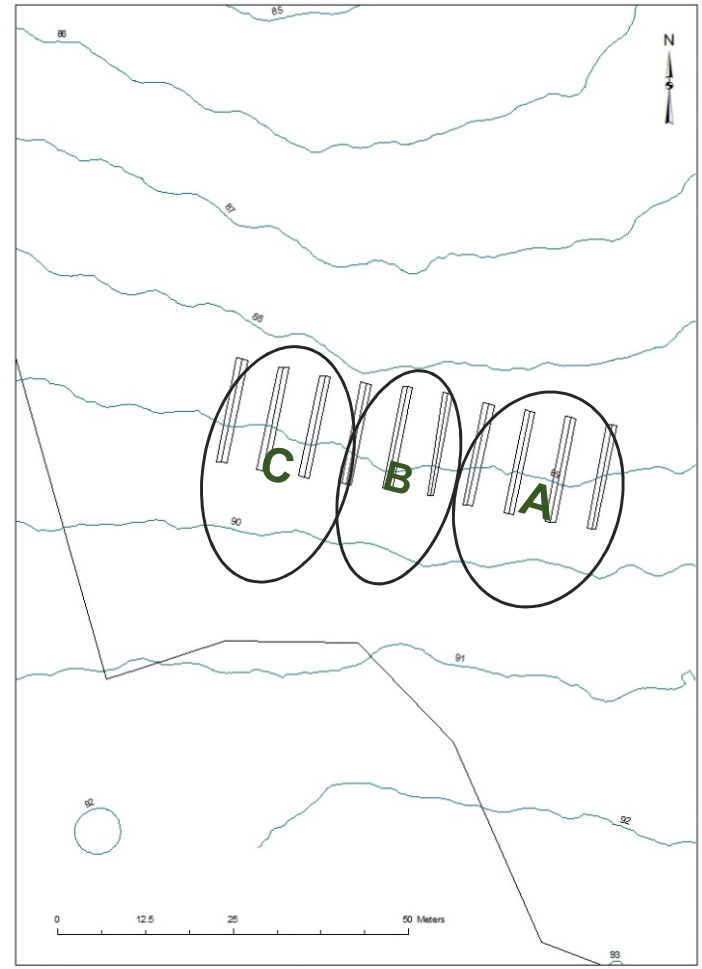


Wheelings

Objective 1

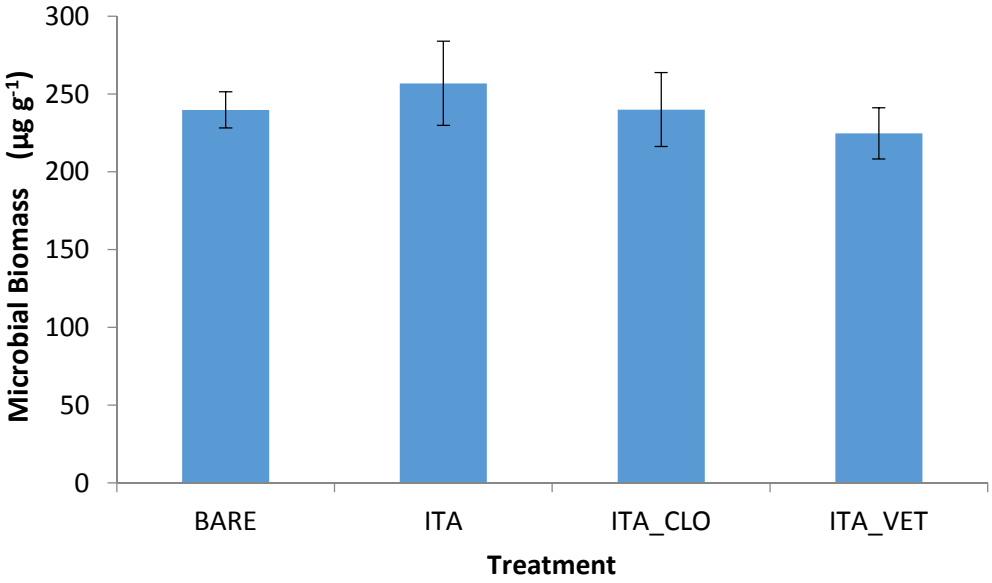
Location of the plots on the slope

Sampling event number	Runoff p values	Soil loss p values	
1rst	0.85	0.55	28 July 2015 – 15 October 2015
2nd	0.01	0.00	27 November 2015 2015 - 21 December 2015
3rd	0.84	0.92	21 December 2015 - 13 January 2016
4th	0.01	0.089	13 January 2016 – 16 February 2016
5th	0.02	0.18	16 February 2016 – 15 March 2016

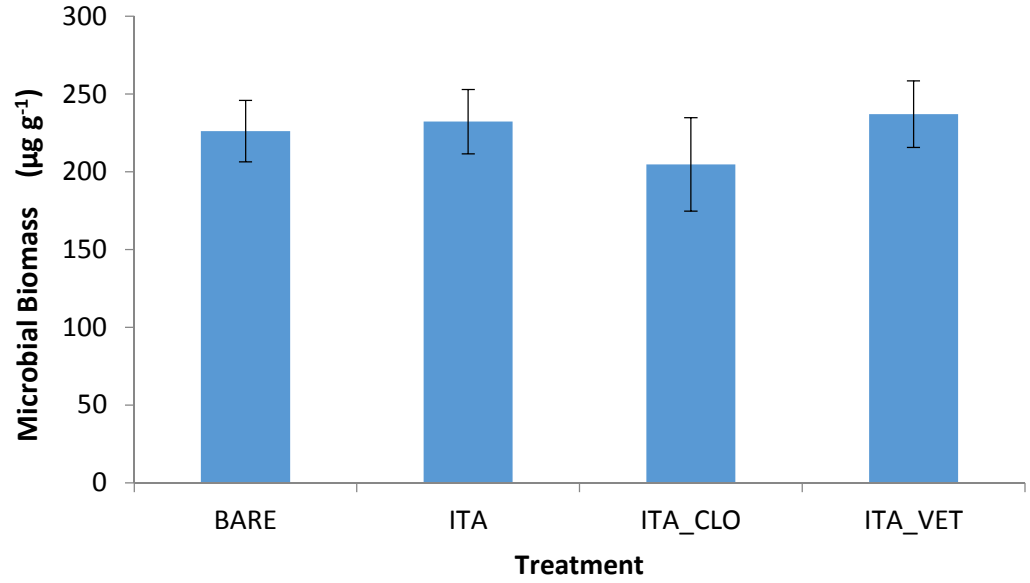


Objective 2

Microbial Biomass in November



Soil collected in the wheelings. Vertical bars indicate 95% Confidence Intervals.

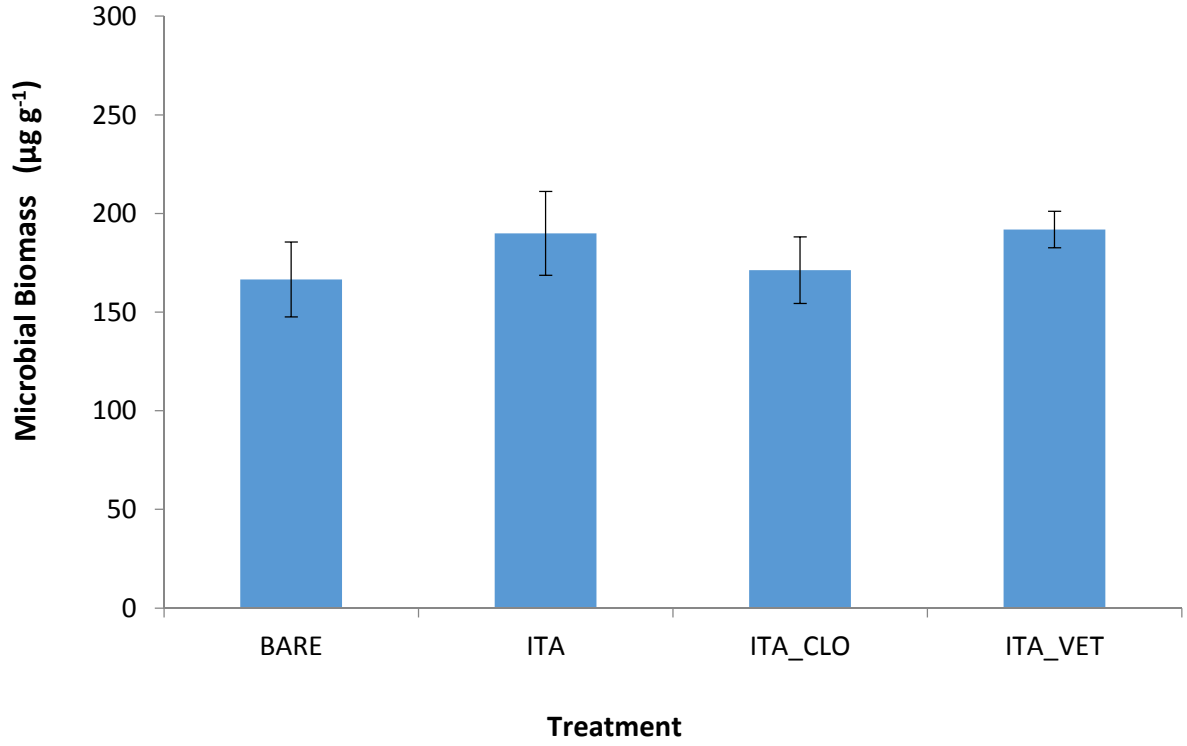


Soil collected outside the wheelings. Vertical bars indicate 95% Confidence Intervals.

No statistical differences $p < 0.05$

Objective 2

Microbial Biomass in March



Vertical bars indicate 95% Confidence Intervals.

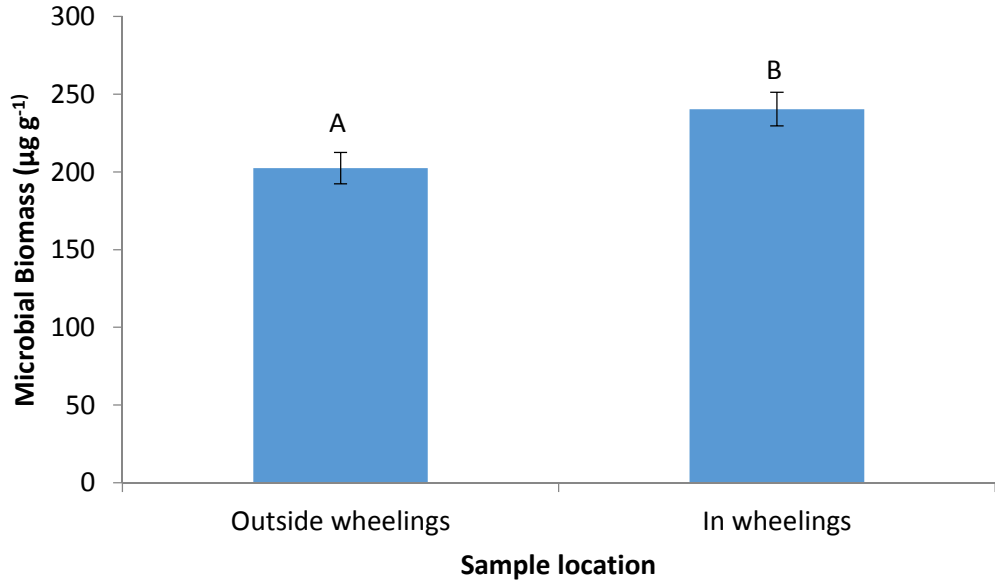
No statistical differences $p < 0.05$

Objective 2

Microbial Biomass comparison

Univariate Tests of Significance for Microbial Biomass Carbon. In colour red p<0.05.

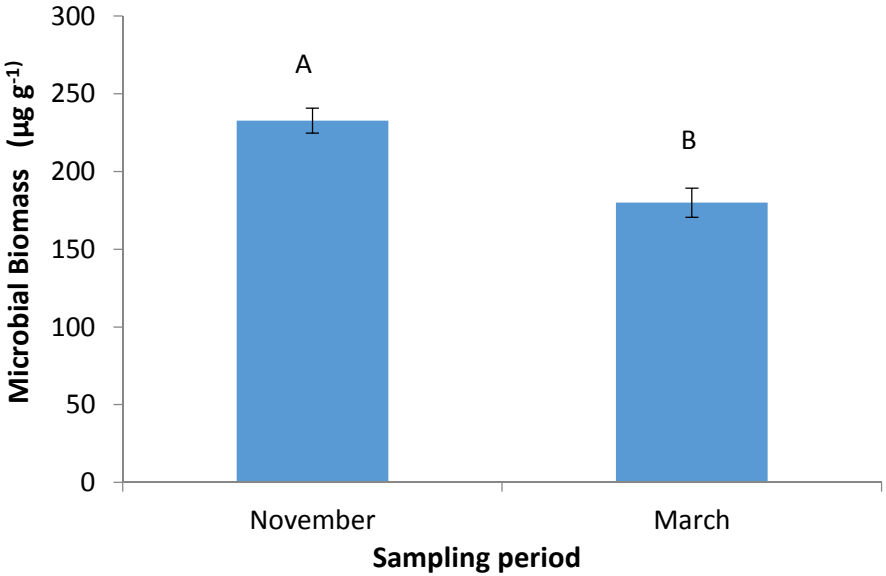
Effect	SS	Degr. of	MS	F	p
Intercept	1766332	1	1766332	3348.50	0.00
Collection location	2359	1	2359	4.47	0.04
Collection Period	20369	1	20369	38.61	0.00
Treatment	3727	3	1242	2.36	0.08
Error	28485	54	527		



Vertical bars indicate 95% Confidence Intervals. Letters refers to homogeneous groups.

Objective 2

Microbial Biomass comparison



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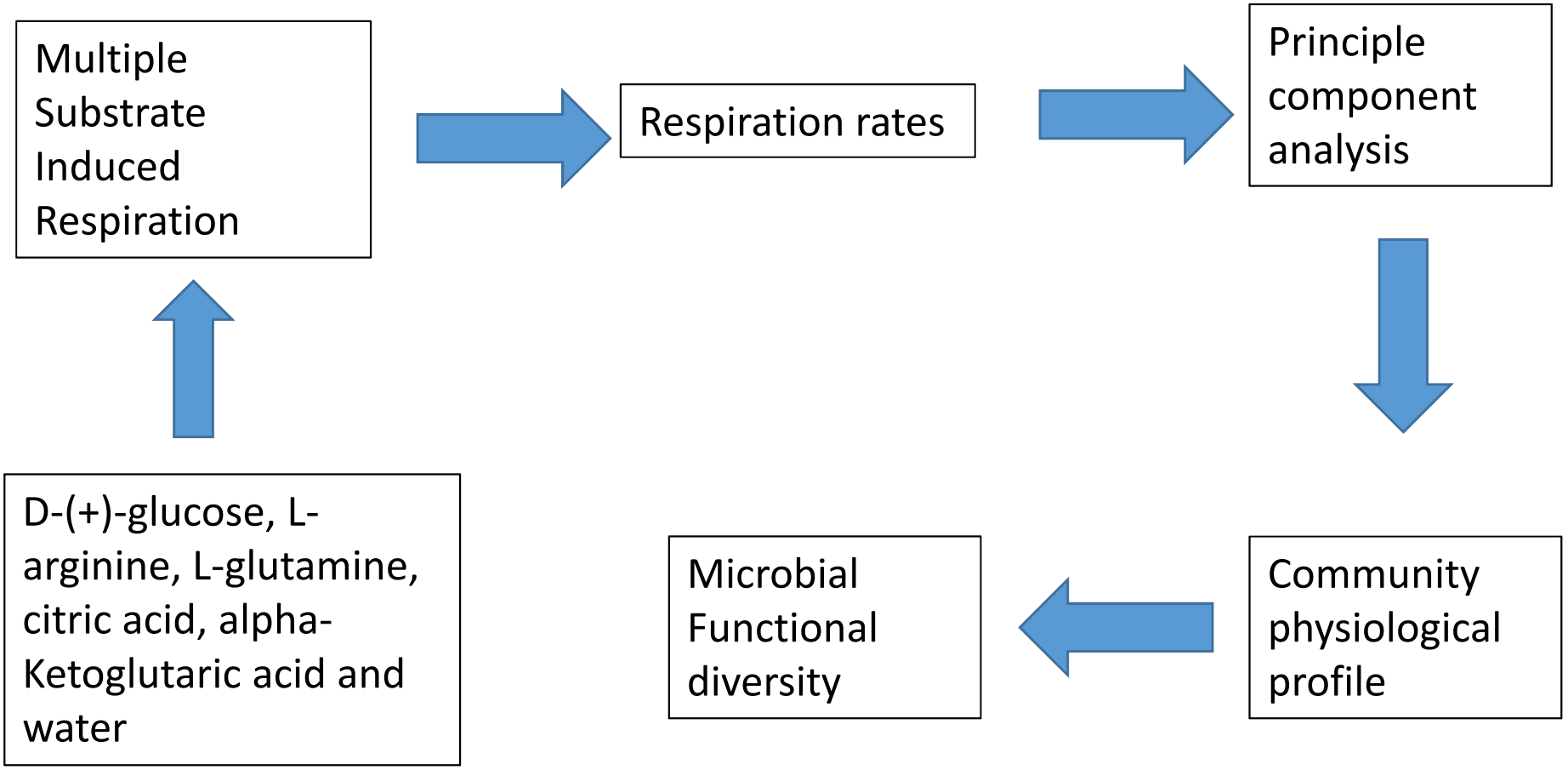
Letters refers to homogeneous groups.

Weather data from Ross-On-Wye weather station (MetOffice), in bold the months when soil samples were collected.

Year	Month	Max Temp. (°C)	Min Temp. (°C)	Air frost (days)	Rain (mm)	Sun (hours)
2015	7	21.2	12.2	0	42.9	191.8
2015	8	20.5	12.2	0	92.5	145.4
2015	9	18.2	8	0	36.3	171.4
2015	10	15.3	7.5	0	38	78
2015	11	12.9	7.4	3	65.7	25.9
2015	12	13.1	8.3	0	125.9	24.9
2016	1	9.2	3.1	5	115.4	48.2
2016	2	9.1	2.1	7	79.5	96.5
2016	3	10.4	1.9	8	68	124.3

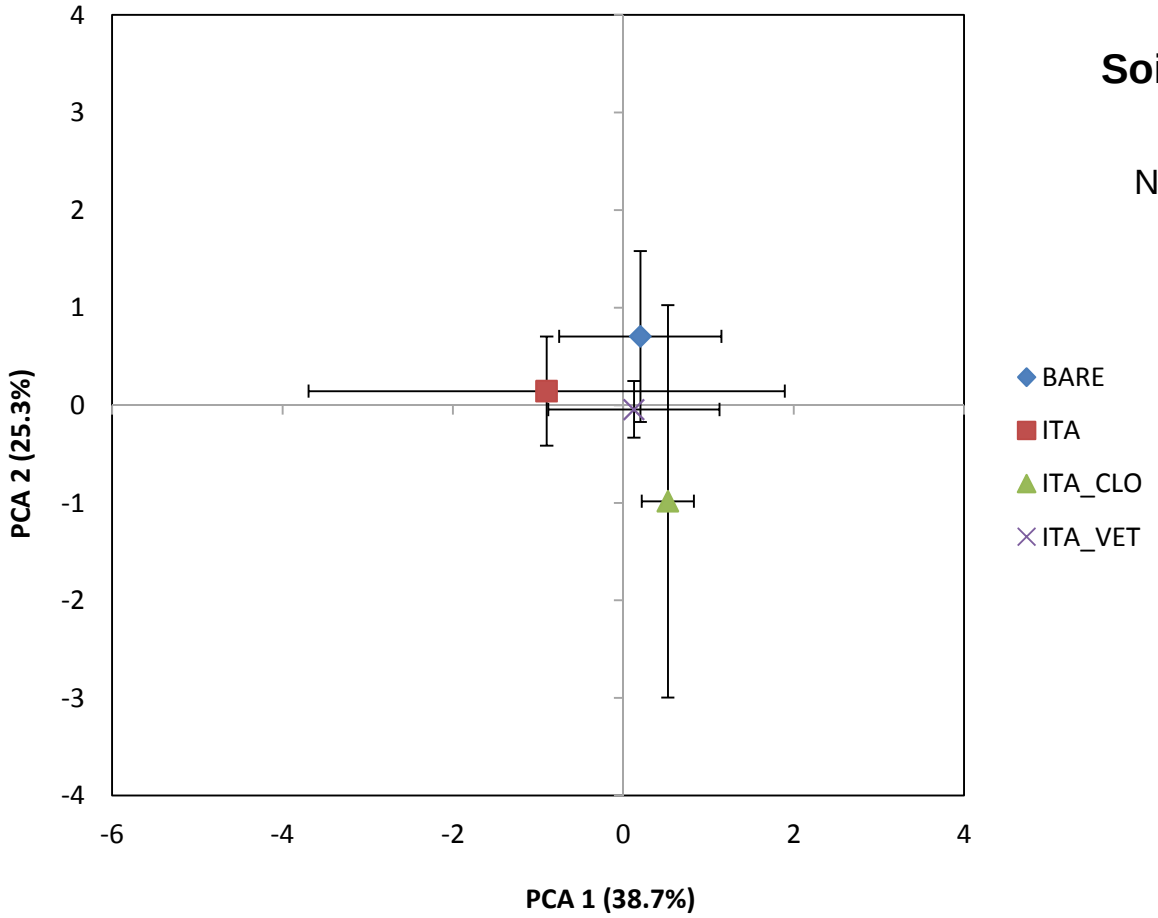
Objective 2

Functional profile of the microbial community



Objective 2

Principle component analysis of the functional profile of the microbial community



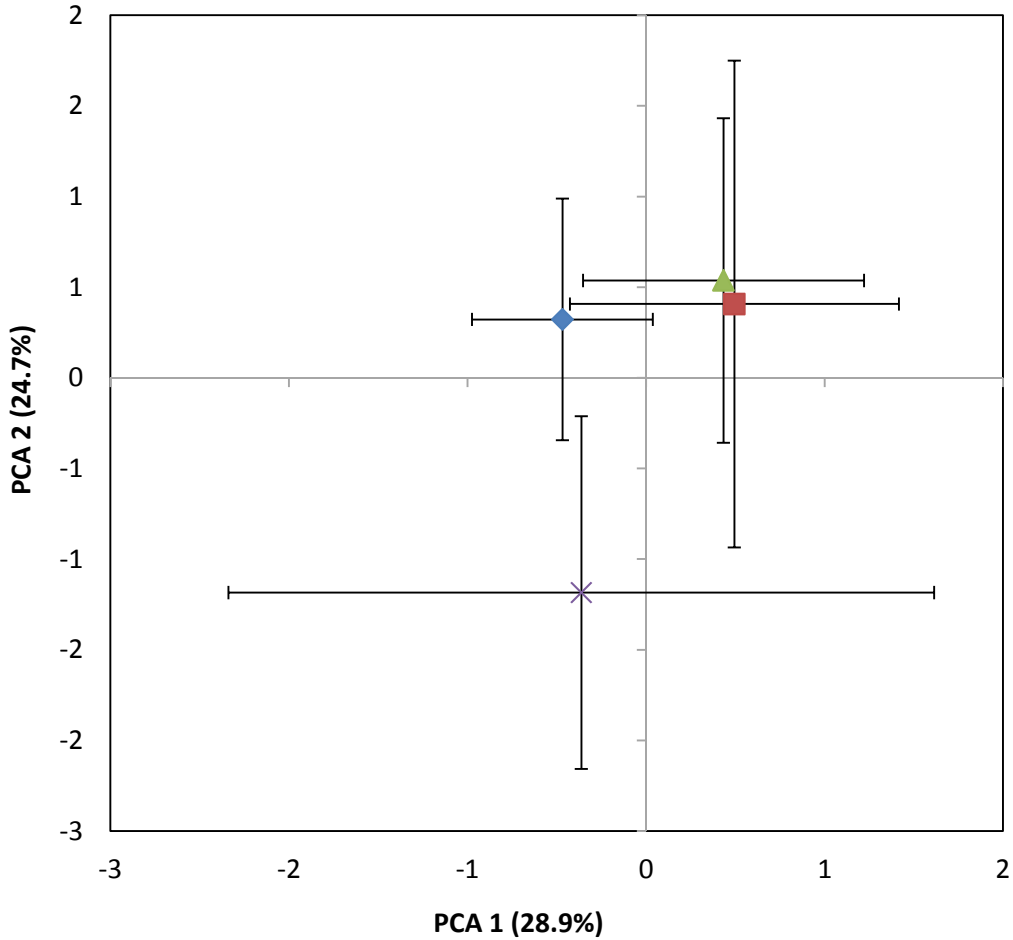
Soil collected outside the wheelings

No statistical differences p< 0.05

Vertical bars indicate 95% Confidence Intervals.

Objective 2

Principle component analysis of the functional profile of the microbial community in March



Soil collected outside the wheelings

No statistical differences p< 0.05

Vertical bars indicate 95% Confidence Intervals.

- BARE
- ITA
- ITA_CLO
- ITA_VET

Interim conclusions

Objective 1: Cover crops for erosion control

- Answer not clear due to variability and complexity
- No evidence of different erosion patterns between cover crop species
- Microtophography could play a important role on shallow slopes
- Limited scale (time and space) of the erosion plots and the lack of natural barriers could compromise the integrity of the results

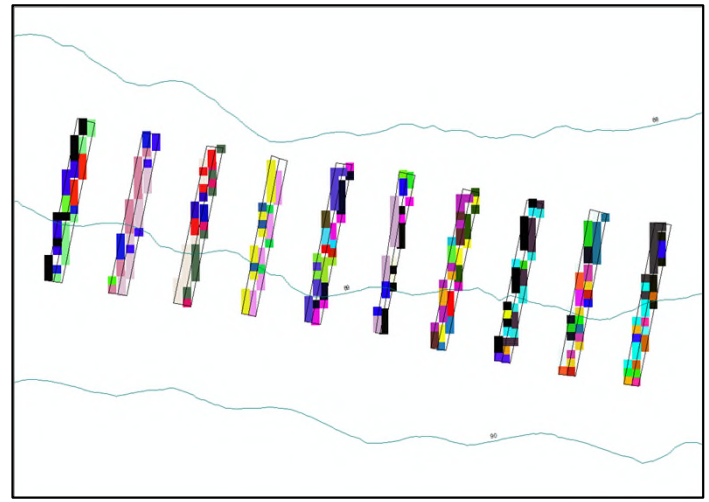
Objective 2: Cover crops for soil heath improvement

- Cover crops do not have an immediate affect on soil microbial community

Experiment 1

Ongoing analysis

Aggregate stability test of the samples collected in November



Microtophograpy analysis

```
    if ten.sum() > 1:
        # Find next zero and end event
        end_index = next_zero_index(df, nz + 10)
        out.append(df.iloc[nz:end_index].copy())
        nz = end_index
        # Keep scanning
        #scan(df, end_index + 1)

    if nz + 10 < len(df):
        scan(df, nz + 1)

scan(data, 0)

for i, frame in enumerate(out):
    frame['no'] = i + 1

# Merge the collected data intp a single dataframe
out = pd.concat(out)
```

```
In [4]: # Double check
        print data.iloc[987:1000]
```

	Time	Rain
987	988.0	0.0
988	989.0	0.2
989	990.0	0.0
990	991.0	0.2
991	992.0	0.0
992	993.0	0.2
993	994.0	0.0
994	995.0	0.2

Correlation rain data and runoff data

Estimation of ground cover using digital imagery

Experiment 2

Future laboratory analysis

Analysis	Soil sampling	Reasoning	Reference
pH	November 2015 and March 2016	Effect of CC on soil baseline and effect of baseline on other laboratory experiments	NR-SAS/SOP 6
Total and organic Carbon and total Nitrogen	November 2015 and March 2016	Effect of CC on soil baseline and effect of baseline on other laboratory experiments	NR-SAS/SOP 9
Organic matter by loss on ignition	November 2015 and March 2016	Effect of CC on soil baseline and effect of baseline on other laboratory experiments	NR-SAS/SOP 7
Phospholipids fatty acid analysis (PLFA)	November 2015 and March 2016	Composition of the soil microbial comunity	041214/MP
Fungal biomass by Ergosterol	November 2015 and March 2016	Role of fungi in soil erosion and aggregate stability	Grant & West 1986
Glomalin related proteins	November 2015 and March 2016	Role of fungi in soil erosion and aggregate stability	Wright & Upadhyaya 1998

Gantt chart

		2016						2016						2017		
Task name	**Preogress to date**	**July**		**August**		**September**		**October**		**November**		**December**		**January**		
Lab analysis	70%															
Paper writing	0%															

Update meeting with DBT

Annual Review

		2017											
Task name	**Preogress to date**	**February**		**March**		**May**		**June**		**July**		**August**		**September**	
Lab analysis	0%														
Paper writing	0%														
Thesis writing	40%														

International conference (Environmental Connection Conference, Atlanta, Georgia)

Ideas for future studies

Objective 1: Cover crops for erosion control

- Long term experiment
- Influence of soil moisture content on cover crops efficiency
- Influence of CC on water infiltration
- Bigger plot scale
- Different soil types
- Different slope gradients

Objective 2: Cover crops for soil heath improvement

- Long term experiment
- Mycorrhizal fungi
- Multiple locations
- Focus in detail on one ecosystem service

Thanks!