EUROPEAN INNOVATION PARTNERSHIP PROJECT:

MAXIMISING ORGANIC Production Systems (MOPS)

GREEN MANURE TRIAL (OCTOBER 2018)

Objectives:

- To evaluate the roles of summer and winter green manures in organic horticultural cropping systems under Irish conditions, using multi-annual trials
- To quantify the effects of different green manures on parameters such as soil organic matter content, soil nutrient content, beneficial insects, weeds, beneficial bacteria, etc.
- To identify green manures which can achieve particular effects for subsequent cash crops

Trials site:

The plan is to carry out the three years of trials (June 2018 - May 2021) on the organic mixed farm of Des Thorpe at Lacken, Enniscorthy, Co. Wexford. The soil on the site for the summer/winter green manure trials 2018/9, which had been grassland for silage, is a sandy loam, pH 5.9, and the nutrient analysis is shown in Table 1.

Table 1. Soil analysis of trial site

Element	Concentration	Index
Phosphorus	0.6 ppm	1
Potassium	40 ppm	1
Magnesium	135 ppm	4
Calcium	1024 ppm	
Manganese	117 ppm	
Boron	0.89 ppm	
Copper	4.9 ppm	
Molybdenum	<0.01 ppm	
Iron	554 ppm	
Zinc	2.5 ppm	
Sulphur	2.0 ppm	
Sodium	25 ppm	
CEC	8.9 meq/100 g	
Organic matter (LOI)	4.4 %	
Organic C	2.6 %	
Total N	2314 mg/kg	

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Department of Agriculture, Food and the Marine

The European Agricultural Fund for Rural Development: Europe investing in rural areas

SUMMER GREEN MANURE TRIAL 2018-2019

The late start of the MOPS project resulted in a delay to the start of the summer green manure trial to late June. The 3000 m^2 site has headlands (consisting of hawthorn, ash, sycamore, elder, brambles, ferns and tussocky grasses) to the S, W and N boundaries, with grassland to the E (Fig. 1). The site was ploughed and cultivated on 26/06/2018. The site was marked out in a completely randomised design as 32 x (9 m x 7 m) plots, 16 plots with winter cabbage as the cash crop and 16 with onion as the cash crop, and four different green manures, with four replicate plots for each (green manure x cash crop) combination. The plots were seeded on 02/07/2018 with a tractormounted Hatzenbichler seeder and rolled.

Summer green manures:

Control (no green manure): weeds were allowed to grow
Buckwheat/phacelia (60/40): 32 kg/ha seeding rate
Rye/phacelia (60/40): 67 kg/ha seeding rate
Persian clover/Egyptian clover/Westerwold's ryegrass (30/30/40): 28.5 kg/ha

The historically hot dry conditions in June/July 2018 following seeding necessitated irrigation using a tractor-mounted sprayer and a slurry tanker, but acceptable levels of green manure establishment were achieved from the three green manure mixes after four weeks (Fig. 1).

Fig. 1. View of summer green manure site, 11/09/2018, facing N. Tall flowering vegetation is the buckwheat/phacelia green manure.

Green manure establishment:

The green manures on the south half of the site grew markedly better than those in the north half. Overall, when the % cover by the green manures was estimated on 11/09/2018, the buckwheat/phacelia green manure achieved the highest ground cover, followed by the rye/phacelia and the clover/ryegrass green manure (Fig. 2). The dominant crop in the green manures differed between the S and N parts of the trial site. In the rye/phacelia mixture, rye (58%) outperformed phacelia (22%) in the low-growth site, but phacelia (42%) outperformed the rye (28%) in the highgrowth rate site. In the clover/ryegrass mix, the Egyptian clover (30%) outperformed the Persian clover (20%) under the high growth conditions, whereas the opposite occurred under the lowgrowth rate site (4% and 24%, respectively). Buckwheat outperformed the phacelia in both the low-(68 and 20%, respectively) and the high-growth rate sites (92 and 5%, respectively).

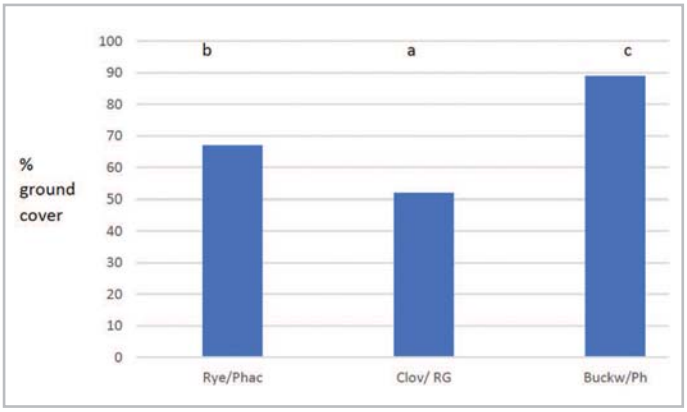

Fig. 2. Percentage ground cover of the three green manure crops after 2 months (11/09/2018).
Any two samples with a common letter are not significantly different (P>0.05).

Weed control:

The main weed species in the trial site were the annuals corn spurrey, fumitory and charlock (from the seed bank) and the perennials dock and perennial ryegrass.

Corn spurrey

Fumitory

Charlock

MAXIMIZING ORGANIC PRODUCTION SYSTEMS

All three green manures achieved significant reductions in annual weed populations, compared to the control plot at 11/09/2018, with the buckwheat/phacelia mix resulting in the lowest weed cover (Fig.3), and a significant negative relationship between green manure % cover and % weed cover. The green manures caused significant reductions in the population sizes of the three annual weeds but had no significant effect on % cover of the perennial weeds.

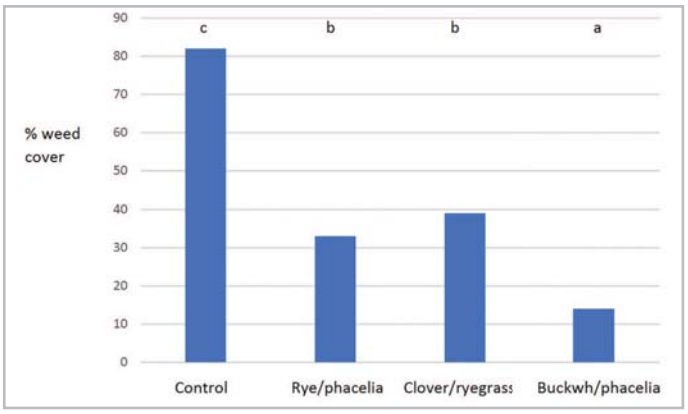

Fig. 3. Percentage weed cover in the green manure plots after 2 months
Any two samples with a common letter are not significantly different (P>0.05).

Beneficial insects:

Common ground beetle

To estimate the density of invertebrates in the different trial plots, 300 ml pitfall traps, each containing 30% ethanol, were set up in each trial plot on 11/09/2018 and the insects trapped collected 48 h later. The main beneficial insects trapped were the ground beetles, which feeds on pest species such as slugs and insect larvae. The number of ground beetles in the different green manures was not associated with the green manure % cover, as the buckwheat/ phacelia mix, producing the highest % green manure cover, harboured the fewest ground beetles, fewer even than the control plots (Fig. 4). Phacelia is usually regarded as a green manure which supports high populations of beneficial insects.

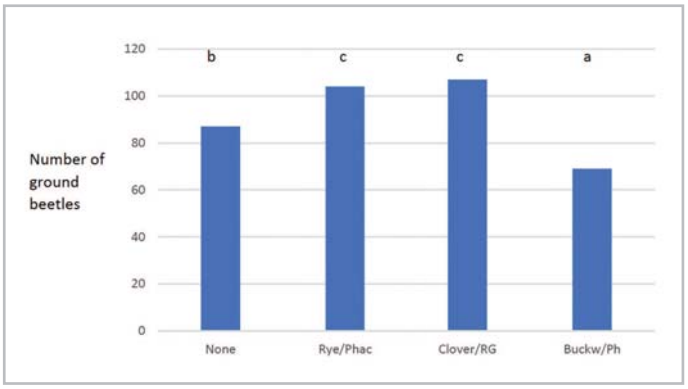

Fig. 4. Number of ground beetles trapped in green manure crops after 2 months.
Any two samples with a common letter are not significantly different (P>0.05).

Bacterial diversity:

Soil samples collected from each plot and from the horizon of the undisturbed neighbouring grassland ("original") were assessed for the quantity and diversity of bacteria, using Community-Level

Physiological Profiling, with Biolog plates. Each 96-well Biolog plate contains three replicates each of wells containing one of 31 different C sources (and control). Suspensions of soil from the different plots were pipetted into each well; after incubation, the development of colour in a well indicates the presence of bacteria in that soil sample which can use the C source in that particular well (Fig. 5). The average intensity of colour over the plate reflects the density of bacteria in the soil (Fig. 6), while Principle Component Analysis of the results (Fig. 7) reflects the functional diversity of the bacteria in each soil sample.

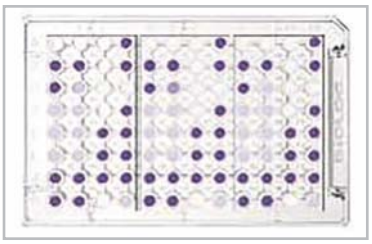

Fig. 5. A developed Biolog plate

Soil samples were collected from each green manure plot on 11/09/2018, i.e. before the green manures were incorporated into the soil. There were clear differences in the total number of bacteria from the different green manures, but the main difference was with respect to the density of pseudomonads, a group of largely beneficial soil bacteria, associated with valuable traits such as pathogen biocontrol and nutrient (e.g. iron) acquisition. All three green manures contained significantly higher densities of pseudomonads than did the control and original plots, with the clover/ryegrass green manure plot containing by far the highest density of pseudomonads (Fig.6). Note that the y-axis (vertical axis) of Fig. 6 is log bacterial density (colony-forming units, cfus, per g soil, so that a difference of 1 on the y-axis represents a 10-fold difference in bacterial density. These effects probably reflect the effect of root exudates from the different plants in each plot. The density of plants in the green manure plots was greater than that in the control plot. The green manure supporting the lowest bacterial density was buckwheat/phacelia (9 x 106), species from plant families (Polygonaceae and Boraginaceae) not commonly found in grassland. The clover/ryegrass mix supported the highest bacterial density (7 x 108), more than 100 x the density in the control plots; legumes, such as the clovers, are known to produce high concentrations of root exudates, largely to encourage N-fixing bacteria to hoe in on the host plant roots.

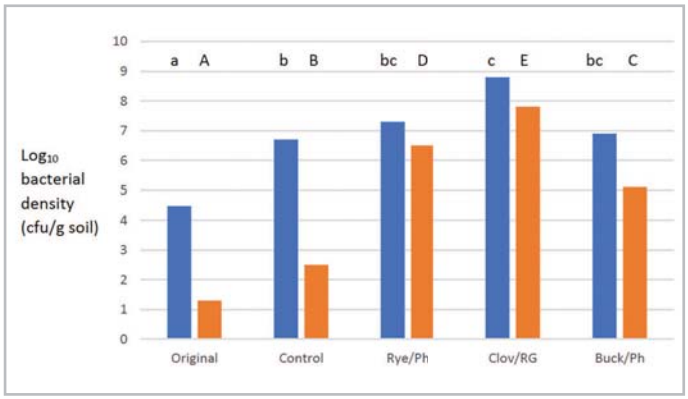

Fig. 6. Effect of different soil sources on log total bacterial density (cfu/g soil; blue) and log total pseudomonad density (cfu/g soil; orange).
Any two samples with a common lower- or uppercase letter were not significantly different (P>0.05).

Functional diversity analysis on the soil samples revealed that the bacteria from the three green manure plots were markedly different from those in the control and original samples. The diversity of the bacteria in the control, original and buckwheat/phacelia plots were similar to one another (Fig. 7), whereas the phacelia/rye and, in particular, the clover/ryegrass plots gave quite distinct diversity signatures, reflecting the results from the bacterial densities (Fig. 6)

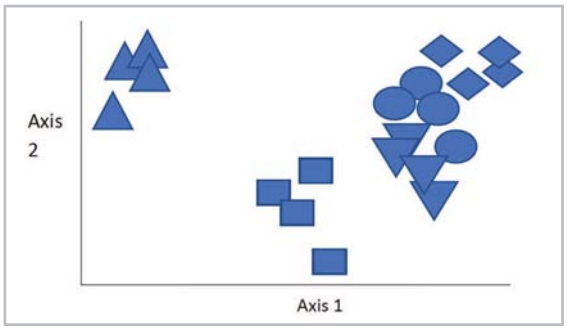

Fig. 6. Principal Component Analysis of Biolog data.
Diamonds: original pasture land; circles: buckwheat/phacelia; inverted triangles: control; squares: phacelia/rye; triangles: clover/ryegrass

Cash crops:

The individual green manure plots (including the control plots) were mulched with a tractormounted Rinieri mulcher, leaving a 0.5 m wide strip along the 9 m length as a refuge for beneficial insects, and incorporated into the soil on 15/09/2018. Granular fertilisers were applied on 15/09/2018 by hand to raise the levels of K (sulphate of potash, 5 kg/plot) and P (rock phosphate, 5 kg/plot) to Index 2. The cabbage plants (cv. Duncan; 28 plants per row, 60 cm inter-row spacing) were transplanted by hand into the S half of the trials site (where green manure growth was better) and the onion plants (cv. Element; 15 cm intra-row spacing, 60 cm inter-row spacing) were transplanted using a Checchi and Magli transplanter on 15/09/2018.

To do:

- Monitor cash crops (survival, feeding damage)
- Carry out soil analysis of the different green manure plots (samples collected and sent for analysis)
- Monitor populations of weeds, beneficial insects
- Carry out crop harvest: assess yield, crop quality, date of harvest.
- Carry out cost-benefit analysis on the different green manures on each cash crop.

WINTER GREEN MANURE TRIAL 2018-2019

The 4000 m^2 trial site was situated directly to the E of the summer green manure trial site, with headlands to the S and N, and was ploughed and cultivated on 05/10/2018. The 32 individual 9 m x 7 m plots (four green manures, including the control, and two cash crops (to be decided), with four replicates of each [green manure x cash crop] combination) were arranged in a replicated randomised block design. The green manures were sown on 08/10/2018.

Winter green manures:

Control (no green manure): weeds allowed to grow
Vetch/crimson clover/Westerwold's ryegrass (30/30/40) (Landsberger): 65 kg/ha seeding rate
Rye/vetch (60/40): 160 kg/ha seeding rate
Squarrose clover/crimson clover/vetch/Japanese oats/wild rye (Wild Atlantic Mix): 100 kg/ ha.