# Demonstration of oat production in diverse environments and management conditions

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## Executive summary

Arable production in Wales currently covers a relatively small area but a number of farmers have expressed interest in growing oats for human consumption, high quality straw for feed and bedding, and for on-farm feeding. Food manufacturers are rapidly expanding their ranges of oat products from the traditional porridge and oatcakes to cereal bars, breads, breakfast cereals and 'oat milk'. The higher protein and oil content of oats mean that they have very high feed value and are a useful replacement for imported soya. This project aimed to demonstrate at a range of scales and locations a number of oat varieties which will explore options for increasing the diversity of cropping systems for Welsh farmers. This project undertook field trials of a number of new varieties of oats under a range of management conditions along with demonstration plots at the Farming Connect Innovation farms at Gogerddan, Trawscoed and at Pwllpeirian at a range of scales. In addition, a range of heritage oat varieties was grown at Gogerddan. A very successful field day was held demonstrating the project to farmers and growers along with a video published on YouTube.

## Introduction

We are faced by an increasing population relying on a limited area of agricultural land, a more erratic climate and crop losses due to plant diseases. The climate emergency has the capacity to cause widespread disruption to global food supplies. Plants are just as susceptible to pathogens as humans are, and recent events have shown we lack resilience in the face of emerging diseases. To increase the resilience and value of cropping systems to rural communities we need to improve agrobiodiversity, identify varieties that perform well in low and high input agricultural systems across environments and develop advanced breeding tools to enable future selection of enhanced novel varieties. Oats have been enjoying something of a revival recently. This is in partly due to their proven beneficial health properties, high feed value and the availability of improved varieties produced by IBERS. Oat

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grains contribute to healthy diets due to high levels of *β*-glucan, which has cholesterol-lowering effects (EFSA[1] and US-FDA approved claims). Oats have also been shown to reduce the impact of chronic diseases such as type 2 diabetes, obesity, hypertension and immune-related diseases. In addition, de-hulled oat grains have a higher proportion of oil (6-12%) and protein (12-20%) than any other cereal as well as a range of unique antioxidants. Oats not only contain high protein contents, compared with wheat, barley and rye, but they contain storage proteins known as avenins which are believed to be less toxic to sufferers of coeliac disease. Oats are thus seen as being safe to consume as part of a gluten free diet, although this is dependent on harvest and processing in an environment clean of other cereals.

Arable production in Wales currently covers a relatively small area but a number of farmers have expressed interest in growing oats for human consumption, high quality straw for feed and bedding, and for on-farm feeding. Food manufacturers are rapidly expanding their ranges of oat products from the traditional porridge and oatcakes to cereal bars, breads, breakfast cereals and even 'oat milk'. The higher protein and oil content of oats mean that they have very high feed value and are a useful replacement for imported soya. Oats are particularly well suited to the marginal cereal growing areas that cover much of Wales; they are good competitors against weeds; they tend to be more disease resistant; and they thrive on low fertility and they fit well into established crop rotations. Traditionally oats were grown on large areas of Wales. In recent years, new varieties of oats have been developed in Aberystwyth along with understanding of the impact of management conditions on grain yield and quality.

Nitrogen fertilisation is a recognised tool for enhancing crop yield, yet nitrogen is potentially a considerable environmental burden in arable crop production. Oats require significantly less

[1] http://faolex.fao.org/docs/pdf/eur112829.pdf

nitrogenous input than other cereals, are considered to be effective sequestrators of nitrogenous compounds, grow well on land less suitable for wheat, and leave less of an ecological footprint when compared with other arable crops. Oats which use nitrogen more efficiently whilst maintaining output would lower nitrogen inputs, reduce the environmental impact of oat production and increase the economic attractiveness of the crop.

This project provided demonstration to farmers on the feasibility of growing oats in a range of different environments and management conditions thus increasing the biodiversity of cropping solutions for Welsh farmers whilst driving innovation and promoting sustainable behaviours at all levels within the supply chain. It also demonstrated the feasibility of growing oats for use as on-farm feed as a sustainable option for example for poultry or ruminants. The project aimed to increase the impact and application of recent scientific advances in the growing and breeding of oats for Welsh farming businesses.

## Methods

The established environmental challenge gradient (i.e. at two sites in Trawscoed and at Pwllpeiran) were used to examine the effects of both variety and environment on establishment, grain and straw yield.

- Site 1 Tygwyn Trawscoed 70 m above sea level, sown 30/4/19
- Site 2 Cwmnewidion Trawscoed 150m above sea level, sown 30/4/19
- Site 3 Cae Bont Pwllpeiran 230m above sea level, sown 29/3/19
- Site 4 Parc Newydd Pwllpeiran 330m above sea level, sown 11/4/19

4 varieties of oats were sown in a replicated plot trial (plot size 6 x 1.5m except site 3 where larger plots were used) at all locations. All varieties used were bred at Aberystwyth

University; Spurtle, Lennon, Galloway and 14355. The latter 2 varieties are both novel low lignin husk type varieties which are very high yielding but contain reduced lignin in the husk which increase their digestibility compared to normal husked oats. Lennon is a naked oat. In addition, at site 3 a diploid oat landrace from Orkney was included. At all 4 sites, black oats (supplied by Olivers seeds) were used as a border. Crops were established using broadcast seed with a seed rate of 470 seeds per $m^2$ at all sites aiming for approx. 400 plants per $m^2$ following rotovation of the land. Fertiliser was included at sowing (sites 1, 2 and 4 382.5g 20:10:10 per plot); site 3 200g K (to correct indices) and 595g 20:10:10 per plot; site 4 180g P per plot to correct indices) and minimal other inputs provided other than a herbicide to control broad leaf weeds. At site 1, a larger scale trial of the variety Galloway was grown for subsequent assessment of its potential for ruminant diets. All plots were monitored for crop establishment, disease incidence (mildew and crown rust), plant height, flowering time, total biomass production at early milk stage and final yield.

At Gogerddan (31 m above sea level) three modern spring oat varieties (Conway, Canyon and WPB Elyann) were grown under 6 nitrogen regimes from 0 added nitrogen to 280kg N/ ha to demonstrate the impact of different management practices. A linear plus exponential model was used to fit grain yield responses to N and the economically optimum N rate (Nopt) was determined assuming the breakeven price ratio to be 5:1 as per the England and Wales Fertiliser recommendations RB209., i.e. the crop yield (kg) needed to pay for 1 kg N. In addition, small demonstration plots were grown of a wide range of oat varieties from ancient to modern including both husked and naked varieties to display the diversity of oats available and the progress made in the breeding programme.

Weather conditions at all sites were monitored using on site automated weather stations. Growing degree days (GDD, °C) and cumulative rainfall at each site were calculated from the day of sowing.

## Results / Discussion

The 4 sites had contrasting weather conditions despite being located geographically in close proximity due to the differing altitude of the selected trials. Site 3 was the wettest site throughout most of the trial (figure 1). Sites 1 and 2 were significantly warmer with 1800 growing degree days (GDD) reached after 125 and 129 days after sowing whereas sites 3 and 4 did not reach 1800 GDD until 148 and 143 days after sowing respectively. Average daily wind speeds were higher however at sites 2 and 4 (figure 3).

Final plant height and panicles per $m^2$ were significantly different between the 4 sites ($p < 0.001$) with the tallest plants at site 1. Plants at sites 2 and 4 were the shortest (figure 4). No significant difference was found between the varieties grown at the 4 sites. Two harvest timings were planned for the trial; the first when the grain reached the early milk stage when the crop would be ready for whole-cropping and a second at grain maturity. Unfortunately weather conditions prevented the final harvest. There was a significant difference between sites in total biomass production (figure 5) with the highest yields obtained at site 3 (11.36 t/ha) but no significant difference between varieties (figure 6). There was a significant difference between the varieties in incidence of mildew with the variety Galloway displaying resistance at all 4 sites. Images were taken of all plots on the 21st June (Figure 8).

Grain yield was determined for the nitrogen response trial conducted at Gogerddan (figure 7). A significant difference ($p<0.001$) was obtained between nitrogen treatments and varieties with the maximal grain yields (6.05 t/ ha) obtained for the variety Conway with no

significant increase in yield beyond an N application rate of 120 kg/ha. Plants grown with no added nitrogen were shorter and had fewer tillers per plant (figure 9).

This project demonstrated the feasibility for growing oats both for whole cropping options and for grain. It would be necessary to repeat the trials in a subsequent year to validate the results obtained. It would also be interesting to sow in the Autumn at all sites to determine the performance of winter oats as an alternative crop for a range of pedo-geographic locations in Wales.

A very successful field day was held on 1st August 2019 with a wide range of farmers and growers attending (figure 10). An 'oat safari' was arranged with visits to all 5 sites including the display of heritage oats growing at Gogerddan. A video displaying results from the project was also produced and published on YouTube:

https://www.youtube.com/watch?v=YjoNBMZyPxs&feature=youtu.be

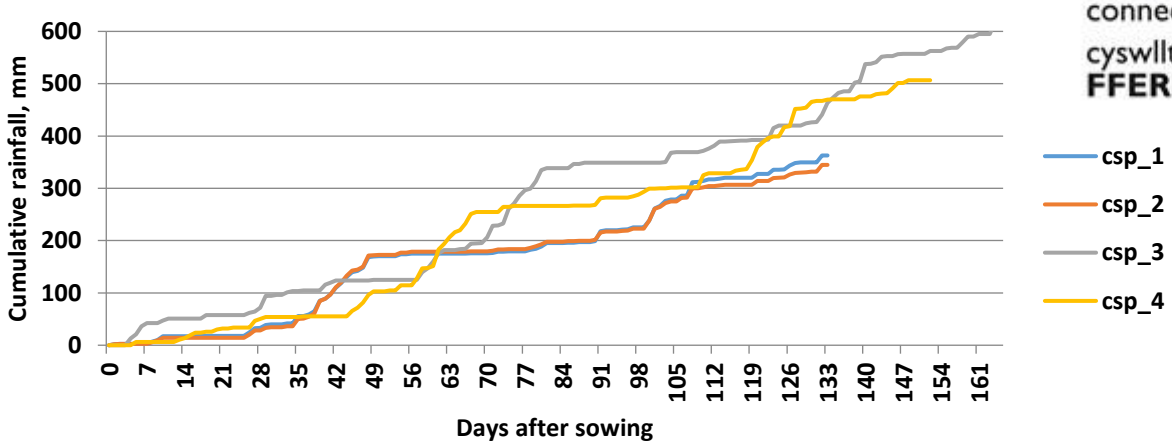


*Figure 1 Cumulative rainfall from day of sowing to final harvest for sites 1, 2, 3 and 4*

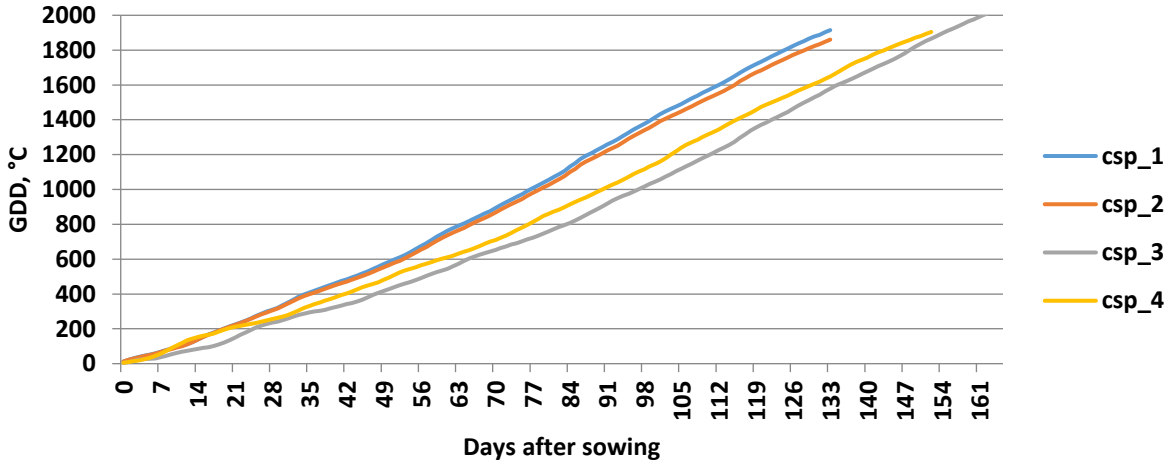


*Figure 2 Growing degree days from day of sowing to final harvest at sites 1, 2, 3 and 4*

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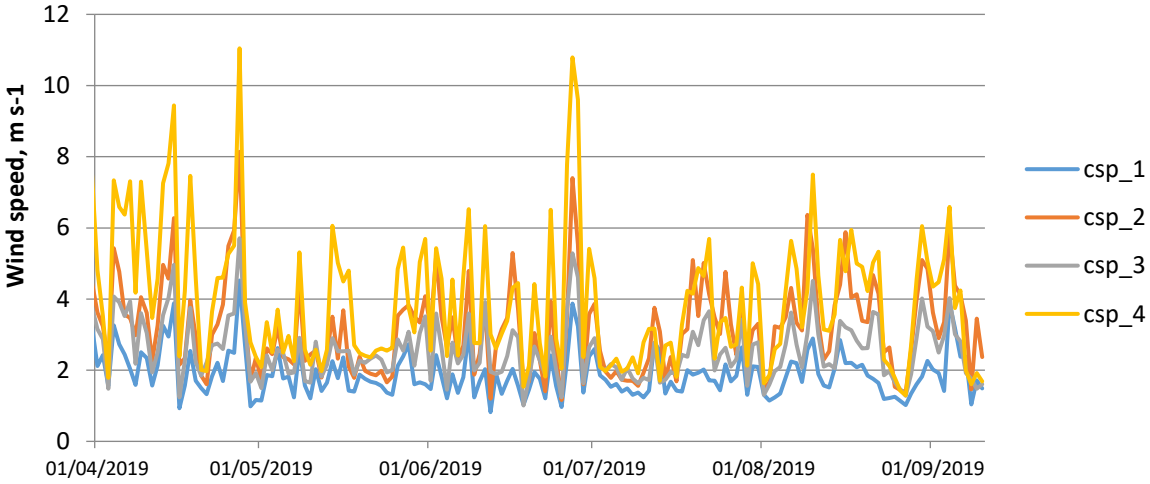


*Figure 3 Average daily wind speed at sites 1, 2, 3 and 4 from 1st April 2019*

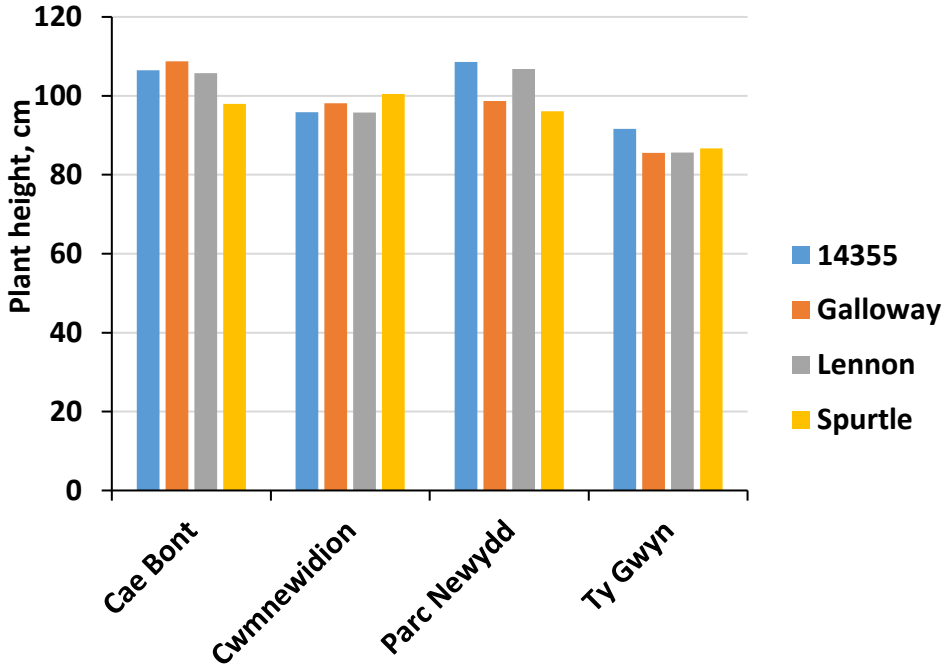


*Figure 4 Plant height at final harvest at sites 1, 2, 3 and 4 for each variety*

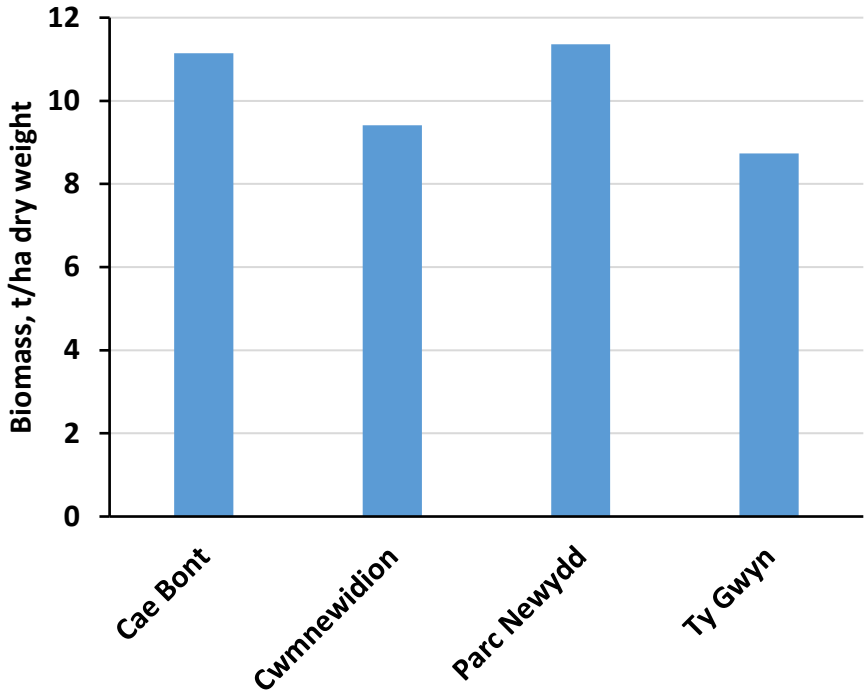


*Figure 5 Total above ground biomass yield at sites 1,2 3 and 4. Whole crop harvested on 16/08/19.*

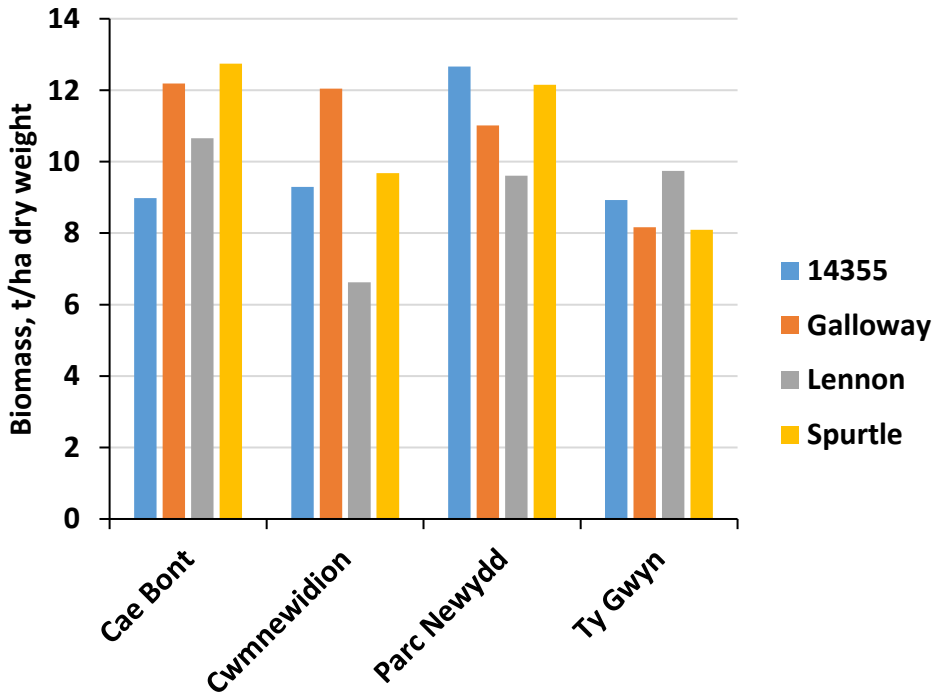


*Figure 6 Total above ground biomass yield at sites 1,2 3 and 4 for each variety. Whole crop harvested on 16/08/19.*

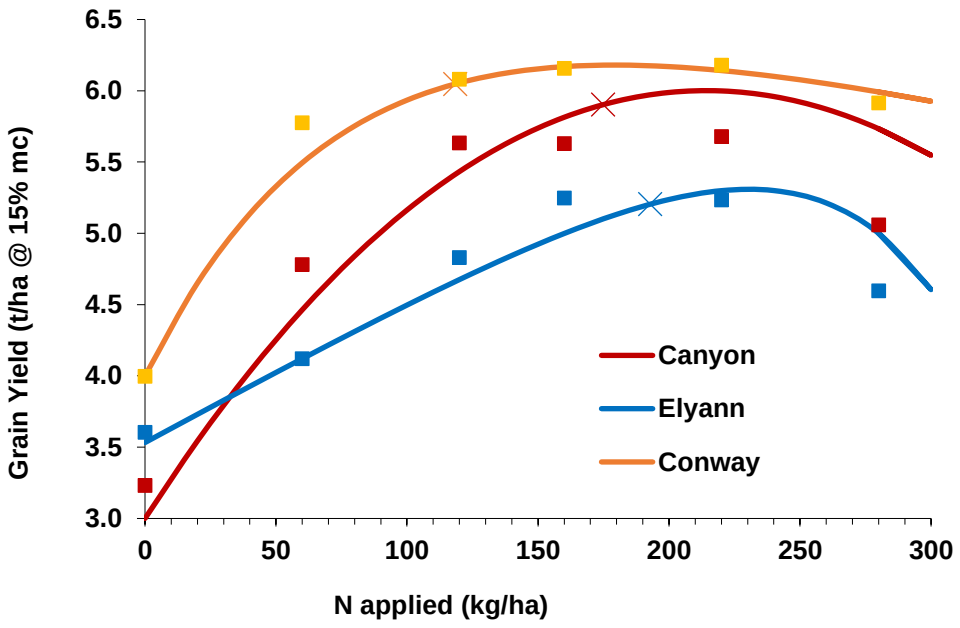


*Figure 7 Effects of N on yield (fitted curves), including yields at optimum N rates (crosses)*

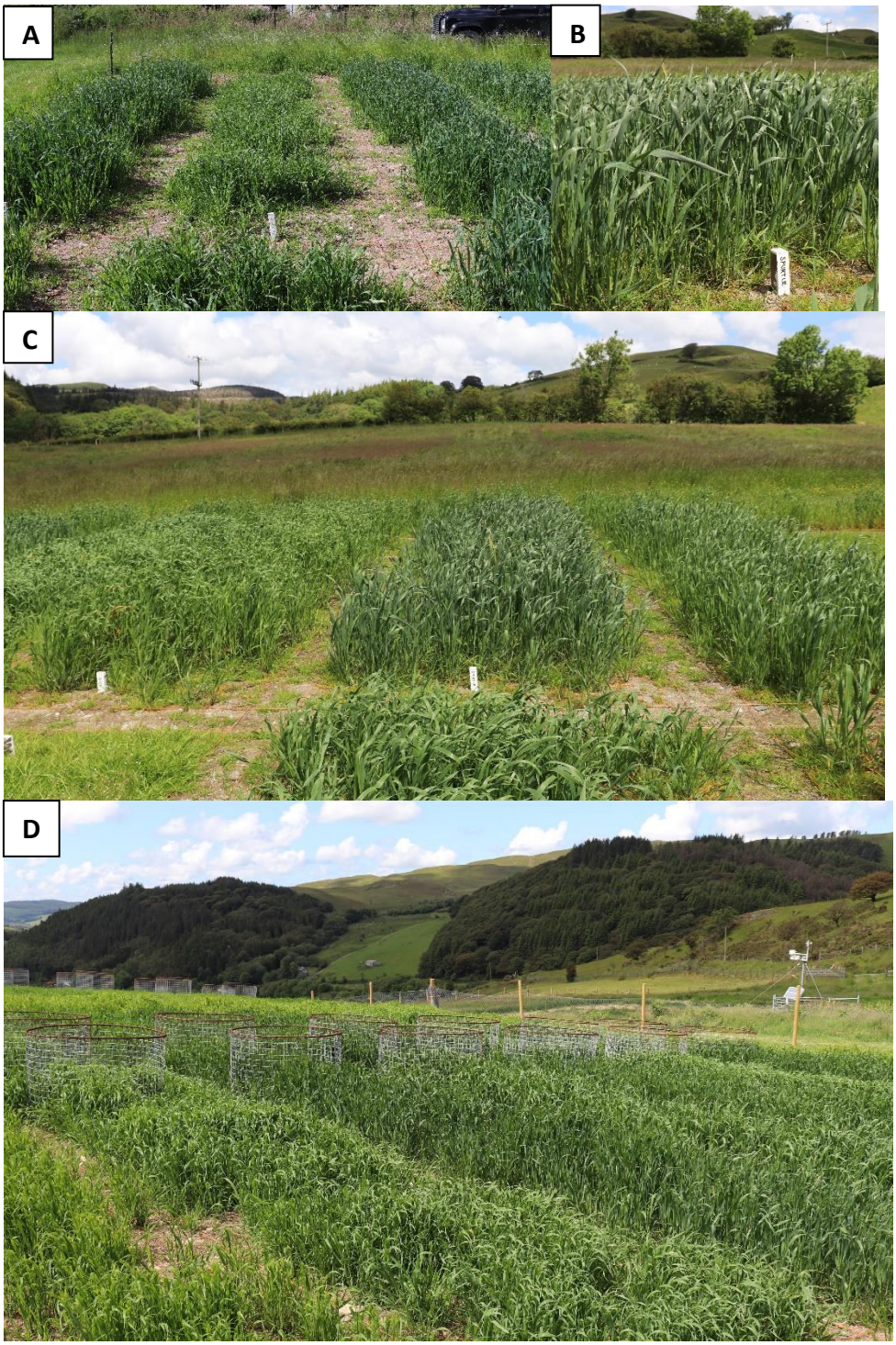


*Figure 8 A. Site 1, B. Close up of Spurtle at site 3, C. site 3, D. site 4. Images taken 21st June 2019*

*Figure 9 Spring Oat Nitrogen Response trial at Gogerddan. 3 plots on LHS at the front have no added nitrogen, 3 plots on RHS at front 280kg N/ha applied*

*Figure 10 Participants at Oat Safari 01/08/19 at site 1*

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