

# Organic Hop Varieties Field Lab

A participatory approach to variety testing and evaluation involving the whole chain



## Year One Report

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## Introduction

### Hops in the UK

At present hop production in the UK faces something of a crisis with declining acreage of non-organic as well as organically grown hops, of which only three growers exist in Britain. UK hop growing is under pressure as a whole from climate change, restrictions in chemical usage and changes in the market where hop flavour and aroma profiles typical of the US West coast hops are more fashionable, with demand falling for the typical British qualities associated with the traditional ales using hops such as WGV, East Kent Goldings, Fuggle and Challenger.

Despite a long history of hop growing in the UK, the climate is particularly challenging for hop cultivation. Furthermore, hops are a challenging crop to grow organically owing to high disease and insect pressures, competition from weeds and low nitrogen availability that cannot be overcome by the use of agrochemicals. Supply of UK organic hops, availability and price are the main barrier to growth of organic brewing in the UK using locally produced ingredients.

Varietal resistance is crucial in the control of diseases and pests but a lack of genetic diversity is one of the main drivers of disease and pest vulnerability in hops, started by a consolidation of breweries and varieties post-WW2 to supply a more commercial beer industry. It is clear, not just for hop production but for many other crops, that with pest, weed and disease resistance to chemicals, the negative environmental impact of fertiliser and pesticide use and with the regulatory banning of many agrochemicals, crop production will need to rely on more integrated approaches using less chemicals and must undergo an agroecological transition (Hill & MacRae, 1996). This presents a challenge to the status quo for both breeders and farmers, making evaluation of varieties under organic and low-input conditions much more relevant as these conditions and the integrated agroecological approach to crop production become more commonplace, with moves to reduce chemical interventions requiring breeding and testing for disease and pest resistance under low input conditions. In fact, many non-organic hop producers already take an integrated approach to pest and disease management and soil health to reduce their reliance on chemical interventions.

Organic hop acreage in the UK is small despite the demand for organic hops being high and may be a result of suboptimal varietal performance and selection due to breeding programmes that focus on high input production and evaluation of varieties under high input farming conditions. Breeding and variety evaluation can play a crucial role in identifying varieties suitable for organic farming. In fact, varietal selection is one of the key decisions for an organic hop farmer. Organic hop growers require better access to information on hop performance within organic systems and hop merchants and brewers wishing to sell and use organic hops need organic farmers to help test new varieties to better understand their qualities under these production systems. For these reasons, a group of organic hops supply chain stakeholders have come together to set up an Innovative Farmers field lab exploring the use of different varieties to overcome production and market challenges.

### Supply chain collaboration

Given the current commercial realities, even small scale organic breeding programmes are not economically viable but, breeding lines and varieties must be screened under organic husbandry to be relevant for organic production. This can be achieved through participatory varietal selection (PVS), to test their resistance to diseases, in environments lacking mineral nitrogen application that can be expected to interact with disease resistance. Resistance to pests particularly the damson hop aphid is also crucial and should be evaluated under organic conditions without the availability of insecticides to help control the pest. Given the reduced

nitrogen availability in organic hop gardens and the increased biodiversity from weeds and natural predators, varietal resistance may be supported by environmental factors. Resilience against pests and disease has been found in lower nitrogen environments (Iskra, 2019), with lower N levels less likely to encourage pests and foliar disease, and resistance to verticillium wilt may also be improved under soils with higher C:N ratios typical of organic sites. Crop immune responses are known to be affected by soil biology with good soil health promoting crop health and mycorrhizal colonization playing a role in plant defence against both biotic and abiotic stress (Jung,2012), necessitating testing in the target growing environments. Hop quality is also affected by growing environments with elevated levels of nitrogen known to improve desirable traits like cone size, resin content and alpha acid levels, with information needed on varieties that can give desired qualities under low input, low nitrogen environments. The PVS process can be expected to provide better information on the Genotype by Environment (GxE) and Genotype by Management (GxM) interactions to identify the best performers for the specific target environments of the farms involved, rather than standard breeding that seeks broad adaption.

It is hoped that connecting members of the supply chain with a shared interest in the continuation and development of organic hops in an integrated way will improve the overall output by combining expertise and fostering collective and shared learning. Farmers cannot operate in isolation of the market and end users, and the market cannot disconnect from the farmers' production and supply meaning by working together the difficulties of the organic hop supply chain are more likely to be overcome. Although there are only three farms growing organic hops in the UK the wider relevance to the hop sector should increase the relevance and impact. In fact, given the low acreage of organic hops the need to support and fund research is even more important as the commercial reality makes organic variety testing difficult and without some support the UK organic hop sector may cease to exist, with this project helping to support the conservation of the sector. Organic hops are high risk and returns marginal but there is a growing demand for organic hops as the wider benefits of organic production are being recognised by consumers. One of the participating growers has stopped conventional production in favour of organic with the ambition that it will attract the required premiums.

### Hop Breeding Process

The process of breeding new varieties is complex and takes many years, starting with thousands of lines that may only lead to one or two commercial varieties. An outline of the overall process from the start to finish can take up to 11 years to produce a commercial variety and is detailed below.

It normally takes at least five years to identify a potential new hop variety and can be a further six years to take it into commerce. The cycle is:

Year 1: Create variety crosses

Year 2: Raising seeds

Year 3: First assessment of individual seedlings (based on resin analyses, and aroma assessment)

Year 4: Mature hop harvesting; yield, plant health and cone shape

Year 5: Selection of potential varieties and propagation of material for commercialisation

Year 6: Planting of small plots

Year 7: Assessment of commercial attributes including suitability for machine harvesting, yield, oil and resin analysis, and disease resistance

Year 8: Assessment of mature plants for habit and pilot brewing trials

Year 9: Propagation of materials for planting on farms

Year 10: Planting on farms

Year 11: Commercial crop

(Source: British Hop Association website)





**Figure 1.0 Photo of Breeding stock at site of Charles Faram Hop Development Programme.**

### Farmer selection

Helping growers to connect to the breeding and development process may not only provide the growers an opportunity to test novel lines they would otherwise not have access to, but can also accommodate grower's requirements and needs from the varieties they seek to grow. It can also open up new market opportunities for breeders, i.e., the supply-chain-based financing model for organic breeding and cultivar testing proposed by the EU LIVESEED project (Rey et al., 2021). Furthermore, the development process can also benefit from the grower's knowledge and expertise in making successful selections with examples in the literature of improvements to varietal development being made by involving farmers directly in a process known as participatory plant breeding (PPB) (Tiwari, 2009). Overall, through either the PPB or PVS approaches, participatory crop improvement (PCI) can be developed as a complement to formal crop improvement (FCI). Successful PVS has four phases according to Witcombe et al. (1996):

1. A means of identifying farmers' needs in a cultivar,
2. A search for suitable material to test with farmers,
3. Experimentation on its acceptability in farmers' fields, and
4. Wider dissemination of farmer-preferred cultivars.



By engaging the growers, phase one has been addressed (see stakeholder perspectives), and by engaging with the Charles Faram Hop Development Programme (CFHDP), phase two has also been addressed but remains an ongoing activity. Phase three will take place through the life of the project and phase four will be an output.



**Figure 2.0. Photo of Grower, John Walker, at CFHDP nursery inspecting a breeding line selected by him for testing**



**Figure 3.0 Photo of Hop research agronomist Peter Glendinning demonstrating differences in phenotype and talking about important traits including height and vigour.**

## Aims

The aim of the field lab is to secure and improve availability and choice of UK grown organic hops through the following set of primary objectives;

- Bring together key stakeholders in the organic hops supply chain including breeders, merchants, growers and brewers to address the issues collectively.
- Identify varieties and breeding lines suitable for organic production and test these in field trials in commercial organic hop gardens.
- Assess hop variety characteristics and qualities for brewing through lab analysis and brewing tests
- Raise awareness of the challenges of UK hop growing through field lab KE activities, engaging consumers through a parallel marketing campaign involving a collaboration with River Cottage and their Food to Inspire Change partnership

Secondary objectives depending on field lab development include;

- Propose and test management strategies to improve organic UK hop production e.g., companion planting, planting density, and varietal mixtures.
- Compare organic and conventional hop growing systems in terms of soil health, carbon and biodiversity

## Methods and Materials

### Group details

The group is made up of key stakeholders in the organic hops supply chain looking to address the challenges of production and market supply, with two organic hop growers, an organic hop merchant and breeder and an organic brewery working together to maintain organic hop production and supply in the UK.

**Table 1.0 Field Lab Group membership details**

Name	Organisation	Role
Greg Pilley	Stroud Brewery	Group co-ordinator and Brewer
Will Rogers	Charles Faram	Hop Merchant/Technical expert
Peter Glendinning	PGhops/Charles Faram Hop Development Programme	Research Agronomist
John Walker	Tedney House Farm, Worcestershire	Grower
Tom Upton	Lowergate Farm, East Sussex	Grower
Dominic Amos	Organic Research Centre	Crops researcher

### Stakeholder perspectives

#### **John Walker, Tedney House Farm;**

“Organic hops are a real challenge. They are not very reliable and although we get a decent premium, you get a lower yield. Pests and disease are a real problem, the main ones being damson hop aphids, downy and powdery mildew, Verticillium Wilt and two-spotted spider mite. The varieties I am trialling are all resistant to aphids and we hope Verticillium Wilt, but I am hoping

to have an ongoing programme of trials as we need to find more than one variety. Brewing trials will be done as we go along to make sure that they have a desirable flavour in the beers.”

John would like to add new varieties to his existing ones and looks primarily for disease resistance in his dwarf hops but also at the phenology for a range of harvest dates with earlier varieties generally preferred. Another trait John looks for is good vigour to offer competition with weeds. The current farm variety Sovereign is reliable but has a short harvest window and if picked early doesn't have the right brewing characteristics. Trial varieties were selected by John from the breeding lines at Charles Farm hop development programme nursery, for disease resistance, vigour and cone characteristics.

### **Tom Upton, Lowergate Farm;**

Tom is looking for a replacement for his current farm variety Challenger which is a challenge to grow under conventional systems due to a lack of downy mildew resistance and vulnerability to late season powdery and sensitivity to Verticilium wilt. Challenger does offer a very sought after classic British flavour and is versatile both for bittering and aroma, which is a characteristic required in at least one replacement variety. Whilst a Challengeresque flavour would be beneficial, as New world citrus and berry aromas continue to dominate the market an easy growing disease resistant and reliably cropping hop is required to ensure that organic tall hops can fulfil as much of the market demand as possible. In short, disease resistance, aroma and yield are the main characteristics which are sought in future varieties.

### **Greg Pilley, Stroud Brewery;**

Stroud Brewery is a dedicated organic brewery supporting organic farming of barley and hops but is finding increasing difficulty contracting and sourcing a sufficient supply of UK grown organic hops. At present 30% or less of the organic hops used in their beers are UK grown. The shrinking acreage of organic hops limits supply and increases demand and hence price. The brewery hopes that cooperation with the farmers and hop merchants through the field lab to test and identify suitable organic hops for growing and for beer making may help secure a supply of homegrown high quality organic hops. It may also help to increase supply as suitable varieties produce higher and more consistent yields and identification of suitable varieties may encourage the uptake of more organic and low-input hop growing.

Hops are only a small contribution (by weight) of the makeup of a beer, so are not a significant contribution to the carbon footprint of our beers but organic hop production has wider benefits, including biodiversity and less pollution and with non-organic production subject to ever tighter regulations on pesticide usage, agroecological growing methods are becoming ever more relevant.

“In terms of brewing qualities, we are looking for good value organic bitterness, from any origin but ideally if we can source this from the UK, buying local and supporting the benefits of organic farming here, this is more desirable for us. Whilst we do source a lot of our organic hops from all over the world; America, Europe (Germany, Spain, Czech Republic), and New Zealand, our preference would be to use more British grown hops. We are also looking for unique flavours and aromas to help us differentiate our beers. We are after significant levels of flavour and aroma, so that they simply manifest in our beers. Testing new varieties that may not be cultivated by the conventional sector may lead to unique organically grown varieties with their own flavour profiles that provide both a USP for the brewery's beers and for the farmers who may find increasing demand for their unique hop varieties.



By collaborating as a supply chain, we are aiming to identify varieties that farmers can grow more confidently, and as a brewer I would like to have regular UK supplies of organic hops. There is also a huge variety of flavours to tap into, which could help British brewers create more distinctive products.”

**Peter Glendinning, Charles Faram Hop Development Programme;**

Now that we have genuinely aphid-resistant hop plants (the first step in avoiding regular catastrophic crop losses), and a more enthusiastic market, I agree we can usefully start delving deeper into the whys and wherefores of genuinely sustainable hop growing. Like other crops, but especially for hops, it all starts with a resilient healthy soil, one that can cope with a plant demanding to double its dry matter in the month of August.

Traditional hop growers have always had to utilise various cultural (non-chemical) techniques to assist in crop protection, but historical pressures forced a combination of variety choice and growing methods (involving chemical interventions) which have long been the subject of research projects. Almost all such research over the last 30 years has been privately funded by British hop growers, all fifty of us! We have been concentrating our efforts into breeding new resistant varieties at Wye Hops, which has given us world-firsts in resistance to both aphids and wilt disease, as well as developing naturally dwarfing plants suitable for growing on low trellis wirework. As we explained, our Charles Faram Hop Development programme is complementary to our national efforts and has succeeded in disproving the old adage that high impact (so called ‘American hop aroma’) cannot be grown here in our maritime climate. It is most encouraging that our new varieties have been breaking new ground in the marketplace and can reward growers better for their efforts.

I believe all hop growers would prefer not to have to rely on chemical interventions to grow a clean crop, and most are constantly looking at ways to grow hops in a more ‘bio-logical’ if not certified ‘organic’ way.



**Will Rogers, Charles Faram Hop Merchants;**

“In its heyday in 1865, there were 77,000 acres of UK hops being grown, but now it is less than 2,000, and we are down to about fifty growers and 25 varieties. At Charles Faram we’re a grower-owned hops breeder, which sells about 70% of the UK’s hop crop. It is a very specialist crop to produce and currently for organic farmers we expect at least a 40% crop loss over five years. The lack of diversity is also limiting flavours for brewers. The company is receiving a growing number of enquiries about organic hops, particularly from craft brewers, but currently most organic hops are imported, particularly from Belgium, Germany, and New Zealand. We see an opportunity for organic hops in the UK but also for export. There are some markets, France in particular, where organic provenance is booming.”

**Figure 4.0. Photo of Will Rogers and Peter Glendinning of Charles Faram hop development programme discussing breeding lines.**

## On-Farms Trial sites

There are only three organic hop growers in Britain with two of them taking part in the variety trials.

Farm one, Tedney House Farm, farmed by John Walker, grows 6ha of organic and 1ha non-organic dwarf hops and is located near Clifton upon Teme, in the Teme Valley on the Herefordshire, Worcestershire border on clay loam soils with moderate to high fertility with parts of the farm also located on silty loam floodplain soils of the river Teme, where the hops tend to be grown.

Farm two, Lowergate Farm, farmed by Tom Upton, grows 2ha of organic tall hops and is located near Rye, East Sussex on clay loam soils with moderate fertility.

## Varieties

The following list of varieties was selected by the growers in collaboration with hop breeders for evaluation in on-farm trials.

Plants for trial were sourced from [Wye Hops Ltd and British Hop Association](#) (BHA) breeding programme bred by Dr Peter Darby and from the [Charles Faram Hop Development Programme](#).

**Table 2.0 Hop varieties tested at Tedney House Farm, Worcestershire**

Variety	Bred By	Description
Sovereign	Wye Hops	Control – Developed by Dr Peter Darby at Wye College, a hop in the “classic English style”, shows good all-round disease resistance and excellent yield potential
Merlin	Wye Hops	Trial variety from Wye Hops
42/10	Wye Hops	Trial breeding line from Wye Hops
65/2011/24	Wye Hops	Breeding line selected by grower from Charles farm nursery plots at CFHDP nursery
64/2011/26	Wye Hops	Breeding line selected by grower from Charles farm nursery plots at CFHDP nursery, high alpha acid content
12/2016/45	Wye Hops	Breeding line selected by grower from Charles farm nursery plots at CFHDP nursery, seedling of Fuggle with good aroma
Endeavour	Wye Hops	Dwarf hop from Wye breeding program, resistant to powdery mildew and tolerant of wilt

**Table 3.0 Hop varieties tested at Lowergate Farm, East Sussex**

Variety	Bred By	Description
Challenger	Wye Hops	Control - high yielding dual-purpose variety from Wye breeding programme released in 1972, good resistance to Downy Mildew but is susceptible to Powdery Mildew and Verticillium Wilt
Harlequin	Charles Faram	CFHDP selection, new aroma variety with high alpha acid selected for its aroma, disease resistance and yield.
Progress	BHA	Developed by Wye as a replacement for Fuggle and has similar characteristics. A variable yielding aroma

		variety susceptible to Downy and Powdery Mildew but shows a high degree of tolerance to Verticillium Wilt
Pilgrim	BHA	Dual purpose hop developed at HRI Wye and released in 2000, has a vigorous growth habit and provides a high yield, with good resistance to both powdery and downy mildew, and one of the most wilt resistant varieties
404	Charles Faram	Breeding line - new CF aroma lines
3294	Charles Faram	Breeding line - new CF aroma lines

## Assessments

### Field observations

On farm trials commencing Summer 2022 will seek to utilise grower observations in order to provide hard data on varietal traits. The following data will be recorded;

- Phenology; Crop growth stage at key timings, ripening date and harvest window.
- Vigour; Early season vigour assessed visually as days to reach top wire.
- Disease resistance; In comparison to farm control varieties, identification of foliar disease symptoms and severity assessment.
- Pests; In comparison to farm control varieties, identification of pest presence and damage assessment.
- Yield; At harvest, fresh weight of cones per unit area, to compare productivity of the varieties under evaluation in comparison to their control variety.

### Quality evaluation and Lab analysis

Hop cone samples from the best performing varieties from the on-farm trials will be sent for analysis of key quality attributes. Standard hop cone qualities will be assessed in the lab by Charles Faram to determine end use quality characteristics for brewing. Specific traits to be measured are alpha acid content and an olfactory analysis.

Advanced quality analysis to be carried out by the US lab HopTechnic with beta acid content, cohumulone, oil composition, total oil and flavour intensity with a complete oil profile analysis on the varieties identified from the field trials with most potential for organic cultivation. R&D into flavour compounds in hops has identified key oils linked to particular desirable flavours that the full oil profile provides.

### Test Brewing

It is important to integrate the agronomy and suitability of the hops for organic production with their end use market linking field performance with brewing performance. Charles Faram will carry out brewing trials with experimental varieties to compare with control varieties and assess brewing qualities, through small batch brews of 50L requiring approximately 200g of hops.

Stroud Brewery will carry out test brews using the best varieties identified from each farm trial based on agronomic performance and hop quality indicators. The minimum requirement for a test brew is fifty litres requiring approximately 150g of dry hops in the brewery's small batch pilot brew kit. A yield of 300g will allow one hundred litres production and possible canning of the product.



## River Cottage Collaboration

Varieties identified through the field suitable for organic with commercial potential will be used in a collaborative brew for River Cottage as part of the *Food to Inspire Change* partnership of organic food producers.

## Preliminary Results

### Field observations

The following observations were made by the growers following visits to CFHDP nursery and from assessment in on-farm trials at Lowergate Farm.

**Table 4.0 Hop variety observations, Tedney House Farm selections 2021**

Variety	Comments 2021 season
Sovereign	Control
Merlin	Showed high levels of powdery mildew. Debating removing. Initially planted ½ acre then added four following the season. Regretted planting the additional without a proper trial
42/10	Showed signs of powdery mildew with low vigour
65/2011/24	Promising, vigorous, generally free from disease although some late season powdery mildew observed on some cones leading to premature ripening and some cone breakage
64/2011/26	Early signs of powdery mildew but infection did not take hold
12/2016/45	Wilt susceptible and discarded from the trial – deselected from the development programme due to susceptibility to wilt and powdery mildew
Endeavour	Replaces 12/16/45 as a disease resistant dwarf type almost immune to powdery mildew and very tolerant of wilt but may have problems with late season downy mildew and aphids.

**Table 5.0 Hop variety observations, Lowergate Farm selections 2021**

Variety	Comments 2021 season
Challenger	Control
Harlequin	Growth was moderate with 50% reaching eight foot in height. Precocious moderate crop harvested by hand from the strongest plants totalling 1kg. Disease resistance was excellent some red spider mite evident but dealt with via bio control
Progress	Failure of most crowns to climb up the strings suspect waterlogging of the crowns. Crop failure - cured with ditching
Pilgrim	Early season downy mildew infection from the crown which persisted all season due to the weather some cones produced but uneconomical to harvest.
404	Early infection of downy but rapid response in growth. Very vigorous with bold cones weighing well
3294	Weak growth, poor crop. Not optimistic for its suitability but will commit to trial for three years.

## Brewing sample results

A sample of Harlequin was collected from Lowergate Farm at harvest 2021 for Stroud Brewery to carry out a test brew. Currently awaiting the brew, to be sampled at the Great Beer Debate during the Oxford Real Farming Conference (ORFC), January 2022.

## Summary

This report details the preliminary year of the field lab set up and development in 2021 ahead of field trials conducted over the next two years until harvest 2023. It presents the current state of hop production as well as issues associated with organic and low input hop growing, including lack of access to relevant information and suitable varieties as well as the steps stakeholders in the organic hop supply chain are taking to address these issues.

Using a Participatory Variety Selection approach involving the whole supply chain, a field lab has been set up to help two organic hop growers find suitable varieties for organic farming showing desirable agronomic traits as well as the hop characteristics required from the market. The participatory approach enables evaluation within target environments seeking to find the most appropriate varieties for the farm rather than conventional breeding seeking broad adaptation to non-organic production systems. Hop merchants Charles Faram have set up a Hop Development Programme seeking to find the best hops for growers and for the market with Stroud Organic Brewery conducting test brews to confirm suitability for brewing.

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## Appendix

### Publicity

One of the aims of the project was to inform and raise awareness of the challenges of hop growing in the UK. Despite having a long tradition of growing hops, drinkers will have little knowledge of these challenges despite the loyalty to UK beers and brewing.

The project has gained a good deal of interest with the publicity gained to date detailed below:

Hops variety field lab [press release](#) - June 2021

BBC Farming Today report <https://www.bbc.co.uk/sounds/play/m000z6fq>

Dan Isles account of Farm and Nursery Visit - 09/07/21. [Photos and videos posted on twitter](#)

Organic research centre blog: <https://www.organicresearchcentre.com/news-events/farmers-collaborate-to-find-hop-varieties-for-the-growing-organic-beer-market/>

Agronomist and Arable Farmer: <https://www.aafarmer.co.uk/agronomy/farmers-collaborate-to-find-hop-varieties-for-a-growing-sustainably-produced-beer-market.html>

Punchline (Gloucestershire): <https://www.punchline-gloucester.com/articles/aanews/stroud-brewery-inspires-change-with-new-river-cottage-beer-range-gloucestershire>

Beer Today: <https://beertoday.co.uk/2021/07/13/stroud-brewery-river-cottage/>

SIAL: <https://newsroom.sialparis.com/topics/organic-wellness/farmer-brewer-hops/>

Farming UK: <https://www.farminguk.com/news/farmers-explore-hop-varieties-for-sustainable-beer-market-58451.html>

Waitrose Weekend