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Focus Site Project Review

Exploring the use of wood chip mulch for weed control in organic vegetable production at Square Farm, Monmouth

Prepared by:-

Helen Ovens/Zoe Morgan

ADAS

Unit 10D

Cefn Llan Science Park

Aberystwyth

SY23 3AH

Tel: 01974 847004

Email: helen.ovens@adas.co.uk

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Cronfa Amaethyddol Ewrop ar gyfer Datblygu Gwledig:
Ewrop yn Buddsoddi mewn Ardaloedd Gwledig
European Agricultural Fund for Rural Development:
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Llywodraeth Cymru
Welsh Government

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1 Summary

1.1 Farm Background

Square Farm is a family-run business established in 1978 focusing strongly on traditional farming methods. The business includes a flourishing farm shop selling home-grown, organically produced foods as well as an expanding range of selected local produce from the Wye Valley and surrounding area.

Square Farm operates as a traditional mixed farm incorporating cattle, sheep, pigs, chickens, ducks, and geese. Cereal and root crops are grown for animal feed and an increasing number of vegetable crops are produced to stock the farm shop. The shop also sells home grown traditionally reared beef, lamb, and pork alongside eggs from a flock of 200 unrestricted, free-ranging poultry.

Organic farming principles are fundamental to the Square Farm system. Land management policies have been devised, incorporating the successful Glastir land management scheme at entry level and advanced level, with plans in place to further increase the diversity and habitat management for wildlife. In recent years more than 400 metres of new hedgerows, consisting of British native plants, have been created, while three small orchards have also been established using traditional fruit trees.

Vegetables are grown to supply a delivered box vegetable scheme including fresh kale, purple sprouting broccoli, carrots, leeks and potatoes. A new venture is the planting of asparagus to be grown organically and supported by a successful European Innovation Programme (EIP) bid. The farm is also a member of an EIP group evaluating the use of a computerised robotic weeding machine.

Business Aspirations

To produce and sell organic food using traditional farming techniques.

To increase biodiversity on farm, and increase the habitats available for wildlife

To reduce reliance on labour for weed control by exploring alternative methods including mulches, robotic weeding, camera guided weeding and mechanical weeding.

1.2 Project Background

The aim of the project was to assess whether the use of waste wood chip from local tree surgeons could be used to suppress weed growth in organically planted vegetables.

Unlike uniformly textured sawdust and bark mulches, arborist wood chips include bark, wood, and often leaves. The chemical and physical diversity of these materials resists the compaction often found with the use of sawdust and bark mulches. This diversity is thought to promote better performance in terms of moisture retention, temperature moderation, weed control, and sustainability. Arborist wood chips are also available free of charge making them an economically practical choice.

Additionally, the materials vary in their size and decomposition rate, creating a more diverse environment that houses a range of microbes, insects and other organisms. A biologically diverse soil community is more resistant to environmental disturbance and will in turn support a diverse and healthy plant population. Wood chips are considered to be slow decomposers, as their tissues are rich in lignin, suberin, tannins, and other complex natural compounds. Thus, wood chips supply nutrients slowly to the system; at the same time they absorb significant amounts of water that is slowly released to the soil. Wood chip has been cited as superior mulch for enhanced plant productivity.

The mechanism(s) by which wood chip prevents weed growth are not fully understood, but likely includes light reduction (preventing germination of some seeds and reducing photosynthetic ability of buried leaves), allelopathy (inhibiting seed germination), and reduced nitrogen levels at the soil-mulch interface (reducing seedling survival). Using locally produced wood chip also helps generate short supply chains, and the reuse of waste plant materials as mulches keeps them out of landfill.

Focus Farm Project key objectives:

1. To determine whether locally sourced arborist wood chip can be used as an effective weed suppressant in horticultural crops
2. To determine whether the wood chip mulch would have any effect on crop vigour. An improvement in crop vigour would suggest benefits of weed suppressions as well as improved moisture retention. Adverse effects would suggest soil nitrogen levels being depleted by the high C:N (carbon to nitrogen) ratio of woodchip.
3. To estimate the financial cost of hand hoeing, and compare that to the use of applying a woodchip mulch, assessing any cost savings made.

1.3 Project Conclusions

Summary of conclusions.

Arborist woodchip can be used effectively as a long term weed control mechanism in horticultural crops grown from transplants.

The cost of hand hoeing to control weeds in organic crops is high. These costs can be avoided through the use of mulch.

Crop vigour was maintained, suggesting the mulch did not compete with the crop for nitrogen. However, for annual crops, the mulch would generally be incorporated with the crop trash after harvest, and would be expected to compete for nitrogen with subsequent crops. Measures to ensure crop vigour does not reduce due to poor nitrogen uptake would be required.

Mulches are likely to be particularly cost effective for perennial vegetable production, where the soil is not disturbed for a number of years.

1.3.1 Effective control of weeds and a reduction in labour costs

The trial did show that woodchip mulch applied to transplanted vegetable crops gave good weed control for a long period. Transplants offer a reduced crop establishment period when crops are vulnerable to weed competition compared to direct sown crops. **Therefore combining the use of transplants with mulching provides an effective weed control plan.**

The celeriac and the purple sprouting broccoli (PSB) mulched plots both showed **useful suppression of weeds** at the 4 September and the 12 October recordings. On 4 September, both crops showed a similar level of weed cover and weed suppression, with both celeriac and PSB having 5% weed cover in the mulched lots, and around 13% weed cover in the control plots.

On 12 October, celeriac had developed much higher weed cover than PSB, which would be expected due to PSB being competitive against weeds while celeriac is not. Mulching did however result in reduced

weed cover in both crops. Mulched celeriac had a weed cover of 20%, compared to 73% in control plots, while mulched PSB had a weed cover of 6.25%, compared to 15% in control plots.

1.3.2 Effects on Crop Vigour –the pros and cons of incorporation

In the celeriac the mulch increased the crop vigour slightly and there was no recordable suppression in vigour in the PSB. This confirms the **mulched plots did not deplete the soil nitrogen levels by upsetting the carbon nitrogen balance, perhaps because the mulch was not incorporated into the soil.** The mulch as an undisturbed layer did not appear to compete for nitrogen with the crop.

For annual crops, the mulch would generally be incorporated into the soil with the crop trash after harvest. As a result, you would expect to see a reduction in crop vigour in the following season due to the high C:N ratio of woodchip locking up nitrogen. This could be mitigated by using permitted manures or by growing a leguminous crop as part of the rotation. Eventually the tied up nitrogen would be slowly re-released and so could provide nitrogen for subsequent crops. For perennial crops, mulches would not be incorporated, and so there would be no issue with locking up of nitrogen.

It is likely that the reduced weed cover and improved moisture retention in the mulched celeriac plots contributed to improved crop vigour. The weed cover in the unmulched celeriac plots was very high on 12 October, with risk of the crop being lost in the weeds. Moisture retention was also of particular benefit due to the dry conditions experienced during the growing season.

It is worth considering that for the purposes of this study, no weed control was carried out on the control plots.

Therefore, if the improvements in crop vigour seen in the mulched plots are associated with weed burdens, then it is likely that mulching may not improve crop vigour where it is compared with a crop managed with an alternative weed control mechanisms such as hand hoeing.

1.3.3 Improvements in soil biological activity

The mulched plots showed an increase in biological activity, including earthworms and fungi. Improved biological activity in the mulched plots suggests that mulching is beneficial to soil health. Earthworms are known to improve soil structure, and earthworm numbers are widely used to assess soil health, with more earthworms being found in healthier soils. The increase in biological activity seen also suggests that the woodchip did perform as expected in terms of providing a diverse environment for microbes and other organisms. This will result in a more resilient soil ecosystem, which is better able to cope with adverse environmental conditions. It also meets Square Farm's goal to increase diversity on the farm, and provide habitats for wildlife.

1.3.4 Financial cost of hand hoeing

The reductions in weeds seen were sufficient that other methods of weed control could be reduced or totally avoided. On organic farms, including Square Farm, the main alternative method for weed control is hand hoeing, therefore mulches allow the business to become less reliant on labour. There are issues in meeting the constant demands for labour to control weeds, as well as a high cost associated with manual weeding. In a conventional system, mulching could be used to reduce the herbicide applications required. Mulching could also be used as part of a weed control strategy for integrated pest management.

The exact cost of hand hoeing any particular crop when used as the sole method of weed control is hard to predict. The weed cover will determine how often hoeing is required, and how long it will take to hoe a given area. Different crop types will take differing amounts of time to hoe, and be variably susceptible to weeds.

The experience of the person carrying out the hoeing will also effect the time taken. However, the costs of hoeing an area once were estimated at £315/ha for french beans, £405/ha for beetroot and £262/ha for PSB. (All costs based on the National Living Wage of £7.50/ hour).

Hoeing would generally need to be carried out twice or three times over the course of the growing season, depending on the severity of the weed burden. Based on these assumptions, carrying out weed control by hand hoeing could cost between £524/ha (based on PSB hoed twice) and £1,215 (based on beetroot hoed three times) each year.

As arborist woodchip is available as a free waste product, the only cost associated with its use is the cost of application. In this trial, woodchip was applied by hand from a loadall bucket, but if the application of mulch became routine, this could easily be mechanised by using a rear discharge manure spreader. Mulch would generally be applied only once per season, or potentially less frequently where it is possible to leave the mulch in situ between crops. **Therefore the cost of mulch spreading will be minimal in comparison to the cost of hand hoeing multiple times a year.**

Mulching also helps to alleviate the reliance on labour. Availability of labour is a limiting factor to effective weed control at Square Farm, and mulching can help to meet the farm's goal of reducing reliance on labour.

2 Project Review

2.1 Methodology

Mulch was applied to recently planted vegetables before weeds were established. The vegetables had been established as transplants. Locally sourced woodchip as a waste product from tree surgeons was used for the mulch. As the farm is organic, it was necessary to confirm the woodchip came from non-sprayed trees. A source of local woodchip was easily located with an internet search and was delivered to the farm.

Crops chosen were Purple Sprouting Broccoli (PSB) and Celeriac -both long term crops, with PSB being a strong competitor against weeds and Celeriac being non-competitive

1. Wood chip mulch 50mm depth
2. Control – no mulch

Plot lengths were 3m long and replicated 3 times across the growing area.

Woodchip was applied by hand from a loadall bucket for the purposes of this trial, on a larger scale it could be easily mechanised with a rear discharge manure spreader for larger areas. The woodchip was applied on the 13th August 2018 to a depth of 50mm of fresh material. After applying mulch the plots were walked to make sure the transplants were not buried.

The plots were recorded on the 4th September 2018 and again on the 12th October 2018. Records were taken of the % weed cover, the weed species and the effect on crop vigour, the latter on a 1-5 scale with 1= Poor and 5= Strong

In order to get some guidelines on likely cost savings timed hand hoeing was carried out at Square Farm by Chris Creed and Elysia Bartel of ADAS, both experienced in organic systems and hand hoeing. The annual cost of weed control through hand hoeing is likely to be greater than this, as hoeing would generally be required more than once in the duration of the crop.

2.2 Results

2.2.1 Trial plots data

The weeds grew strongly on the non-competitive celeriac, with unmulched plots getting to 73% weed cover by 12 October with risk of the crop being lost in the weeds. By comparison the mulched plots had only 20% weed cover on this date. The unmulched PSB plots had 15% weed cover on 12th October, compared to only 6.25% weed cover in the mulched plots.

In the celeriac the mulch increased the crop vigour slightly as could be expected in a dry season, and there was no recordable suppression in vigour in the PSB. This confirms the mulched plots did not deplete the soil N levels by upsetting the Carbon Nitrogen balance when not incorporated.

Annual weed species identified during the project were chickweed, spear thistle and redshank.
Perennial weeds identified during the project were docks, dandelions and couch grass.

The woodchip visibly increased soil moisture in a dry year, encouraged worm activity and several fungi soon colonised the mulched plots.

Table 1. Weed Cover and Crop Vigour in Mulched and Control Plots of Celeriac and Purple Sprouting Broccoli

Results	4 Sept 18		12 October 18	
	% Weed cover	Crop vigour	% Weed cover	Crop vigour
Celeriac				
Mulch	5	3	20	3
Control	13.3	2.3	73	2.3
Purple Sprouting Broccoli				
Mulch	5	4.25	6.25	5
Control	12.5	4.25	15	4.75

2.2.2 Hand hoeing costs

The time taken for hand hoeing the different crop types varied considerably, from 35 hours/ha for PSB to 54 hours/ha for beetroot. This means that the annual cost of hand hoeing could vary greatly, depending on crop type, and the number of times hoeing is required over the course of a year.

Table 2. Time Taken to Hand Hoe Horticultural Crops, and the Associated Cost Based on the National Living Wage of £7.50 per hour

Crop	Time taken for hand hoeing (hours per ha)	Cost of Hand Hoeing once (£ per ha)	Cost per year if hoed twice (£ per ha)	Cost per year if hoed three times (£ per ha)
French Beans	42	315	630	945
Beetroot	54	405	810	1,215
Purple Sprouting Broccoli	35	262	524	786

2.3 SWOT analysis

STRENGTHS	• Effective weed suppression over the growing season. • Improved crop vigour for crops which are not weed competitive • Improved moisture retention. This may reduce the need for irrigation in crops where this is a consideration. • Reduced costs as the need for expensive weed control methods such as hand hoeing are eliminated. In a non-organic system, this could include reductions in the requirement for herbicide treatments. • Reduced reliance on the availability of labour to provide effective weed control • Woodchip suitable for organic use was easily sourced and delivered direct to the farm free of charge.
WEAKNESSES	• Potential for locking up of nitrogen could become an issue in subsequent seasons once woodchip is incorporated with the crop trash.
OPPORTUNITIES	• Making use of a by-product can reduce costs and benefit the environment. • Woodchip may be an appropriate mulch for perennial crops where incorporation of high C:N ratio manures is not an issue • Adopting mulches more widely could improve the efficiency and productivity of horticultural systems
THREATS	• Potential issues with consistent supply of woodchip depending on farm location. • Organic farms must ensure that woodchip is sourced from unsprayed trees.

3 Impact on the industry

3.1 Alignment to sector's strategic goals

This work contributes to the Welsh Horticulture's strategic objectives, specifically in relation to the following:

- Improve the business performance of producers and processors in response to changing environmental requirements
- Help the ongoing development and improve agronomic and other technical skills to support horticulture in Wales.
- Deliver many benefits that help to service a range of environmental, social and economic benefits.
- Inform/educate the industry about cost saving/conservation, energy and water efficiency, ways to reduce waste and ways to improve knowledge, openness and transparency.

3.2 Impact on individual business

Arborist woodchip mulch proved to be an effective weed control technique, with sufficient reduction in weeds to eliminate the need for hand hoeing. Crop vigour was equal to or better than that of the unmulched plots, meaning that productivity can be maintained or improved through the use of mulch.

This is a positive outcome for the business, as it provides an alternative, low cost option for weed control going forward, with reduced reliance on labour. This can help the farm to meet its goal of reducing the reliance on labour for weed control. It also helps the farm to meet its overall goal of producing organic food using traditional farming techniques, as keeping the costs of production down and becoming less dependent on the availability of labour will help the business to be more resilient long term.

The improvements in biological activity noted in the mulched plots can help the farm meet its goal of increasing biodiversity and providing wildlife habitats. It may also lead to improved productivity in the long term due to improvements in soil health, and the increased resilience of a soil ecosystem with greater diversity.

Going into the project, the farmers were concerned about sourcing woodchip suitable for an organic system. Once it was determined that any woodchip from unsprayed areas of trees was suitable, it was easy to source woodchip to be delivered to the farm free of charge. There were also concerns over how the woodchip would be applied. This was easily overcome by shovelling the woodchip from a loadall bucket, which was very easy and fast. If mulching was to be carried out over a wider area, the process could also be mechanised.

At the end of the trial, the area for vegetable growing is to be rotated to another area of the farm. This means that the woodchip used for the trial will be incorporated into the soil for grass establishment. However, the farmers are hoping to establish a new woodchip mulch area for vegetable growing, with a view to using the mulch on a long term basis.

3.3 Take home points for the industry.

- Arborist woodchip can be used effectively as a long term weed control mechanism in horticultural crops grown from transplants.
- The cost of hand hoeing to control weeds in organic crops is high. These costs can be avoided through the use of mulch.

- Crop vigour was maintained, suggesting the mulch did not compete with the crop for nitrogen. However, for annual crops, the mulch would generally be incorporated with the crop trash after harvest, and would be expected to compete for nitrogen with subsequent crops. Measures to ensure crop vigour does not reduce due to poor nitrogen uptake would be required.
- Mulches are likely to be particularly cost effective for perennial vegetable production, where the soil is not disturbed for a number of years.

3.4 Impact on Welsh Government's cross cutting and priority themes

Making the best use of resources

Mulching offers a use for woodchip, which would otherwise be seen as a waste product, and could potentially end up in land fill. By using locally sourced woodchip, the farm is minimising the distance travelled by the product. If this was implemented by more farms across the country, considerable volumes of waste woodchip could be used in a sustainable way.

The mulch also improved water retention. In this case, the farm was not irrigating the crop, however in circumstances where irrigation is used, mulches could be used effectively to reduce the volume of water required for irrigation.

Soil conservation and management

The project demonstrated that the high C:N ratio of the woodchips did not lead to inhibition of crop growth due to locking up of nitrogen, at least in the first season of use. This means woodchip can be used effectively as a mulch for perennial crops where mulches are never incorporated. Further trials would be needed to determine the impact of regularly incorporating woodchip into the soil, and the best methods of mitigating any associated issues.

Biodiversity and Resilience of ecosystems

The arborist woodchips used are a non-homogenous product, and therefore act as a habitat for a range of microbes, insects and other organisms. The project found that the mulched plots were colonised by fungi, and increased earthworm numbers. An increase in soil biota allows the soil to become a more resilient ecosystem, which is able to support a greater diversity of plant and animal life.

Tackling Poverty

As a free by-product, woodchip mulch offers a reduced cost method of controlling weeds in horticultural crops. In an organic system, the alternative method of weed control is likely to hand hoeing, which represents a high labour cost. In conventional systems, mulching could be used to reduce the requirement for herbicide applications and associated costs. More cost efficient business practices result in the potential for increased returns, whether that be from on or off farm income.

Future Generations

The project is an example of how farm efficiency can be improved through innovative solutions. This encourages young farmers who are working in the sector to be forward thinking and to grasp opportunities to run a business more efficiently. This includes reducing cost, potentially labour and time; all are increasingly important post Brexit in such a volatile industry.