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EVALUATING THE POTENTIAL OF BIODEGRADABLE FILMS AS ALTERNATIVES TO FOSSIL FUEL-DERIVED PLASTIC MULCHES FOR WEED CONTROL IN ORGANIC FIELD VEGETABLE SYSTEMS

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Abstract: Plastic mulches are increasingly used in vegetable production systems where they are a cost effective means of weed control. However they are usually made from fossil fuel-derived plastic and so there is concern about the environmental implications of their production, use and disposal. This paper describes two trials that were conducted in the UK in 2019 under organic management to compare a durable woven polypropylene mulch, a polyethylene film mulch, two commercial GM-free corn starch biodegradable film mulches and two innovative potato starch biodegradable film mulches with weeded and unweeded controls. In the trial with onions as a test crop the weeds were very competitive and quickly overwhelmed the crop both in unweeded controls and when using mulches that were easily damaged by weeds that grew beneath them. In the trial using cabbages as the test crop the more fragile mulches were able to suppress the weeds during the critical early growth period until the plants became competitive. Plant based biodegradable film mulches have an environmental cost in terms of the inputs needed to grow, process and transport them. More research is needed to evaluate the potential of locally sourced mulch materials such wood chips from agroforestry systems and to continue to develop better biodegradable materials.

Introduction: Plastics are widely used in many forms of farming but especially in horticulture, for example as polytunnel coverings and in produce packaging. The EU funded H2020 project Organic-PLUS, concerned with contentious inputs in organic agriculture, identified weed supressing mulches as a particular issue (Schmutz et al, 2018). These are an effective means to reduce the need for herbicides and to minimise the need for expensive manual labour but are usually made from polythene or other fossil fuel-derived polymers; their production requires non-renewable resources, they are difficult to recycle due to contamination with soil and they can have detrimental effects on the environment as they degrade into microplastic particles and release plasticisers such as phthalates that can be taken up by crops (Steinmetz et al, 2016). A number of biodegradable film mulches are commercially available, often based on corn starch as a raw material. However, these are relatively expensive and can degrade too rapidly in the field. This paper describes replicated trials that were conducted with the aim of comparing fossil fuel-derived mulches with both commercial and innovative starch-

derived mulches with respect to their effects on crop performance, weed suppression, soil contamination and overall environmental impact.

Material and methods: Two trials (using onions and cabbages as test crops) were established in 2019 located near Coventry in the English Midlands; the site had been organically certified by the Soil Association since 1985 and was a completely stockless field vegetable system with the fertility being maintained by green manures supplemented by green waste compost. The soil type was a sandy loam with an organic matter content of 5.4 %. A randomised complete block design with four replicates was used, integrated into a bed system (wheelings spaced at 1.65 m and each plot was 3.75 m long). Six mulch materials were used; two were commercial fossil fuel-derived plastic (a woven polypropylene fabric and a polythene film), two were commercial GM-free corn starch biodegradable films and two were innovative translucent-white potato starch films developed by a partner in the Organic-PLUS project (Postawa et al, 2020). There were also two unmulched control treatments, one unweeded and the other kept weed free (by hand weeding) throughout the growing season.

The mulches were laid by hand and tucked into the soil at the edges of the beds, mimicking the effect of tractor drawn machinery. Holes were then punched through the films (or burnt through with a blowtorch in the case of the woven polypropylene mulch) at appropriate intervals. The onion trial followed potatoes grown in 2018; the mulches were laid and the onions sets (*Allium cepa* 'Red Baron') were planted in early May 2019. There were five rows per bed at a spacing of 25 cm within each row). The cabbage trial followed ryegrass sown as a green manure in 2018; the mulches were laid and the cabbage transplants (*Brassica oleracea* 'Impala') planted in mid May 2019. There were four rows per bed at 50 cm spacing, staggered between the rows. The crop was covered throughout its growth with an agricultural mesh to exclude pest insects and to minimise bird damage.

In September 2019 a participatory event for farmers and other stakeholders was held at the trial site to discuss the issues surrounding the use of plastic mulches, potential alternatives and to identify areas where further research and development was required.

Results: ONION TRIAL. An abundance of annual weeds (especially *Chenopodium album*, *Veronica persica*, *Stellaria media* and *Lamium purpureum*) germinated rapidly and some perennial weeds (*Rumex* spp., *Cirsium arvense* and *Symphytum* spp.) were also an issue; in the unweeded plots weeds achieved almost 40 % ground cover within a month of the trial beginning (Figure 1). Initially all the mulches were effective at suppressing weed development. However, the weeds grew vigorously beneath the two innovative mulches that were both translucent. All the other mulches were black. Eventually the weeds burst through the innovative mulches although CUT 1 lasted a little longer than CUT 2 which contained calcium carbonate as a filler material and was consequently more brittle. By the time that the onions were harvested in late August weeds in the control plots and in the damaged mulch plots were completely dominant reaching a height of over 1 m and an average fresh biomass of 3.5 kg/m^2. With effective weed control a marketable yield of approximately 2 kg/m^2 was achieved. The yield was negligible (0.1 kg/m^2) in the unweeded plots although it was a little better in the CUT 1 plots which had maintained weed control for an extra ten days (Figure 2). Soon after harvesting the onions the remaining film mulches, especially the polyethylene, began to fragment although there was less autumn weed growth in them than in the CUT 1 and CUT 2 plots. The woven polypropylene mulch remained completely intact and robust enough to be used again.

CABBAGE TRIAL. A similar pattern of mulch degradation was seen in the cabbage plots. However, this trial was planted two weeks later than the onions; this gave time for another cultivation before the mulches were laid resulting in lower weed pressure early in the season. This meant that the translucent mulches CUT 1 and CUT 2 remained intact for longer

and were able to suppress the weeds until the cabbages achieved over 80% ground cover in early August; only in the unweeded control plots did the weeds become dominant and overwhelm the crop.

Discussion: These trials confirmed that biodegradable mulches can be an effective method for supressing weeds, ensuring that crops of acceptable yield and quality are produced. However, they must have a sufficient level of robustness in order to give effective control, particularly in the case of a less competitive crop such as onions. Translucent mulches were found to permit weed growth beneath them, leading to failure early in the season. The physical deterioration of these mulches is described in more detail in Postawa (2020).

A workshop held at the trials site and attended by UK growers of field vegetables, glasshouse crops and fruit confirmed that the use of disposable polyethylene mulches was becoming less acceptable with their customers and that it was very difficult to arrange for them to be recycled. Advantages of the woven (usually polypropylene) products were their durability and permeability to air and water – there was concern about the effects of the film mulches on soil health. Many of the growers would consider switching to a biodegradable alternative although there were issues with cost, availability and durability; it was also pointed out that any fragments in a bagged salad would cause customer complaints.

In contrast to both the polythene mulch and the biodegradable mulches used in these trials the woven polypropylene mulch could be used for many years. A life cycle analysis will be conducted to evaluate the overall relative merits of the different products. This will also consider the potential of mulch materials that could be sourced on-farm, contributing to resilience of the system by reducing the need for external inputs.

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Image:

Figure 1. The development of weed ground cover in an onion crop grown with different weed suppressing mulches.

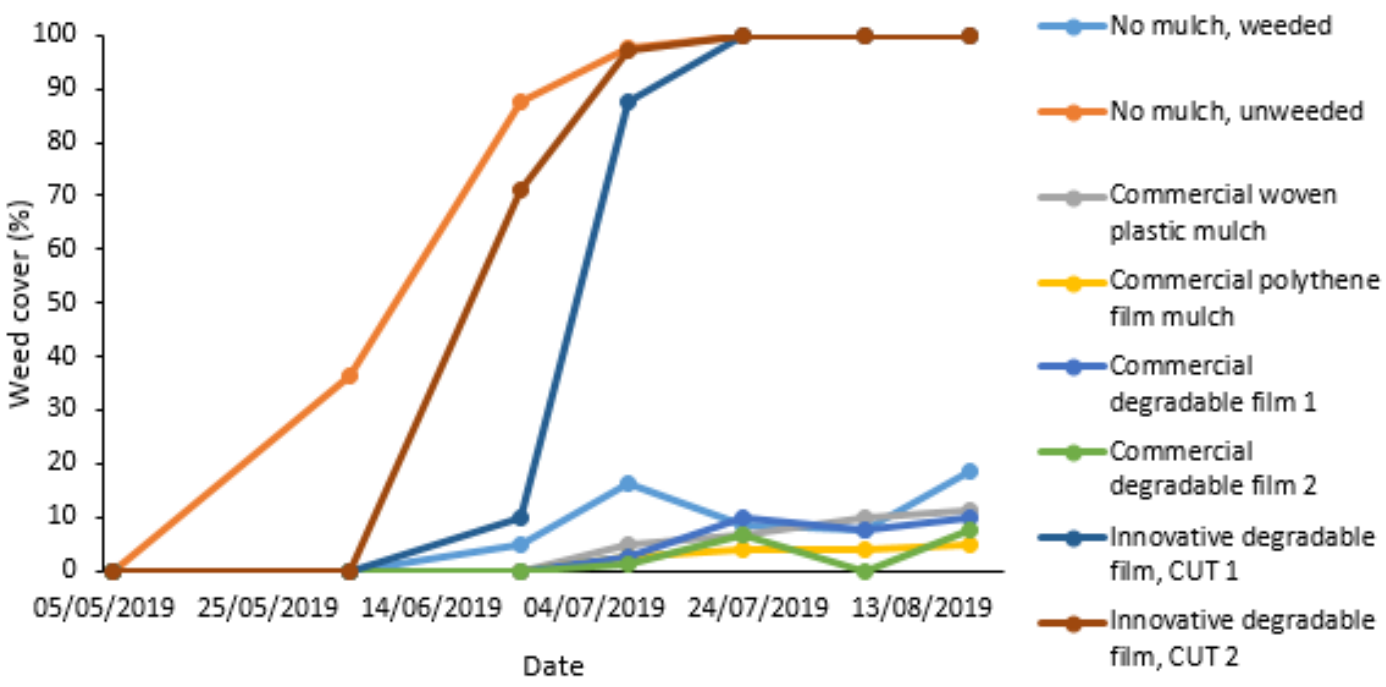
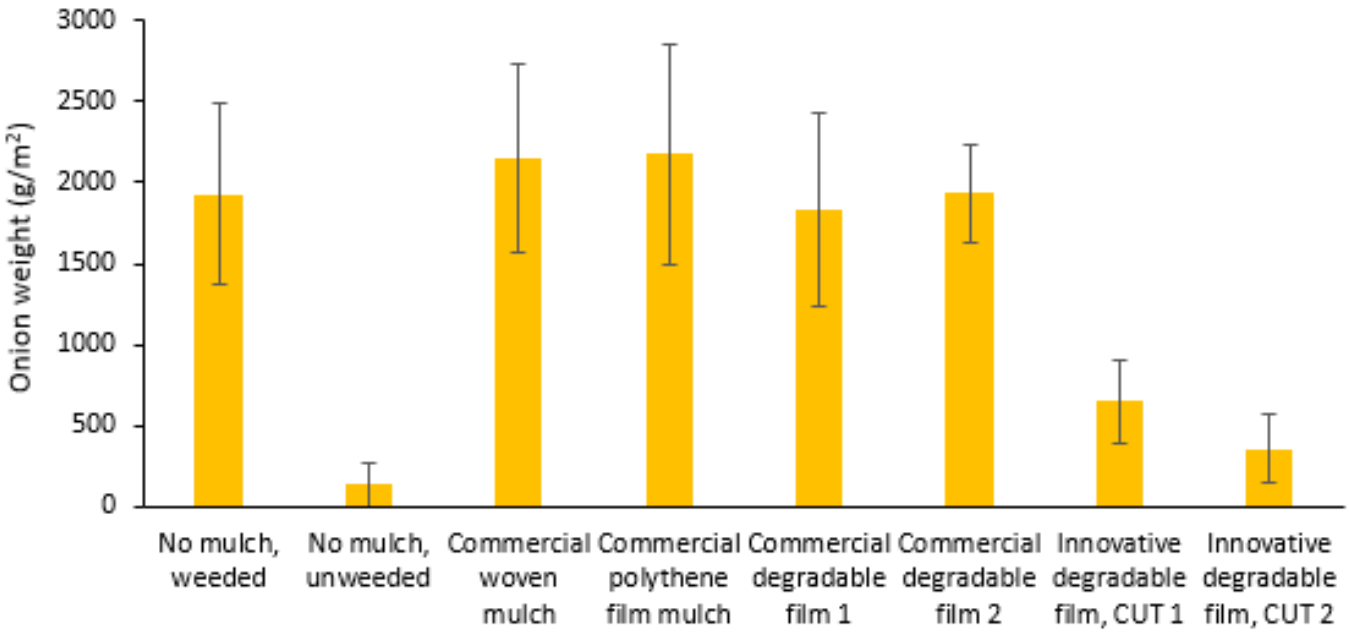


Image 2:

Figure 2. Marketable yield (air dried bulbs>25mm) of onions grown with different weed suppressing mulches. Veritcal bars indicate standard deviations either side of the mean.



Disclosure of Interest: None Declared

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