Organic potatoes, reduced tillage and mulch

One of the aims of the EU-funded OSCAR (Optimising Subsidiary Crop Applications in Rotations) project is to research the optimisation of minimum tillage methods in organic systems. At the University of Kassel we started two long-term experiments in 2010 and 2011, comparing regular ploughing with non-inversion tillage, combined with various cover crops and with and without compost amendments.

All experiments started with two years of grass/clover, after which the differential tillage methods (ploughing to 25-30cm depth versus simple non-inversion tillage by grubbing the soil to about 12-15cm depth) were applied, before sowing winter wheat in 2012 and 2013 respectively. A first compost application at 5t dry matter ha^{-2} was made to the wheat; this is the maximum average amount allowed per year in Germany. Wheat was grown either with a living mulch of under-sown white or subterranean clover, or without living mulch. The clovers were left to grow together with spontaneous vegetation or without further tillage. Where no living mulch was grown either summer vetch or a black oat/tillage radish mix was grown as winter cover crop.

Application of freshly-cut mulch materials in mid-May with a manure spreader to 8-10 cm depth on the potato plots.

In 2014 and 2015 potatoes were grown as second main crop. Several practitioners of minimum tillage in organic farming had reported to us that combining reduced tillage with a thick layer of fresh green mulch reduced late blight and Colorado potato beetle (*thankfully the latter is not a problem in the UK - Ed*) in potatoes. Potatoes were planted in all plots. In the ploughed plots they were regularly ridged, whereas in the non-inversion system they were mulched. The mulch was applied as soon as possible after the first ridging in early to mid-May, and consisted of about $5kg/m^2$ of a freshly cut winter pea/rye or vetch/triticale mixture in 2014 and 2015 respectively, that was shredded to about 10cm pieces. Application was done with a simple manure spreader.

According to the recommendations, the material should be high in nutrients and would also be fit to feed to milking cows. After mulching no more mechanical operations were performed until harvest. In addition, half the plots received 10t dry matter ha^{-2} of a high quality yard waste compost (since none was applied in the previous year following wheat, twice as much could be applied this year within the regulations), while the other half received equivalent amounts of P and K via rock phosphate and organic potassium fertiliser. A series of pictures documenting the sequence of activities can be found at: http://bit.ly/1SYZ20o.

June 6, 2014: the mulched potatoes in the foreground are less lush and green than the ploughed potatoes in the background.

Weather and mulch effects

The weather conditions in the two years were extremely variable. In 2014, water availability was normal to high in spring, and the summer temperatures were the highest in more than 100 years. In 2015, the spring was very cool and dry with extreme drought in May, followed by normal summer temperatures. This affected the potatoes very differently. In 2014, mulched potatoes were

8 July, 2015: Potatoes in the ploughed treatments (left) suffered severe drought but not in the minimum tilled and mulched treatments.

retarded in their growth, most likely due to the mulch keeping the soil cooler. In 2015, after initial slow growth, the mulched potatoes overtook the ploughed potatoes. Mulched potatoes were greener and the canopy closed, whilst due to the drought the ploughed potatoes never closed their canopy.

We observed very nice growth of fine roots into the mulch in both years (see pictures on the website). In 2015, we therefore measured the dynamics of the N-contents in the leaves. The mulched plants had consistently higher N-contents than the non-mulched plants.

Late blight, weeds and erosion

In 2014, we had a 'normal' late blight epidemic starting in early July. Spread of blight across the mulched treatments was slower by about two weeks, and cumulative disease as expressed in the area under the disease progress curve (AUDPC) was 880 under mulch and 1330 in the ploughed plots (Hohls et al. 2015). The most likely explanation for the reduction of late blight in the mulched plots is that overall the temperatures in the canopy are higher during the day due to the reflection of light by the dried mulch, resulting in a non-conducive microclimate for germination of the late blight sporangia. We could feel the differences in temperature in the field and have measured these in other experiments before, but not in these experiments.

Aerial photo of the plots July 14 2014 during the late blight epidemic.

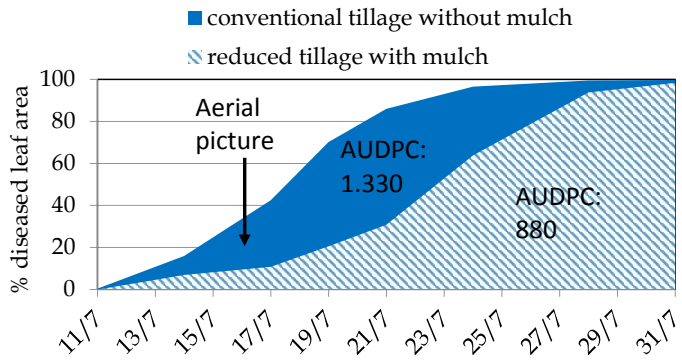


Fig. 1: Disease progress of P. infestans in 2014 under conventional tillage and under reduced tillage with dead mulch. The arrow indicates when the aerial picture, above,was taken.

Effects of mulching on weed infestation in early August 2015.

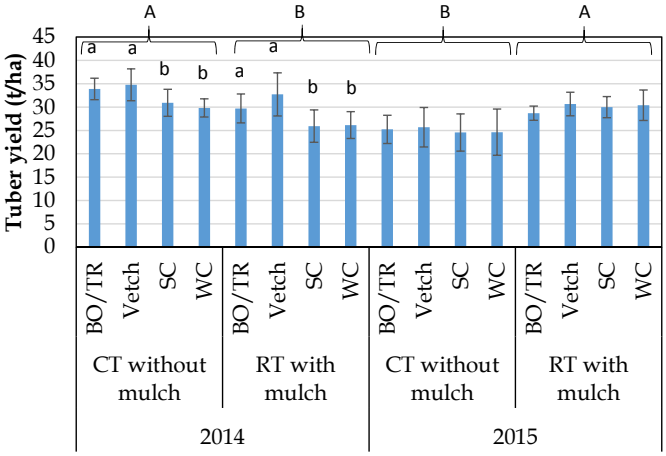
Effects of mulching on late season erosion after defoliation in August 2015.

Photos: University of Kassel

In 2015, there was no late blight at all due to the drought. In early August the plants were topped to prevent excessive starch formation and to prepare for harvest. Mulch greatly reduced weed problems at that stage. In addition, mulch also prevented heavy erosion due to a strong but not extreme rainfall event, when more than 100mm of rain fell in one and a half days.

Yield effects

Despite the very good performance with respect to late blight in 2014, yields in the mulched potatoes were considerably lower than in the ploughed and non-mulched plots (Fig. 2). However, when summer vetch was used as a cover crop, the yields in the mulched and unmulched plots were most similar compared to when any other cover crop was used (obviously, the directly available nutrients to the potatoes were higher with vetch whether mulched or not, while in the other treatments there was a lack of nutrient availability). In contrast, in 2015, mulching increased yields by 5 t ha-1(Fig. 2). Clearly, protection of the potatoes from drought was the most important effect of mulching in that year. Common voles seriously damaged all legumes in the second experiment before onset of winter 2014/2015. Therefore, there were no differential effects of the different cover crops on tuber yields in 2015.



Marketable (35-65 mm size) tuber yields (t ha-1) with standard deviations in 2014 and 2015. Treatments were ploughing (CT) without mulch, reduced tillage (RT) with mulch and cover crop or living mulch pre-crop species (black oat/tillage radish mixture (BO/TR), summer vetch, subterranean clover (SC), and white clover (WC)); different letters in diagram show statistically significant differences between treatments with Tukey-Test and H-Test for 2014 and 2015, respectively; N=8.

Conclusions

The experiments with mulching were done in a systems approach, comparing potatoes as they are typically produced in Germany using ploughing, with a system of non-inversion tillage combined with mulch. As the plots are integrated in two long-term experiments comparing ploughed versus minimum tillage it was not possible to integrate a mulched ploughed treatment or a non-mulched non-inversion tillage due to restrictions in plot size. We tested the effects of mulching in a ploughed system in 2015. There was no late blight but good erosion control and yields were increased through mulching. Compost effects on the system were so far not clearly visible. It will most likely take several more years of regular applications to start seeing changes in system performance.

Overall, mulching will change the potato system and it will depend very much on the local soil and climatic conditions if and when mulching will have positive effects (Table 1). On the one hand, mulching is labour-intensive and requires the availability of materials to use. Besides freshly-cut materials, silage is an alternative option that some farmers are using in vegetables in Germany. This reduces the dependence on the growing conditions for the mulch production early in the season and likely also increases the fertilisation effect. Farms that have no animals often mulch with grass-clover. This will suppress N-fixation by the clover due to the nutrients in the mulch and thus reduce the usefulness of the grass-clover for nutrient accumulation. In addition, it may result in leaching and thus loss of nutrients and even potentially harm the environment. Using the first and most rich harvest as mulch in the potatoes or alternatively making silage for later use is easier than composting such materials. Once the mulch is applied, no more mechanical weed control is done, saving labour and energy. More importantly, it will also reduce the mechanical damage done to the potato foliage that makes them more susceptible to infections and it allows for profuse growth of fine roots into the applied mulch materials. Mulching also reduced Colorado potato beetles in both years to some extent but this data needs confirmation. Also, the residual effect on the subsequent crop after the potatoes due to the increased input of organic amendments still needs to be studied.

Ecologically speaking, mulching has many advantages. These advantages are especially important in water-restricted areas. However, whether mulching is feasible and economical, and how it is to be done, will depend on the specific conditions and organisation of a farm.

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OSCAR Cover Crop and Living Mulch Toolbox

The Toolbox consists of three main elements; a user-fed wiki; a species database; and a decision support tool, presented as a series of web-based tools. The content draws on scientific literature, technical information and results of the OSCAR project field trial, it is interactive and designed for farmers, advisors, researchers and the general public. A working version of the Toolbox can be accessed at www.covercrops.eu.

Your comments and input would be greatly appreciated. Contact Sally Westaway at the Organic Research Centre, partners in the project. sally.w@organicresearchcentre.com

Table 1. Effects and potential problems of mulching on the potato system and how the system might be adapted.

Effects	Potential problems
Reduces soil temperatures, particularly early in the growing season.	Retarded early plant growth.
If applied too late may suppress already emerged potato plants.	Early in the season not enough mulch materials may be available.
Increased solar light reflection and therefore dryer canopy.	In extremely hot conditions may get too hot if no canopy closure.
Protection from drought.	Too much water could sometimes become a problem.
Reduced damage to foliage as no more ridging carried out.	If too little mulch is applied or if the mulch disappears too quickly, weed problems may result.
Possibility for fine roots to grow undisturbed into the mulch and to use this as direct source of nutrients.	Insufficient depth of planting and first hilling may result in some green tubers.
Erosion control.	Cooler and moister soils may pose a problem depending on site.