Weed control with laser beams using autonomous vehicles: pros and cons

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Weeds are one of the most devastating yield-reducing factors for crop production worldwide. Herbicides are widely used to control weeds. Limitations on the choice of herbicides due to stricter regulations and increasing resistance of weeds towards herbicides will limit their use in the future. In addition, for the safety of users, consumers and the environment, decision makers are aiming for a drastic reduction in the use of pesticides, and for a transition to a more sustainable agriculture. Accordingly, we need alternative green solutions to protect our crops to ensure food and feed production both in conventional and organic farming.

Today, soil tillage and crop rotation are the main alternative to herbicides. However, soil tillage also has disadvantaged as it dries out soils with limited water content, increases the risk of soil erosion and leaching of plant nutrients, and harms beneficial organisms like earthworms in the soil and spiders above the ground. Flame weeding has been used in organic agricultural production but requires a large amount of gas and may not be considered environmentally sustainable in the long term due to the CO2 derived production. Therefore, there is a need for developing new techniques supplementing or replacing present weed control methods.

The fast development in laser technology seems to open up new opportunities for weed control based on electricity. Laser beams can deliver high-density energy on selected spots, which warm up the weed tissue and may result in the death of the weed plant.

WeLaser is a European research project that aims to merge current technologies to build, assess and push into the market a precision weeding system based on high-power laser sources and autonomous mobile systems with the main objective of eliminating the use of herbicides while improving productivity and competitiveness. Based on experience from the project we present consideration about advantages and disadvantages concerning using laser technology for weed control including challenges with identification of weeds and crop, regrowth of weeds, working speed of the robot, and safety.
Laser beams can be focused to extremely small spots, achieving a very high irradiance.

Can be based on electricity from water power, wind mills and non-fossil fuels (sustainable!)

The energy consumption is rather high.

It is essential, that an efficient recognition tool guides the laser to the target.

Artificial intelligence and deep learning techniques make it possible to locate and identify weeds and crops.

The laser beam hits the meristem of the weed and damage or kill it.
Dose-response experiment with the weed *Chenopodium album* (Fat Hen)

**Two leaf stage**

**Six leaf stage**
Only a very small proportion of the area in the field is exposed to the treatment.

If the laser beam has a diameter of 3 mm, and there are 100 weed plants/m², the exposed area is equal to $1.5^2 \times \frac{22}{7} \times 100 = 710$ mm², which is 0.71% of the total area.

Therefore, almost all living organisms avoid to be exposed to the treatment.

If 20 out of 100 weed plants do not reduce crop yield or quality and can be located and identified by the recognition system as non-target, they can avoid the treatment (e.g., endangered species).

Leaving some weed plants in the field creates feed, hiding and nesting places for beneficial insects and other animals and support pollinators.
Temperature increase limited to a very small area

Laser treatment at room temperature: Only a very small spot is affected!

Soil surface temperature measurement with a infrared camera of a tray experiment

Blue: 18,5 °C
Small, light vehicles do not compress the soil and influence the soil structure and soil organisms like heavy machines do!
Weeding Capacity?

- Small autonomous vehicles cover a small area, but can work day and night!
- The time window for the laser weeding is short!
- Wet plants require more energy to kill!
- How often do the batteries or engine need to be loaded?
- Several treatments might be necessary!
- How fast can the laser system work (4-6 km hour\(^{-1}\))?
- Should we combine laser weeding with other methods?
- Do we need a fleet of laser robots to cover large fields and areas?
• Same safety issues as other autonomous vehicles!
• Laser can be harmful for humans and animals!
• Reflection of laser beams from stones can pose a danger
• Leaving a spark in the field may start a fire!

• Can we leave the autonomous laser vehicles alone in the field, or do we need surveillance?
• Great potential to replace herbicides and thereby avoid negative side-effects of herbicides
• Great potential to replace mechanical weed control
• Great potential to avoid soil compaction, erosion and unnecessary mineralisation
• Great potential to increase biodiversity

But

• Weeding capacity could be a limited factor for the success
• Some serious safety issues need to be taken into account
Thank you for your attention!

Find more information on https://welaser-project.eu/

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