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In-row hoeing in oil pumpkin: how far can AI replace manual labour?

Location: Innovation Farm Mold

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DETAILS

Partners: Ullmanna s.r.o

Samo Maschinenbau GmbH

Product, technology: Samo Vario Chop AI, in-row hoeing technology to reduce manual labour hours and residual weed infestation

Supervisor: Florian Krippl, Innovation Farm Mold

Period: April 2026 to December 2026

Project objective: The trial aims to show to what extent the use of an in-row hoe, compared with a conventional camera-guided hoe plus hand hoeing, increases efficiency in weed control. Two main objectives are in focus:

- Reducing the labour time required through less manual work after mechanical treatment.
- Improving weed control by detecting and removing weeds within the crop row.

Implementation: The trial compares a conventional hoe with hand hoeing and an in-row hoe in pumpkin. The focus is on reducing the labour time required and on assessing the remaining weed infestation.

Conclusion: The trial shows that mechanical weed control in oil pumpkin can be effectively extended into the crop row with AI-assisted in-row technology. Immediately after treatment, the combination of front hoe and Samo Vario Chop AI achieved a result of 5.5 % residual weed cover, close to manual follow-up work with 3.45 %. At the same time, plant detection was rated reliable and handling practical in the trial.

Details and videos: www.innovationfarm.at

Funding: Supported by the Austrian federal government, the federal provinces and the European Union

Background and research question

Camera-guided hoes have become established in row crops as a precise method of mechanical weed control between the crop rows. Their classic limit, however, lies directly in the crop row: to avoid damaging the crop plants, a protective zone usually remains untreated there. It is precisely in this zone that competitive weeds can keep growing and – depending on the crop, weed pressure and quality requirements – often have to be removed by hand in an additional pass.

Especially in crops with wider row spacing and a high value per individual plant, this follow-up work can require considerable labour time. Rising labour costs and the increasingly limited availability of seasonal workers are therefore increasing interest in technical solutions that can also treat the area within the crop row automatically.

This is where in-row hoeing technology comes in. The Samo Vario Chop AI calculates the root centre of the crop plants and controls the hoeing tools so that the area between the individual plants within the row can also be treated mechanically. The aim is to close the treatment gap that has remained so far and, above all, to reduce the subsequent manual labour.

Against this background, the Innovation Farm at its Mold site examined the performance of AI-assisted in-row hoeing technology in a field trial in oil pumpkin, compared with the established process chain of front hoe followed by manual work. The focus was on work quality immediately after treatment, the development of residual weed infestation over the rest of the growing season, and the labour and economic assessment of the methods.

For practical use, the decisive question is not only whether an in-row system can work within the crop row at all. What matters is how close mechanical treatment comes to the quality of manual follow-up work, whether this has a lasting effect on residual weed infestation, and under which operating conditions the additional technology pays off economically.

How the trial was carried out

The trial was set up in an oil pumpkin crop with a row spacing of 1.40 m and a plant spacing of 40 cm within the row. The aim was to compare two practice-relevant strategies of mechanical weed control directly. The central question was whether the manual work previously required within the crop row can be replaced, or at least significantly reduced, by automated in-row hoeing technology.

The standard variant was the process chain established in practice: a front hoe followed by manual correction. The front hoe handled mechanical weed control between the pumpkin rows. Weeds remaining within the crop row or in the protective zone around the crop plants were then removed by hand.

This variant was compared with the in-row variant. Here too, the area between the rows was first treated with the front hoe. Weed control within the crop row was then carried out by the Samo Vario Chop AI. The system detects the position and centre of the individual pumpkin plants and controls the hoeing elements so that the space between the crop plants can be treated mechanically. This is intended to cover the area that usually remains untreated with conventional row hoeing in order to protect the crop plant.

The trial design thus allows a direct comparison of two complete process chains: front hoe plus manual labour versus front hoe plus automated in-row treatment. It is important that the front hoe itself is not replaced. In both variants it forms the common basis for weed control between the rows. What was examined was which method is better suited to treating the remaining area within the crop row.

This distinction is also essential for the subsequent economic assessment. The costs of tractor and front hoe arise in both variants and are therefore considered a common baseline. For the actual comparison, the additional costs of manual follow-up work or of the in-row technology are relevant. This makes it possible to assess from what level of manual labour and at what work rate the use of automated hoeing technology can pay off compared with the conventional process chain.

Drone analysis shows differences in work quality

To evaluate weed control, the work result was recorded both by spot assessments and by automated drone analysis from a flight altitude of five metres. Weed occurrence was determined before and after each pass. The immediate effectiveness of each method was derived from the change in weed density.

To validate the automated analysis, the detected crop and weed plants were additionally checked by hand. In total, 16 ha of oil pumpkin on five fields were included in the evaluation. This allowed work quality to be assessed not only at individual points but under different practical conditions and across a larger area.

The results immediately after treatment first illustrate the limit of the front hoe alone. After the hoeing pass, on average 65 % of the weeds previously present remained. This is mainly due to the untreated protective zone within the pumpkin row.

When the front hoe was supplemented by manual cleaning of the crop row, residual weed cover fell to 3.45 %. The combination of front hoe and Samo Vario Chop AI achieved a similarly high level of control with 5.5 % residual weed cover. Immediately after treatment, the in-row technology was thus only about two percentage points behind manual follow-up work.

At the same time, the results of the in-row variant showed less variation. The range of results for the Samo Vario Chop AI was around 3 percentage points lower than for manual follow-up work. Under the conditions examined, this indicates a comparatively uniform work result across the different fields.

When interpreting the results, however, an essential difference between the two methods must be taken into account. Manual work is selective: specifically those weeds are removed that are visible at the time of treatment and are classed as harmful. In-row technology, by contrast, treats the soil across the whole area between the individual crop plants within the row. The two methods therefore differ not only in their degree of automation but also in the type and intensity of treatment.

Despite these different working methods, the direct comparison gives a clear picture: under the trial conditions, AI-assisted in-row technology achieved a work quality close to manual follow-up treatment.

The differences became particularly clear in a further assessment in early August after flowering. At this point the picture was different from immediately after the hoeing pass. In the variant front hoe plus manual labour, residual weed cover of 32 % was recorded. In the variant front hoe plus Samo Vario Chop AI, by contrast, it was only 10 %. The mechanised in-row variant thus showed 22 percentage points less residual weed cover over the rest of the growing season.

The difference between the two variants is due to the different type of treatment. While manual labour specifically removes existing weed plants, in-row technology mechanically treats the soil across the whole area between the pumpkin plants.

One conclusion above all can be drawn for practice: the quality of an in-row system should not be judged solely on the work result immediately after the pass. Equally decisive is how lasting the weed control is over the rest of the growing season and what residual infestation remains until canopy closure.



Figure 1 Drone analysis of weed density from 5 m

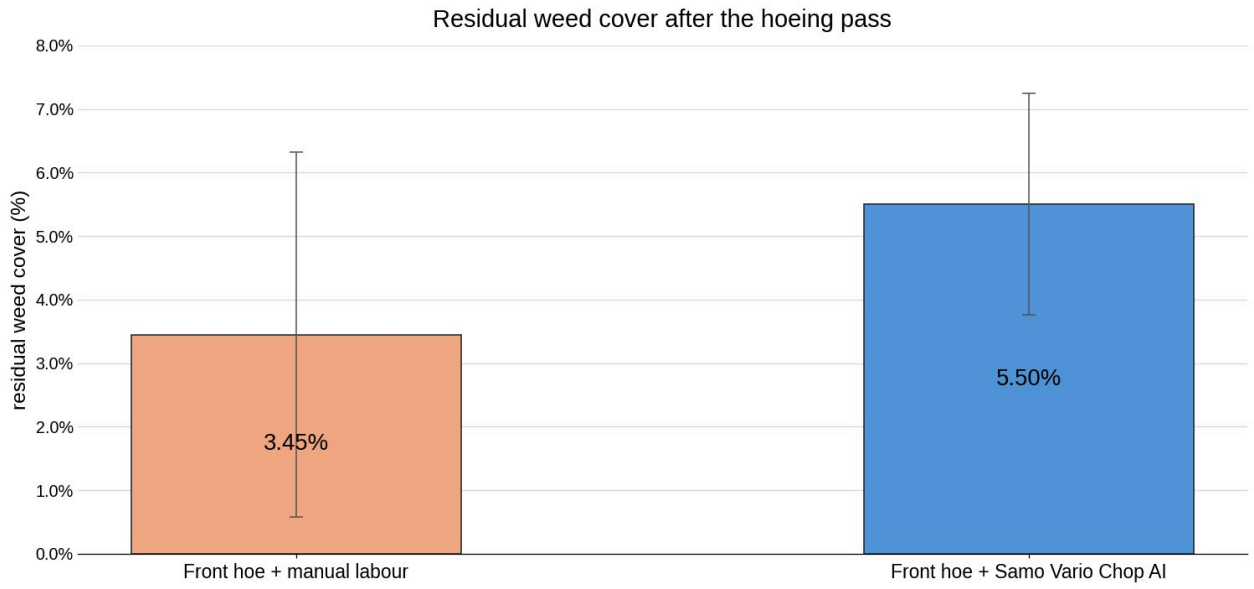


Figure 2 Residual weed cover after the hoeing pass

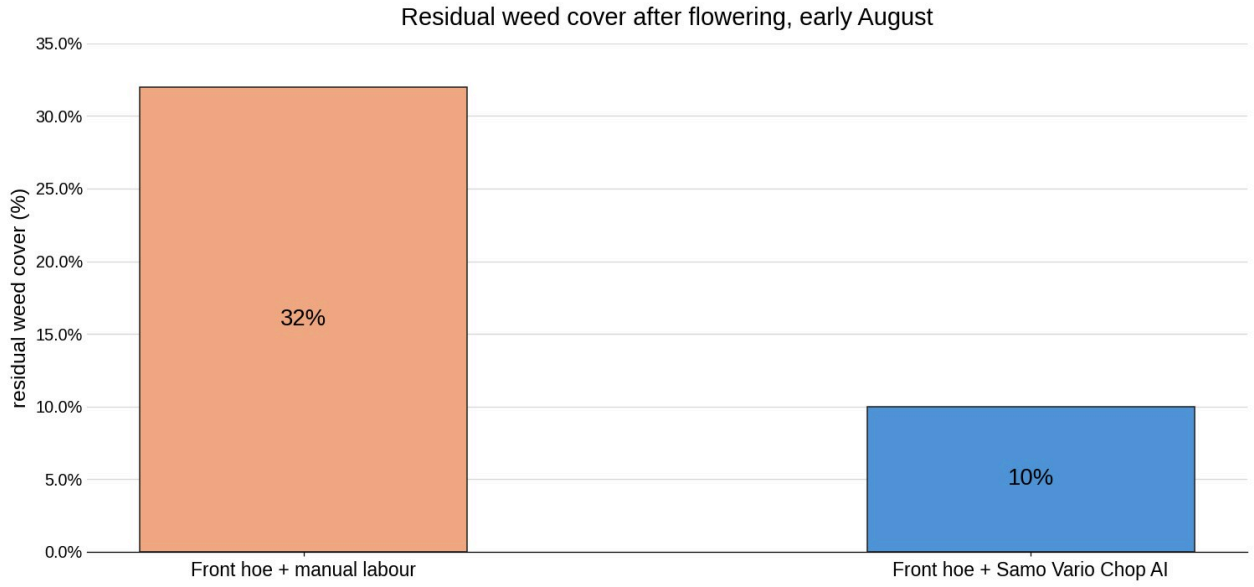


Figure 3 Residual weed cover at pumpkin flowering in summer

Economics

Technically, in-row hoeing technology can significantly reduce the need for manual follow-up work. Whether its use also pays off economically, however, depends largely on annual utilisation, the work rate actually achieved and the farm's need for manual labour. Especially with a comparatively capital-intensive special machine, low usage has a marked effect on costs per hectare.

The economic calculation in the trial is based on ÖKL guideline values. For a 140 hp tractor, €61.63/h net is assumed; for a worker, €18/h. The in-row hoeing technology was calculated with a net purchase price of €80,000. Assuming annual utilisation of 100 operating hours, or around 150 ha, the machine costs of the in-row system come to €112/h.

The perspective is decisive here: in the combined pass, tractor and front hoe are already in place as the basis. The costs of the in-row technology are therefore to be understood as additional costs on top of the hoeing pass that is needed anyway.

Assuming a work rate of 1.5 ha/h or 5 km/h, the calculation results in additional costs of around €74/ha for the combined use of front hoe and in-row technology. For separate solo use of the in-row unit including tractor and driver, the trial evaluation shows around €127/ha.

Comparing these values with the calculated manual labour costs of €18/h shows the economic break-even range. For combined use, €74/ha corresponds arithmetically to about 4.1 hours of manual labour per hectare. For separate solo use at €127/ha, the break-even point is around 7.1 working hours per hectare.

This makes it clear: if only two or three hours of manual labour per hectare are needed after the conventional hoeing pass, manual follow-up work is cheaper under the assumptions made. If the need for manual labour rises significantly, however, mechanisation becomes more attractive economically. The decisive factor is therefore not only the purchase price of the technology, but above all how many hours of manual labour can actually be replaced.

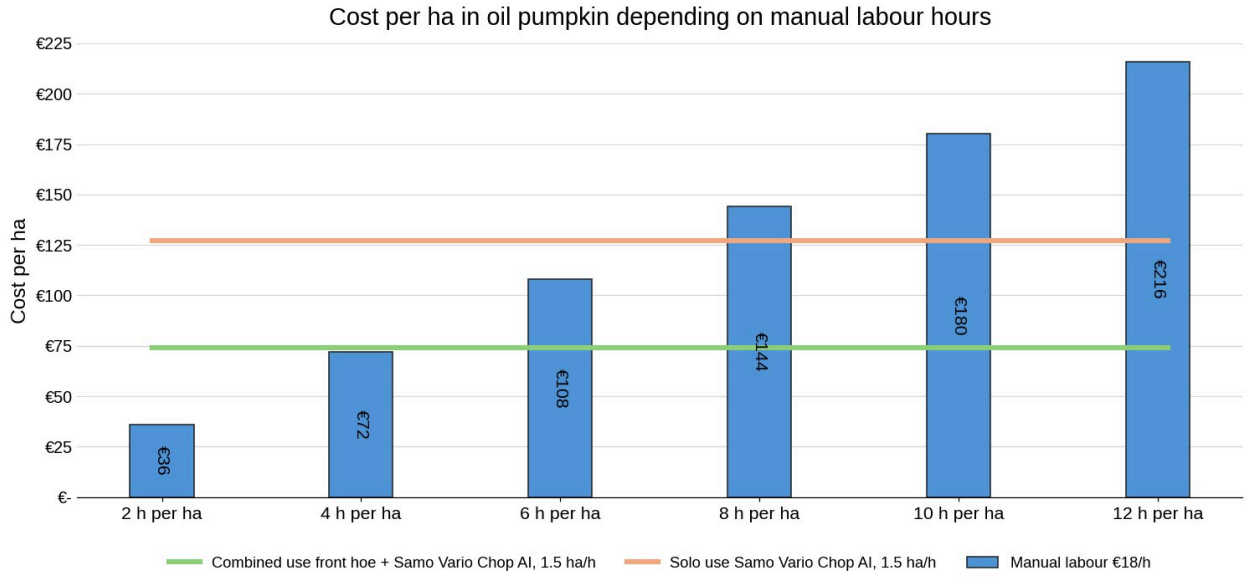


Figure 4 Process costs per ha with varying manual labour hours

Utilisation lowers costs per hectare

Annual machine utilisation has an equally large influence. For solo use at a work rate of 1.5 ha/h, the calculation shows a clear cost degression effect: at 50 operating hours per year, costs are around €194/ha. At 100 hours they fall to €127/ha, at 150 hours to €105/ha and at 200 hours to around €94/ha.

With special technology in this price class, annual utilisation thus becomes a central economic factor. For farms with a small area of their own, shared use across farms can therefore be of interest. Machinery rings, joint purchase or use via contractors can help spread fixed costs over more operating hours and hectares.

The pure cost calculation, however, reflects only part of the labour assessment. Especially in time-critical work peaks, it is not only the wage rate that matters, but also whether enough workers are available at the right time. If an automated in-row system can reduce manual labour and make the operation easier to schedule, this creates additional benefit for the farm that can only be partly reflected in a pure €/ha calculation.

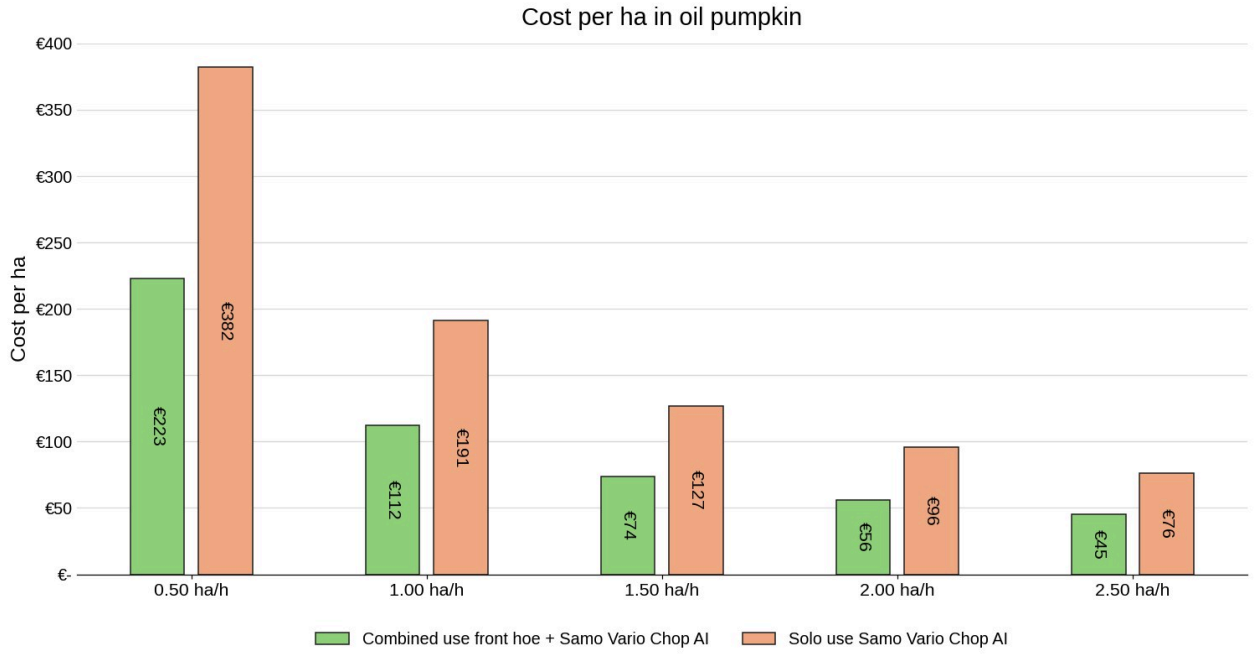


Figure 5 Process costs per ha with varying work rate

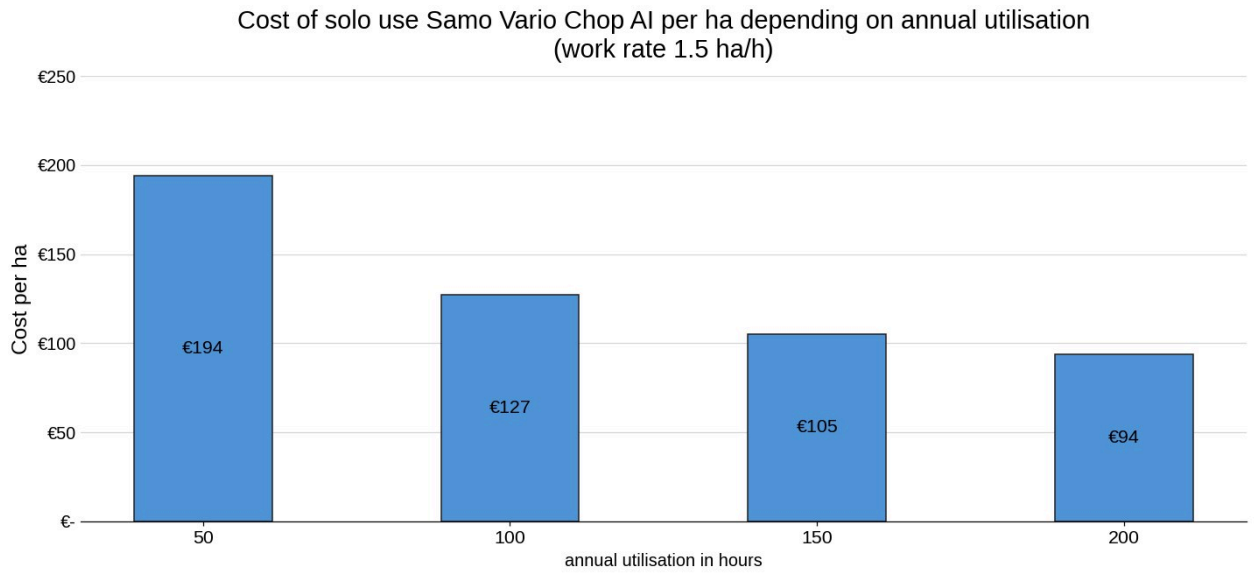


Figure 6 Process costs per ha with varying annual utilisation

Conclusion

The trial shows that mechanical weed control in oil pumpkin can be effectively extended into the crop row with AI-assisted in-row technology. Immediately after treatment, the combination of front hoe and Samo Vario Chop AI achieved a result of 5.5 % residual weed cover, close to manual follow-up work with 3.45 %. At the same time, plant detection was rated reliable and handling practical in the trial.

The development over the rest of the growing season is particularly relevant. In the assessment in early August, residual weed cover in the in-row variant was 10 %, while 32 % was recorded after front hoe and manual follow-up work. Under the conditions examined, whole-area mechanical treatment within the row thus led to

significantly lower weed infestation in summer. This shows that the assessment of a hoeing method depends not only on the immediately visible work result but also on how lasting weed control is as the crop develops.

Economic viability, however, depends strongly on the conditions on each farm. With a low need for manual labour, manual follow-up work remains cheaper. As the labour time required increases, the calculation shifts in favour of mechanisation.

From around four hours of manual labour per hectare, combined use breaks even – every further hour counts in favour of the machine. Thanks to whole-area treatment, the lower residual weed cover in many cases saves a second manual pass and thus has a lasting effect. Additional factors such as predictable work output and, with it, independence from external staff, consistent work quality and use by day and night are difficult to value in monetary terms and were not included in the cost calculation.

Overall, the potential of in-row hoeing technology does not lie solely in replacing manual labour. What matters is the combination of high work quality, lasting weed control and sufficient work rate. The method becomes particularly interesting where a high need for manual follow-up work meets scarce labour and sufficiently large areas of use.



Figure 7 Trial tractor and implement in operation

Funding: This article was produced at the Innovation Farm (www.innovationfarm.at), which is supported with funds from the Austrian federal government, the federal provinces and the European Union.

Video links:

https://youtube.com/shorts/OQXmVHPLMrU

https://youtube.com/shorts/tVdviTlRlE0

https://youtube.com/shorts/ToDKJtM8ecA

https://youtube.com/shorts/py7_OSO8F6c

https://youtube.com/shorts/0ioyHRLBCvE

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