ECONOMICS OF MECHANICAL WEEDING

BY A SWARM OF SMALL FIELD ROBOTS

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Abstract

Today's agricultural production systems with large machinery are facing limits due to problems with road regulations, soil compaction, social acceptance as well as nutrient and pest management. At the same time, current developments in the field of digitalization and automatization have the potential to lead to the development of small autonomous agricultural robots for seeding, cultivating and harvesting, which could help to overcome those limitations. This study evaluates a first concept of mechanical weeding by a swarm of small field robots within a new plant production system.

Keywords

CareRowBot, approximation of future product prices, swarm of field robots, operating costs, hexagonal spacing of seeds

1 Research problem

There are just a few studies about the economics of autonomous machinery in arable farming. GOENSE (2003) showed that in the future, autonomous inter-row cultivation can become economically feasible due to the effects of increasing labour costs and decreasing prices for navigation systems and small robots. HAVE (2004) demonstrated that machinery sizes are much lower in an autonomous tractor-implement combination than in conventional systems, assuming twice as many working hours for an autonomous tractor. PEDERSEN et al. (2005) designed economically feasible robotic systems for crop scouting and autonomous micro spraying in sugar beets. Especially labour-intensive crops with high yields and high returns per area unit like sugar beets, potatoes and vegetables are considered for new autonomous systems (PEDERSEN et al. 2007). There are first concepts of large (CASE 2017), medium (PRECISION MAKERS 2017) and small autonomous machinery (BOSCH 2017). NAIO (2017) sells weeding robots already. The present study goes one step further and analyses the economics of a swarm of small field robots for mechanical weeding in wheat.

2 Methodology

For the new plant production system, we assumed hexagonal spacing of seeds, so that the wheat plants have the optimal space to develop (GRIMSTAD ET AL. 2015, DEMMEL ET AL. 2000). The small autonomous machines can drive in the space between the plants. As there is no need for conventional wheel tracks, more space is left for cultivable area. As a benchmark, we assumed working days for mechanical weeding based on a modelled farm in the Magdeburg Börde. We developed a concept-study for mechanical weeding named *CareRowBot* with robots that are small enough to drive between the rows of plants. There are no market prices, repair and energy costs available for those very small field robots. That is why we made an approximation of future product prices.

We calculated the current material costs of one robot by defining all construction parts needed and assumed that the material prices will get lower due to scale effects when more robots are produced (KIRCHGEORG 2017). In addition, we supposed that the material prices decline, mainly driven by the developments in battery technology (NYKVIST and NILSSON 2015) as well as

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information and communication technology (FEDERAL STATISTICAL OFFICE 2013). In this approach, we estimated the product price including production costs and profit margin (WILDT 2016, ANKER 2013) and calculated the number of robots that is needed to weed 740 ha wheat of the modelled farm in a given time. Finally, we calculated the operating costs of mechanical weeding by a swarm of small field robots.

3 Results

The modelled farm would need 245 field robots (width 0,09 m, speed: 2 km/h) to weed 740 ha of wheat five times a year within 35 field working days (24 hours per day). The estimated market price of one *CareRowBot* is 626 €. The operating costs of mechanical weeding accounted to 30 €/ha (Table 1).

Table 1: Operating costs of mechanical weeding by a swarm of small field robots

Cost type	Capital costs	Repair costs	Energy costs	Operating costs
€/ha	26,9	1,6	1,7	30,2

Source: Own calculation based on EDWARDS, 2015: 2 and UNIVERSITY OF HOHENHEIM, 2016

4 Discussion and Conclusion

Mechanical weeding by a swarm of small field robots could be a competitive alternative for crops especially with high costs for herbicides. In addition, the utilization of the *CareRowBots* with other crops or procedures could lower the operating costs per ha. If the lightweight field robots could work during difficult weather conditions, additional benefits would be gained in comparison to large and heavy machinery. So far, there is no information available about field working days of small field robots so that further research is needed. The competitiveness of mechanical weeding by a swarm of small field robots would even raise if the risk of chemical resistance of weeds and the negative environmental effects through the use of herbicides would be taken into account (EUROPEAN CHEMICALS AGENCY 2017).

References

ANKER, S. (2013): Das Geheimnis der Gewinnspanne beim Autokauf. Online: https://www.welt.de/motor/article116695390/Das-Geheimnis-der-Gewinnspanne-beim-Autokauf.html (28.03.2017).

BOSCH (2017): BoniRob ausgestattet mit dem Stempelaktor. Online: https://www.deepfield-robotics.com/de/Weeding.html (09.03.2017).

CASE (2017): Autonomous Concept Vehicle. Online: https://www.caseih.com/northamerica/enus/Pages/campaigns/autonomous-concept-vehicle.aspx (09.03.2017).

DEMMEL, M., HAHNENKAMM, O., KORMANN, G., PETERREINS, M. (2000): Gleichstandssaat bei Silomais. 55 Landtechnik 3/2000. Online: https://www.landtechnik-online.eu/ojs-2.4.5/index.php/landtechnik/article/viewFile/2000-3-210-211/3389 (09.03.2017).

EDWARDS, W. (2015): Estimating Farm Machinery Costs. Online: https://www.extension.iastate.edu/agdm/crops/html/a3-29.html (22.03.2017).

EUROPEAN CHEMICALS AGENCY 2017: Glyphosate not classified as a carcinogen. Online: https://echa.europa.eu/-/glyphosate-not-classified-as-a-carcinogen-by-echa (22.03.2017).

FEDERAL STATISTICAL OFFICE (2013): Preisentwicklung der IT-Produkte. Online: https://www.destatis.de/DE/Publikationen/WirtschaftStatistik/Preise/ErzeugerpreisindizesIT_Dienstleistung_42013.pdf?__blob=publicationFile (28.03.2017).

GOENSE, D. (2003): The economics of autonomous vehicles. In: Proceedings of the VDI-MEG conference on Agricultural Engineering, Hannover 7-8 November 2003. Düsseldorf: VDI Verlag, pp. 283-290.

GRIMSTAD, L., PHAN, H. N. T., PHAM, CONG D., BJUGSTAD N., FROM, P. J. (2015): Initial field-testing of Thorvald, a versatile robotic platform for agricultural applications. Online: https://agrifood roboticsworkshop.files.wordpress.com/2015/11/grimstad2015iros_afr.pdf (09.03.2017).

HAVE, H. (2004): Effects of automation on sizes and costs of field machinery. In: AgEng2004 – Engineering the future – Book of Abstract (1), Leuven 12-16 September 2004, Leuven: Technological Institute, pp. 366-367.

KIRCHGEORG, M. (2017): Erfahrungskurve. Online: http://wirtschaftslexikon.gabler.de/Archiv/9291/erfahrungskurve-v9.html (28.03.2017).

PEDERSEN, S. M., FOUNTAS, S., HAVE, H. AND BLACKMORE, B. S. (2005): Agricultural robots: an economic feasibility study. Precision Agriculture '05: 589-596.

PEDERSEN, S. M., FOUNTAS, S., BLACKMORE, S. (2007): Economic potential of robots for high value crops and landscape treatment. Precision Agriculture '07: 457-464.

PRECISION MAKERS (2017): Greenbot – First driverless machine in the green sector. Online: www.greenbot.nl (09.03.2017).

UNIVERSITY OF HOHENHEIM (2016): Maschinenkosten, Richtgrößen für die jährlichen Reparaturkosten. Online: https://www.uni-hohenheim.de/i410a/etloes.def/makost.htm (22.03.2017).

NAIO (2017): Autonomous robots for easier farming. Online: http://www.naio-technologies.com/en/ (09.03.2017).

NYKVIST, B. and M. NILSSON (2015): Rapidly falling costs of battery packs for electric vehicles, Nature Climate Change 5, 329-332.

WILDT, A. (2016): Preiskalkulation. Online: https://www.controllingportal.de/Fachinfo/Kostenrechnung/Preiskalkulation-Wie-kalkuliere-ich-meinen-Verkaufspreis.html (28.03.2017).