Selection of a non-chemical method for weed management on railway tracks

C. Archut[1], N. Jendrny[1], A. Schulte-Marxloh[2], M. Eberius[3], U. Conrath[2] and C. Schindler[1]

[1]Institute for Rail Vehicles and Transport Systems (IFS), RWTH Aachen University, Germany
[2]Plant Physiology Department (iPP), RWTH Aachen University, Germany
[3]crop.zone GmbH, Aachen Germany

Abstract

Vegetation on railway lines causes negative effects on the infrastructure and endangers the safe operation of railway systems as well as worker's safety. The current methods for vegetation control are primarily based on different herbicides, which in future might lose their approval by regulatory bodies.

This paper presents a systematic analysis of the state of the art for the selection of a nonchemical method for weed management. The aim is to compare different physical methods either individually or in combination and to evaluate their capacity for vegetation control.

The development and evaluation of such a method involves knowledge from the areas of biology, agriculture, railway technology and mechanical engineering, which is difficult to combine. In order to get an overview and to select the most promising methods, this paper presents a systematic analysis of the state of the art. Additionally requirements for a future method were gathered and used to rate the different methods. As a result, the most promising methods for weed management on railway tracks have been identified.

This work is part of a project commissioned by the German Centre for Rail Traffic Research at the Federal Railway Authority (DZSF at the EBA). It aims to build a

prototype and define procedures to allow sustainable and economically viable vegetation control on railway tracks.

Keywords: Herbicide-free weed management; railway infrastructure maintenance; vegetation management requirements; alternative methods for vegetation management

1 Introduction

Vegetation on railway lines can have negative effects that endanger the safe operation of railway systems as well as worker's safety. Especially on the ballast bed and the transition area, vegetation can damage the under part of vehicles, create a lubricant film on the rails reducing breaking power and block the ballast bed which causes a reduced draining capacity. This in return increases humidity in the ballast bed making the sublayers soft and unstable and decreasing the lifetime of infrastructure. [1]

Therefore, weed management is an essential element for reliable and secure operation of railway systems. Most European countries treat the direct track area with different foliar and soil herbicides. One of the most applied herbicides is Glyphosate, a foliar herbicide that raises ecological and health concerns. As a consequence, this substance might lose its approval by the EU in 2022 [2].

A total ban of the named substance would leave many European rail infrastructure companies with no approved alternative herbicide for replacement. Considering this it is inevitable to develop non-chemical methods of vegetation control that are effective, economic, environmental friendly and legally compliant.

Until now, no alternative method is known to be as efficient and sustainable as the combined usage of herbicides. The development of such method is an interdisciplinary task not only involving knowledge about railway technology but also the understanding of vegetation morphology and its biological reaction to herbicides and alternative methods. In addition, the alternative technologies for vegetation control are based on different working principles, e.g. electrical, thermal, mechanical, whose development or refining requires specialised engineering knowledge.

This paper presents a systematic analysis of the state of the art for the selection of a non-chemical method. The aim is to compare different physical methods either individually or in combination, to evaluate their capacity for vegetation control.

This work is part of a project commissioned by the German Centre for Rail Traffic Research at the Federal Railway Authority (DZSF at the EBA). It aims to build a prototype and define procedures to allow sustainable and economically viable vegetation control on railway tracks.

2 Methods

On the basis of the product development process [3], the state of the art of vegetation management on railway lines was analysed. According to the process, a list of requirements for the new product shall be specified. Furthermore, in a second phase, solutions fulfilling the demands shall be identified and evaluated against each other.

In this work the demands are given from all the factors involved to control weeds without damaging railway infrastructure but also from the characteristics of chemical methods applied until now, for they set the expectations in the new method. This process of collecting requirements was done by means of literature research concerning the following topics:

- Vegetation: Identification of common flora on railway tracks, mode of propagation, frequency of appearance, resilience to herbicides.
- Railways tracks: Definition of infrastructure components and their sensitivity to external factors, identification of possible risks, regulations and technical standards.
- Chemical methods: Effectivity, mode of action, working speed, energy requirement, costs, limitations (e.g. environment and health risks).

As solutions, the existing methods for vegetation control with possible application on railways were gathered. The requirement list was used to rate the different alternative methods and possible combinations but also to identify knowledge gaps, which need to be experimentally fulfilled. This second phase is a combination of literature research and data generated by experiments. Following topics were evaluated:

- Alternative methods: Effectivity, mode of action, working speed, energy requirement, costs, maturity of the technology, environment and health risks.

For the evaluation of the different methods, a point system for each of the mentioned topics was specified. This facilitates the identification of the methods with higher potential for further development.

3 Results

Most studies of common species on railway tracks list the species that were found without reporting the exact location (e.g. Brandes [4–6]); consequently, this literature review was extended by excursions to railway-lines. More than 300 species were found through literature research. Already 134 different species could be identified by own research on four different chosen test tracks.

The current chemical procedures combine different plant control mechanisms by using different substances (foliar and soil herbicides). Chemical methods are applied

once or twice a year reaching 40 km/h max. velocity. The costs are about 250 €/km [7].

The rail infrastructure can be roughly divided into constructional components and signalling equipment/electrical components. As most components have not been tested concerning aspects of possible future methods for vegetation management (e.g. electroweeding), the key parameters that can already be identified are gathered, to estimate the possible impact of any chosen new method.
In general these parameters can be divided into:

- Mechanical strength
- Electromagnetic compatibility
- Dielectric strength
- Temperature resistance
- Waterproofness
- Dimensions and position on the track

Apart from the vegetation itself and the existing railways installations, requirements were gathered in respect of economical, technical and legislative points of view. 22 requirements comprising the general operation of the methods and 13 requirements concerning the interaction between method and infrastructure were formulated. Some examples are effectiveness against different plant parts (roots, leafs or seed), maximum treatment speed, number of necessary treatments per year, total energy demand and possible hazards for human, animals and environment.

A total number of 18 alternative methods have been identified from systems existing in railway sector as well as from agricultural and urban applications and methods, still undergoing research (see Table 1). Applications for rail-bound vehicles can be found for electro-weeding [8], hot water [9, 10], infrared [11], mulching [12, 13], and suction [12, 14].

mechanical	thermal	radiation (non-thermal)	electric
Brushing	Hot water	UV-C	Electrical current
Mowing / Mulching	Steam		
Pressurised water	Hot foam		
Extraction by suction	Infrared		
Mechanical weeding / epilating	Freezing (CO_2, or liquid N_2)		
Manual weeding	Hot air		
	Burning		
	Microwaves		
	Laser (cutting)		
	Laser (overheating)		

Table 1: Alternative methods.

Information regarding the application of the methods on ballast bed is limited. The data generation for all methods is complex and unnecessary for not promising solutions. For this, a literature research and some experiments filling gaps were performed, at first instance, to compare the methods among the 22 general criteria. Afterwards, solutions showing potential were theoretically evaluated under railways requirements. Possible hazards were identified.

4 Conclusions and Contributions

With the previous work, the state of the art to develop a non-chemical method for weed management in the railway lines was elaborated. Under this systematic analysis, an overview of the requirements for the new methods as well as of the possible solutions with their strengths and weaknesses was created. It has been concluded that no method by itself can conduct a proper vegetation management. A combination of two or more methods is necessary.

Methods able to attack the plant root, have been identified as highly potential due to the reduction of number of applications per year, energy consumption, risk and in general the costs. This effect can only be achieved by electrical and certain mechanical methods. Thermal methods show an effect in the upper layer (10 to 15 cm) of the soil, having a very limited effect on plants situated in the ballast bed, since their roots are located in deeper layers of the railway infrastructure. Besides the limited operational capabilities of thermal methods, their high energy consumption has also been identified as a major disadvantage, as it directly correlates with the efficiency of the treatment and, depending on the chosen thermal method, is difficult to realise using renewable energy sources.

Working speed is another important parameter for vegetation management on railway tracks. Vehicles with low speed disturb the traffic flow as well as the proper operation of certain signalling systems. This is a disadvantage especially for radiation methods (e.g. UV-C) which need long exposure times for an effective application.

Besides the theoretical evaluation of the selected alternative methods under the infrastructure requirements, there is a need for further fundamental research to fully understand the action mechanisms of the selected methods on the ballast bed. The identified hazards must be assessed as well. Therefore information about the plants' behavior in ballast needs to be determined.

In the coming project phase, a prototypical vehicle carrying the promising methods will be designed and used for further tests to meet the research needs. In this way, the selected solutions will be progressively optimised so that a proper combination of methods can be achieved. In addition to testing and adapting the prototype, ongoing monitoring of vegetation in the track is conducted to contribute to the overall understanding of the effect of the prototype on vegetation.

Acknowledgements

The authors acknowledge the support of Rurtalbahn GmbH enabling the use of their railway tracks as well as the support of C. Langenbach and the DZSF.

References

[1] M. Below, H. Kuppelwieser, and F. Gächter, “UIC “Vegetation Control” Project,” 2003.
[2] Commission Implementing Regulation (EU) 2017/2324 of 12 December 2017.
[3] Entwicklung technischer Produkte und Systeme: Gestaltung individueller Produktentwicklungsprozesse, VDI 2221, VDI, Berlin, 1993.
[4] D. Brandes, “Hauptbahnhof Rostock: Exkursionsnotizen zur Flora,” Institut für Pflanzenbiologie der TU Braunschweig, 2002.
[5] D. Brandes, “Bahnhof Freising: Exkursionsnotizen zur Flora,” TU Braunschweig, Oct. 2002.
[6] D. Brandes, “Zur Flora des Bahnhofs Halberstadt,” TU Braunschweig, 2004.
[7] Deutscher Bundestag, Ed., “Kosten von Alternativen zu klassischen Breitbandherbiziden: Antwort der Bundesregierung auf die Kleine Anfrage der Abgeordneten Karlheinz Busen, Frank Sitta, Dr. Gero Clemens Hocker, weiterer Abgeordneter und der Fraktion der FDP,” Berlin Drucksache 19/15447, Nov. 2019.
[8] Certis Europe Railservice, Prospekt Railservice.
[9] C. Bohren, G. Adolph, and L. Tanner, “Wirkungsvergleich Heißwasser und Herbizid” 29. Deutsche Arbeitsbesprechung über Fragen der Unkrautbiologie und -bekämpfung, 2020, doi: 10.5073/jka.2020.464.063.
[10] M. van der Meer and S. Buholzer, “Vorprojekt «Begrünung von Geleise-Banketten und Vegetationskontrolle ohne Herbizide»: Bericht zur Machbarkeitsstudie 2018”, 2019.
[11] E. Atmatzidis and S. Behrendt, Ökologischer Vergleich der Verfahren zur Vegetationskontrolle bei der Deutschen Bahn AG unter Berücksichtigung von Kostenberechnungen. Berlin: IZT, 1995.
[12] R. Nolte et al., HERBIE - Guidelines, State of the Art and Integrated Assessment of Weed Control and Management for Railways. Paris: UIC-ETF, 2018.
[13] Niedersächsisches Ministerium für Ernährung et al., “Vegetationsmanagement an Bahntrassen der Deutschen Bahn AG in Niedersachsen: Ein Leitfaden für die Zusammenarbeit zwischen Naturschutz-, Waldbehörden und DB”, 2019.
[14] C. Müller et al., “Vegetationskontrolle auf Bahnanlagen,”, 2001.