Session 2 : Train application – State of the art and parameters to be inspected (TWG 7)

Testing of weed seeking systems for spray trains - development of a test procedure

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Introduction

G&G is a Hungarian company working as a service provider within the field of vegetation control on railroad tracks. Due to the fact that organic matters can reduce the necessary elasticity of the track installation, weed control is an important issue for the safety of railroad traffic in general. For this reason weed growth in the roadbed and alongside has to be controlled continuously, whereat due to the total size of the railroad network the application of herbicides is the only procedure being economically in our days. From an environmental and also economical point of view the spraying should only take place if weeds really exist within the target area. If not, spraying should be interrupted in order to avoid the disposal of herbicides and to safe them. For this reason G&G has developed a precision spraying system for weed control on railroad tracks, consisting of weed detection and mapping unit as well as a controllable spraying device being able to apply herbicides on nine different segments separately within the target area (Fig. 1).

Therefore a project has been initiated with the aim to establish methodologies to determine the quality of the weed detection and mapping system as well as the quality of the precision spraying device related to the target area. The objectives of the project was to determine the

- sensitivity and accuracy of the weed detection system with different speeds of the spray train,
- influence of different lighting conditions on the detection system,
- longitudinal distribution of the application system,
- lateral distribution of the application system and the
- switching delay of the application system.

To figure this out empirical experiments on a test track were done using pieces of artificial turf of different sizes for the measurement of different parameters being able to characterize the accuracy of the application.

Fig. 1. Spray train spraying the side of the railroad track. The weed detection unit is in front of the locomotive (between the headlamps) (Phot. G&G).

Material and Methods

The tests were done on a railroad track in Deszk (Hungary). In preparation of the tests the whole test site was treated with a total herbicide on a length of two kilometers weeks before in order to destroy all green plants which could influence the experiments. Within the test site three test tracks with a total length of 150m each were calibrated and marked in five meter steps with paint.

The spray train has a total working width of 8.06m and is equipped with a multitude of nozzles on a support frame beneath the wagon (Fig. 2). The application of herbicides can be done in nine different sectors parallel to each other but also independently from each other. The onboard operating unit gets the information which nozzle has to be opened or closed from a sensor system located in front of the train (cf. Fig. 1). This system is able to detect different shades of "green" within the target area. From this information a weed map is compiled and used as a basis for the control of the herbicide application (Fig. 3). The system also compiles an additional map showing all areas where an application of herbicides had been done. Together with the GPS-data these maps are also used for reasons of documentation. The spray train is equipped with a system of direct injection being able to apply four different herbicides at same time.

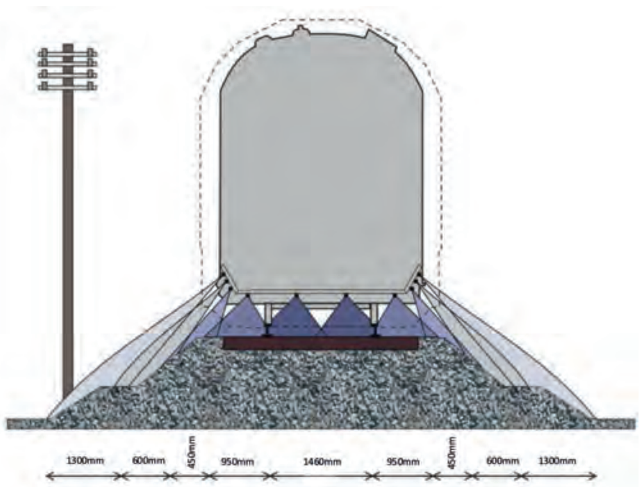

Fig. 2. Schematic image of the spray train showing the position of the nozzles and the nine different sectors were it is able to perform the application separately from each other. (Phot. G&G).

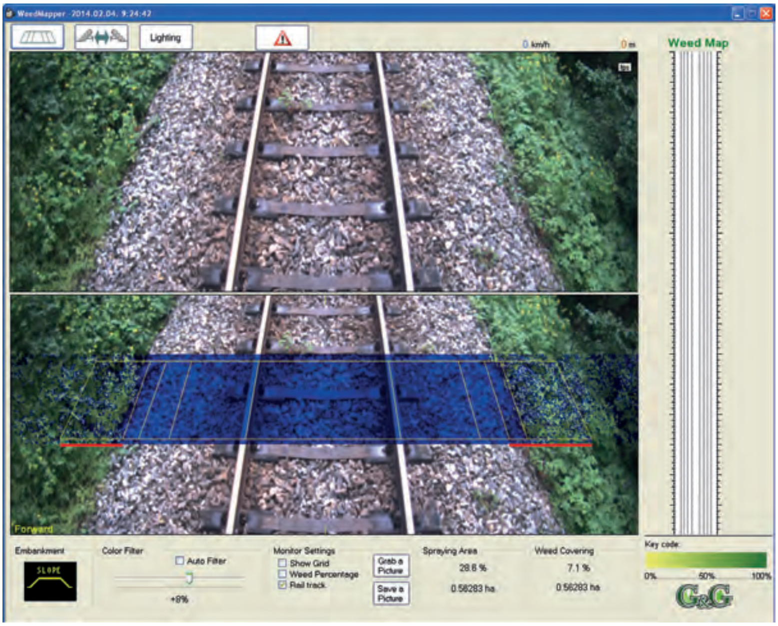

Fig. 3. Screen-shot of the control program of the spray train. Above the tracks are shown from the position of the weed detecting system, beneath are the nine different sectors which can be used for autonomous application. On the right side a weed map is compiled with all detected weeds and their GPS position. (Phot. G&G).

The sensitivity and accuracy of application was tested in the first test procedure using samples of different sizes (3x3cm, 5x5cm, 10x10cm, 20x30cm and 30x40cm) made of artificial turf. A total number of 50 of these samples were placed in a certain design within all sectors of the railroad track. Beside each sample a piece of water sensitive paper of same length as the sample was placed for application control. The experiments were done with different speeds of the spray train (40 km/h and 60 km/h) and were repeated twice. The spray train performed the application using pure water on a basis of 350l/ha. The following picture shows a scored test object (4).

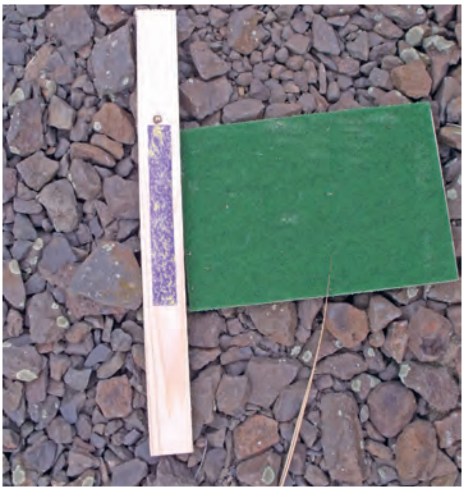

Fig. 4: Scored test object along the test track being 20x30cm of size. (Phot. Pályi)

To find out about the longitudinal distribution of the application system was the objective of the second test procedure. This test was important to answer the question in which distance to a detected test object the application starts, from which distance to the test object the application dose was a 100% and how far behind the test object these 100% would last and when did the application ended. Therefore, the test tracks were loaded with 95 test objects of different sizes (5x5cm, 10x10cm, 20x30cm) in a certain design. The test was repeated once. In this and all following test procedures a 0.25% nigrosine solution was used with an application dose of 350l/ha. Instead of water sensitive paper the test objects were equipped with filter paper. The filter paper was laid out 4m before and 4m behind the test objects (Fig. 5). The decision where the application started/ended and where it reached a dose of 100% was made by sight inspection.

Fig. 5. Measurement of the longitudinal distribution of the spray train with filter paper. (Phot. Wegener).

Within the third test procedure the lateral distribution of the application system was tested using 95 test objects of different sizes (5x5cm, 10x10cm, 20x30cm) in a certain design. In this context not the variation-coefficient was aim of the test, but the question if the application system confirms its total working width and the working widths of each separate sector under practical conditions. Furthermore it was tested how the spraying systems behaved if a test object is right in between two sectors. The test was done at a speed of 40km/h and was not repeated. The quality of the lateral distribution was judged by sight inspection.

Fig. 6. Testing the lateral distribution of the spray train with filter paper. (Phot. Wegener).

To test the influence of different lighting conditions on the weed detection system was the aim of the fourth test procedure. All three test tracks were used for this experiments at five different times (6:40 a.m., 12:10 p.m.,6:45 p.m., 8:45 p.m., 9:50 p.m.) and loaded with 95 (test track 1) and accordingly with 37 (test track 2 & 3) test objects of different sizes (5x5cm, 10x10cm, 20x30cm) in a certain design. The test was done at a speed of 40 km/h. The decision if the test object were scored by the spray train was made by sight inspection of the filter paper laid out beside the test objects.

In the fifth test procedure the determination of the switching delay of the application system was the aim of the experiment. In order to find out two marks with a distance of 150m were painted on one test track. The GPS-data of the positions marked were uploaded to the spraying system. The area in between those two marks was simulating a "restricted area" where the application of herbicides is forbidden. Within the experiment the spray train drives down the track with running application and should shut down the application system as close as possible before the first mark and start the application again as close as possible behind the second mark. In order to determine the switching delay 4m of filter paper were laid out before and behind the two marks. The results were analyzed by sight inspection.

Results

As a result of the methods used to judge about the weed detection system and the quality of the spray train´s application a number of tables were composed (Fig. 7). Within these tables the weed map and spray map compiled from the computer system of the spray train were combined with the design of the placement of the test objects and the results of the sight inspection. Thereby, these tables include all information about the tests done in one figure. In a further step all of these tables were analyzed according to misdetection (detection and application without the presence of a test object) of the system.

Distance to zero-point [m]	Banquet ri.	Bank ri.	Shoulder ri.	Rail ri.	Middle	Rail le.	Shoulder le.	Bank le.	Banquet ri.
0,53	0 0	0 0	0 0	0 0	0,5 1 1	0 0	0 1	0 0	0 0
1,64	0 0	0 0	0 0	0 0	0 1	0 0	1,5 1 1	0 1	1,5 0 0
2,20	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 1	0 0
2,75	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 1	0 0
3,86	3,5 0 0	0 0	0 0	0 0	0 0	0 0	0 1	3,5 0 0	0 0
5,53	0 0	0 0	0 0	0 0	0 0	0 0	0 1	0 0	0 0
6,64	0 0	0 0	0 0	0 0	0 0	0 0	0 1	0 0	0 0
7,75	0 0	0 0	0 0	0 0	0 0	0 1	7,5 1 1	0 0	0 0
8,87	0 0	0 0	0 0	0 0	0 0	0 1	0 1	0 0	0 0
9,98	0 0	0 0	0 0	0 0	0 0	9,5 1 1	1 1	0 0	0 0
10,54	0 0	0 0	0 0	0 0	0 0	0 1	10,5 0 1	0 0	0 0
11,65	0 0	0 0	0 1	0 0	0 0	0 1	0 0	0 0	0 1
12,76	0 0	0 0	0 1	0 0	0 0	12,5 1 1	0 0	0 0	0 1
13,32	0 0	0 0	13,5 1 1	0 0	0 0	0 0	0 0	0 0	1 1
13,87	0 0	0 0	0 1	0 0	0 0	0 0	0 0	0 0	14,5 0 1
16,10	0 0	0 0	1 1	0 0	0 0	0 0	0 0	0 0	0 0
16,65	0 0	0 0	16,5 0 1	0 0	0 0	0 0	0 0	0 0	0 0
17,76	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
18,87	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
19,98	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
21,09	0 0	0 0	0 0	0 1	0 0	0 0	0 0	0 0	0 0
22,20	0 0	0 0	0 0	22,5 0 1	0 0	0 0	0 0	0 0	0 0
23,31	0 0	0 0	0 0	0 1	0 0	0 0	0 0	0 0	0 0

Detected Area | Applicated Area | Objects scored | Objects not scored

Fig. 7. Example showing the tables being composed to jugde about the working quality of the weed detection systems and the application system of the spray train. The first column shows the distance of the measured event from the zero point of the test track. The following columns show each of the nine sectors.

Lessons learned

What can be learned from this test procedures is, that first of all the tests done are quite extensive, complex and expensive. The preparations (herbicide treatment of the test tracks) have to be done weeks in advance and a test track has to be available at all. The positioning of the test objects including water sensitive or filter paper along the test tracks is time and staff consuming. Due to the repetitions done concerning the tests under different lighting conditions the work days have been quite long, too.

The utilization of 0.25% nigrosine solution combined with filter paper is a sufficient method in order to judge about the working quality by sight inspection. What could be enhanced is the test object itself. Concerning the sensor system the artificial turf used is only a 2-dimensional object. A result of the first experiment was that test objects being smaller than 5x5cm are not detected under any circumstances. Despite this fact the sensor and the spraying system often triggered at positions where no test objects were laid out. In these cases we usually found "green objects" on the tracks (e.g. garbage, drifted leaves, sprouting weeds) which were mostly smaller than 5x5cm. From this experience we assume that the utilization of 3-dimensional test objects would be a better way in order to judge the whole ability of the weed detecting system. Furthermore, the repetition of the test under different lighting situations is a very important thing which must be done in order to judge about the quality of the weed detector, since the impact of different lighting conditions on the results can be significant under certain circumstances.