Testing of work quality characteristics of real-time precision application technology

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Összefoglalás

Napjainkban a szigorú környezetvédelmi előírások megkövetelik a vegyszertakarékos, környezetkímélő, pontos kijuttatást. A G&G Kft. Szeged (a Szegedi Tudományegyetem és a Pannon Egyetem közreműködésével) kifejlesztett egy olyan gyomfelismerő, gyomfolt permetező rendszert, amellyel megvalósítható a vasúti pálya mentén lévő gyomfoltok precíziós kezelése. Ez a permetező vonat egy optikai érzékelővel rendelkezik a gyomborítottság mértékének felismeréséhez a sínpálya mentén, annak kilenc különböző szektorában, és képes ezeket célzottan növényvédő szerekkel szelektíven kezelni.

A berendezést szabadalmaztató, gyártó és üzemeltető G &G Kft. 2014-ben megbízást adott a Julius Kühn Institut, Braunschweig és a PE Georgikon Kar Agrárműszaki Tanszéke részére a permetező vonat kijuttatási pontosságának felülvizsgálatára. A vizsgálati feladatok közé tartozott az érzékelő minimális szenzitivitásának, a detektálás és kijuttatás pontosságának, a permetezési pontosság különböző fényviszonyok (napszakok) melletti reprodukálhatóságának, valamint a helymeghatározás (GPS) pontosságának mérése, értékelése.

Az eredmények összegzése alapján megállapítható, hogy a gyomfelismerési érzékenység vizsgálatánál, 40 km/h sebesség mellett, a 100%-os biztonsággal felismert mintalap méret 5x5 cm volt. A gyomfelismerés pontossága, ill. a detektálási hiba szempontjából nem az egyes permetezési sávok, hanem a különböző napszakok (fényviszonyok) mérési adatai között tapasztaltunk nagyobb eltéréseket. A berendezés kielégíti az általános és feladatspecifikus munkaminőségi követelményeket, alkalmazásával egy gazdaságos, vegyszertakarékos, környezetkímélő, automatikus, célzott permetezési technológia valósítható meg.

Kulcsszavak: permetező vonat, pontosság, szenzitivitás, gyomfelismerés, célzott permetezés

Abstract

Nowadays strict environmental regulations prescribe the economical use of chemicals, their environmental friendly and precise application. The G&G Ltd. in Szeged (with the contribution of Szeged University and the University of Pannonia) developed a weed detection and weed patch spraying system that makes the precise control of weed patches possible along railway lines. This spraying train is equipped with an optical sensor to detect the amount of weed by the railway lines in its nine different sectors and it is able to apply targeted control by using herbicides selectively.

In 2014, the G&G Ltd., the manufacturer and operator, which took out the patent for the equipment, requested the Julius Kühn Institut, Braunschweig and the Department of Mechanisation at the University of Pannonia, Georgikon Faculty to supervise the application precision of the spraying train. The task was to measure and evaluate the minimal sensitivity of the sensor, the precision of detection and application, the precision of spraying during different parts of the day, and the precision of the GPS.

After summing up the results, it can be established that at a speed of 40 km/h the size of the sample sheet detected 100% was 5 x 5 cm. After examining the precision of detecting weeds and detecting mistakes the biggest deviations can be observed between the measurement data of the different parts of the day (lighting) and not between the spraying sectors. The appliance meets the general and task specific work quality requirements, its application can provide economical, environmental friendly, automatic and targeted spraying technology, which uses chemicals sparingly.

Keywords: spraying train, precision, sensitivity, weed detection, targeted spraying

Introduction

The dual aim – the protection of our environment ensuring the efficiency and quality of plant protection – demands the improvement of the precision of application, besides the decrease of the use of active substance. To achieve this aim it is essential to develop the methods of application technology, to introduce new, up-to-date technical solutions, to decrease losses and to ensure targeted application.

Besides the application of pesticides in agriculture there is another special but important field: the solution of weed clearing next to railway lines. The G&G Ltd. Szeged has been clearing weeds along the railway lines with its equipment developed on their own since 1997. As a result of continuous development –, cooperating with university research workshops (Szeged, Keszthely)- the traditional appliance that used a lot of chemicals was converted into a precise, environmental friendly spraying train that ensured targeted spraying and used real-time system (Gaál-Szatmári-Pályi, 2004). In the EU we cannot find any railway spraying systems that use similar methods. This system was introduced to the representatives of European railway companies in a successful, professional meeting in Brussels on 12 June 2008 (Pályi, 2008). The recognition of the technology is shown by the fact that since 2008 several EU states (Austria, Belgium, Denmark) have ordered weed clearing by the spraying train that was built and installed by them for their railway companies.

According to the 8th article of the 2009/128/EK Directive of the European Parliament and the EU Council, which determines the common framework of the sustainable use of pesticides, the EU states ensure the examination of the spraying appliance installed on trains at least once until 26 November 2016. Moreover, the member states ensure that the above-mentioned appliances are examined regularly.

Before issuing the final Hungarian requirements in the form of a decree the G&G Ltd. had the complete, periodical and technical check-up of the appliance carried out in compliance with the 2009/128 EK Directive (24 June-9 July 2014), then they had the application, weed detection and repeatability tested on the railway line (26-29 August 2014). Our article shows the tasks, method and results of the latter test program. The tests, processing and evaluation of the measurement data were carried out by the Department of Mechanisation of the University of Pannonia, Georgikon Faculty and the JKI Institut für Anwendungstechnik im Pflanzenschutz (Braunschweig) and by (Dr. Alfréd László), retired head of department at the University of Pannonia as an expert. We also gave an account of the new method of weed detection previously in the SPISE 5 Workshop, (Wegener-Rautmann-Pályi-László, 2014).

Material and method

The examined spraying system consists of an optical based weed detection unit equipped with a camera, a hydraulic spraying appliance, and a computerised controlling and data processing sub-system. The principal of application: the necessary chemicals in the required amount are added into clear water flow right before nozzles and sprayed on the detected weed patch by the weed detection system in each spraying sector in real-time mode.

9 spraying sectors were made on the target surface by the spraying appliance at cross resolution. (figure 1). In order to level the big range of speed (40-60 km/h) the spraying appliance consists of 9 modules that operate 4-4 nozzles (15-30-50-70 slotted nozzles) and only the necessary nozzles work depending on the dose and the speed.

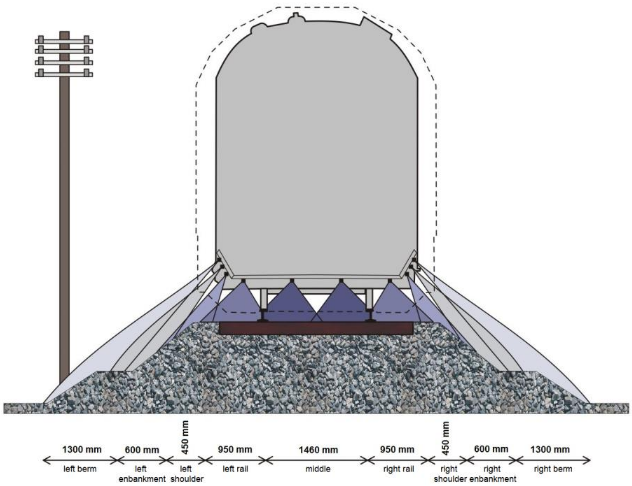

Figure 1. 9-section spraying frame to spray embankments

The liquid circle of the 4 chemicals has the same structure: Membrane pumps feed the agents into a common flow pipe then the necessary amount of chemicals is set by the rev of the hose pumps.

A self-developed weed detection system was installed when the postmergent applications by trains were carried out. The system checks the railway line automatically on the way and it applies spraying only where there are weeds. This real time weed detection and the weed patch application in sectors meet the most demanding environmental requirements as it applies place specific technology and uses chemicals sparingly. The train is suitable to work at night as well and there is continuous meteorological measurement and data recording on board.

Testing took place next to Deszk on the railway line (between Szeged and Makó), from 26 to 29 August 2014.

We did not have an approved standard for the testing method therefore the first step was to prepare a plan by an expert which was made more precise and finalised after being conciliated by the contributing places of research (P.E. Georgikon Faculty and JKI Braunschweig). For the test line 3 weed free sample areas were created, each of them was 150m long (marked as 1, 2, 3,). On the basis of 1-1 manual sample map, sample sheets covered with artificial grass (figure 2) were positioned precisely and their spraying was checked and evaluated. The sample sheets had different sizes. (3 x 3 cm, 5 x 5 cm, 10 x 10 cm, 40 x 30 cm). After measuring the precision of spraying, the detection fault and the previous determination of minimal sensitivity, we decreased the number test surfaces and we used only the 5 x 5 cm, 10 x 10 cm and 20 x 30 cm sample sheets. We carried out the tests in 4 periods of the day (at dawn, at noon, at dusk and at night) with one repetition therefore the influence of the different light conditions could be tested as well. Besides the sample sheets covered with artificial grass, we applied water sensitive paper to test sensitivity, and filter paper (with 0.25% Nigrosin marker) at the other tested parameters. The spraying speed was 40 km/h, (at the determination of minimum sensitivity it was 40 and 60 km/h), the spraying norm was 350 dm^3/ha. Depending on the sample area we used 37-37-95 sample sheets per measurement, (when we measured sensitivity we used 50).

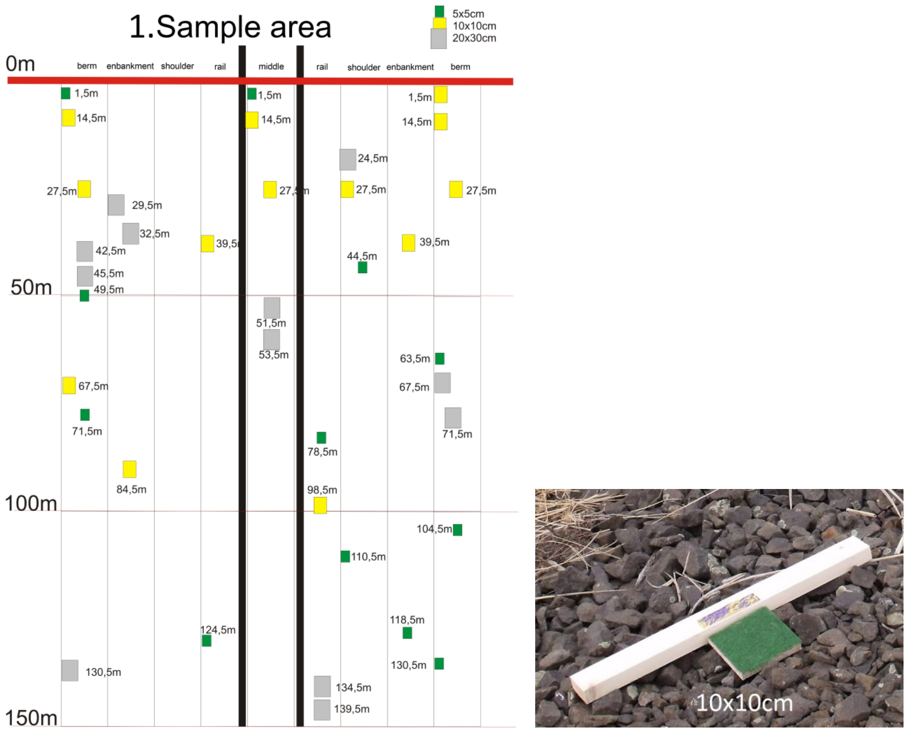

Figure 2. Map of sample area, sample sheet with artificial grass and water sensitive paper

Summarised tests, parameters:

- The measurement of minimum sensitivity. It is necessary to give the rate of percentage for the weed patch sizes and the size which was identified 100%. Sample area (1 and 3): 50-50 pieces of artificial grass and water sensitive paper of the same length along with them.
- Precision of weed identification, examination of mistakes of detection and their reproduction and different lighting (part of the day). Evaluation of the target precision of yes-no spraying at different sectors. Sample area (1-2-3): 37-37-95 pieces of artificial grass with filter paper next to them.
- Examination of distribution lengthwise, measurement of spraying to the front and behind. Sample area (1): artificial grass with 4-4m of filter paper in front of it and behind.
- Examination of the distribution of spraying across. In the case of sample area 1 artificial grass and filter paper was laid across at 27.5 and 32.5m of the sector. In

sample area 3 at 44.5m artificial grass was laid at all sectors and next to it filter paper was put at right angles to the railway line along the whole working area.

- Examination of the precision of GPS controlled switching on and off mechanism at objects and level crossings. In sample area 3 at the points of switching on and off 8-8 m of filter paper was laid in direction of traffic.

Results and Discussion

As the first step of the whole examination the minimum sensitivity was determined. In the case of the smallest 3 x 3cm test surfaces the target precision (detected/total pieces) was not acceptable: at 40km/h it was 2 at repetition 3/11, at 60km/h 2 at repetition 1/11. The smallest size which was detected 100% was 5 x 5cm at 40km/h and over that size we did not perceive unattended surfaces. Higher speed (60km/h) increased the percentage of mistakes slightly. The average target precision was 96.2% for the weed patches at or over 5 x 5cm taking both speeds into consideration.

As a result, we measured the precision of weed detection, spraying and the reproduction in different lighting (parts of the day) from surfaces of 5 x 5cm (at 40km/h). Weed detection takes place at the same time with application in the 9 sectors independent from each other. (figure 3).

Figure 3. Camera photo

After comparing the maps of the sample areas, weed detection and spraying, target precision, false and missed detections and sprayed areas can be proved exactly (figure 4).

distance to zero point [m]	right berm	right enbank-ment	right soulder	right rail	middle	left rail	left shoulder	left enbank-ment	left berm
0,19	0 1	0 0	0 0	0 0	0 0	0 0	0 1	0 0	0 0
1,03	0 1	0 0	0 0	0 0	0 0	0 0	0 1	0 0	0 0
1,88	0 1	0 0	0 1	0 0	0 0	0 0	0 1	0 0	0 0
2,72	2,5 1 1	0 0	0 1	0 0	0 0	0 0	0 1	0 0	0 0
3,56	1 1	0 0	0 1	0 0	0 0	0 0	0 1	0 0	0 0
5,25	0 1	0 0	0 1	0 0	0 0	0 0	5,5 1 1	0 0	0 0
6,10	0 0	0 0	1 1	6,5 0 0	0 1	0 0	1 1	0 0	0 0
6,94	0 0	0 0	7,5 1 1	0 0	0 1	0 0	0 1	0 1	0 1
6,94	0 0	0 0	0 1	0 0	0 1	0 0	0 1	0 1	1 1
9,48	0 0	0 0	0 0	0 0	0 1	0 0	0 0	0 1	8,5 1 1
10,33	0 0	0 0	0 0	0 0	10,5 1 1	0 0	0 0	0 1	0 1
11,17	0 0	0 1	0 1	0 0	1 1	0 0	0 0	0 1	0 1
12,02	0 0	0 1	0 1	0 0	0 1	0 0	0 0	12,5 1 1	0 1
13,71	0 0	0 1	0 1	0 0	0 0	0 0	0 0	1 1	0 1
14,55	0 0	0 1	0 1	0 0	0 0	0 0	0 0	0 1	0 1
15,40	0 1	0 1	0 1	0 0	0 0	0 1	0 0	0 0	0 0
16,24	0 1	0 1	16,5 0 1	0 0	0 0	0 1	0 0	0 0	0 0
17,09	0 1	1 1	1 1	0 0	0 0	0 1	0 0	0 0	0 0
18,78	0 1	0 0	0 0	0 0	0 0	0 1	0 0	0 0	0 0
19,62	19,5 1 1	0 0	0 0	0 0	0 0	19,5 1 1	0 0	0 0	0 0
20,47	1 1	0 0	0 0	0 0	0 0	1 1	0 0	0 0	0 0
21,31	0 1	0 0	0 0	0 0	0 0	0 1	0 0	0 0	0 0
23,00	0 0	0 0	0 0	0 1	0 0	0 0	0 0	0 0	0 0
23,85	0 0	0 0	0 0	0 1	0 0	0 0	0 0	0 0	0 0

Positioned sample sheet

Detected sample sheet

Non detected sample sheet

Sprayed sector

Figure 4. Proof of target precision in a part of the sample area

After summing up the results we can establish that the average target precision of the real-time, yes-no spraying system was 92.8%, calculating the results of the spraying sections and the parts of the day (in the case of sample areas of 5 x 5cm or above). If we examine the precision of weed detection and detection mistakes we can see bigger differences between the measurement data of the different parts of the day (lighting) and not that of the spraying sections. The spraying target precision of the laid weed patches was the best at dusk (98.5%), however we could measure the most undetected test surfaces at dawn, facing the light, (in sample area 3), the mistakes of detection were the highest in this case. Its cause is that according to the sensor system the artificial grass test objects appear as 2 dimension target surfaces and they show very little contrast when lighting is unfavourable. As a result, we can decrease the rate of detection mistakes in the future if we apply 3 dimension surfaces which represent real surfaces covered with weed more efficiently.

A further task of measurement technology and development is to decrease the rate of false detection (detection without a real test object) because it is not the fault of the system but it happens if the area is not well-prepared. In some sectors the amount of green plant residues left behind was significant mainly on the berm.

The supervision of the distribution of length wise spraying in each sector proved the application and amount of front and behind spraying because of safety, control and stream technology. Its value increases together with the speed, at a higher speed e.g. 40km/h it reached 3 or 4 m as well. The position and the distribution width of the **cross** spraying sections were set precisely it derived from the nominal values within the margin of error. The sections were sprayed precisely, the width of distribution was slightly larger as a result of overlapping (e.g.: right rail 1000mm, middle 1500mm, left embankment 800mm.

The precision of the GPS controlled switching in and off mechanism was the same as that of the measurement results of the GPS controlled agricultural spraying machines (Herbst-Osteroth-Spranger 2012). The deviation is 0.1-0.4m. The values were checked by repetitions. It is such high precision that cannot be reached by traditional hand controlled systems at a high speed like this.

Acknowledgement

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