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Effect of sprayer boom movement on spray deposition and biological efficacy

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Summary

During the growing season of a potato crop late blight must be controlled with approximately 15 sprays. For each spraying, sprayer boom movement was measured for a sprayer passing along the same track over a field. We show how sprayer boom movements change during the growing season as tracks change due to repeated passage over them. Spray deposition was measured over a 10 m length (on collectors spaced at 50 cm intervals) to evaluate variations in spray deposition due to sprayer boom movement. Potato leaves were picked from this 10 m length also at 50 cm intervals to evaluate the correlations between spray deposition pattern and protection against late blight. Results show a clear relationship between changing sprayer boom movement patterns, spray deposition and biological efficacy.

Key words: spray deposition, sprayer boom movement, biological efficacy, late blight, *phytophthora infestans*

Introduction

The reduction of the emission of plant protection products to the environment is for a long period now an issue in the Netherlands (Zande *et al*., 2000a). Spray free and crop free buffer zones were introduced, to minimise the risk of mainly spray drift (Water Pollution Act, Plant Protection Act). The increase in efficiency of the application of crop protection products leads directly to a reduction of the emission. A better placement on the target and a more even distribution are ways to minimise the required dose. As dose is reduced concentration of actives in spray drift are reduced and therefore also the risk for the environment. This requires however more advanced spray techniques. Especially the effect of sprayer boom movements was seen as a source for variation of spray deposit (Jong *et al*., 2000a; Ooms *et al*., 2003) and biological efficacy in the field. It was assumed that during season, as sprayers move repeatedly through the same spray track, boom movements increase as the spray track becomes more pronounced. This can cause peaks and gaps in the spray applied and can possibly cause also the spots where late blight infections are seen first in the field. To evaluate the effect of the variation of spray distribution and biological efficacy in the field, a series of experiments were started. This paper describes the first results of the field experiments.

Materials and Methods

During the 2002 growing season a field trial was established in a potato-crop (cv. Agria) at the Oostwaardhoeve experimental farm. The field consisted of two pairs of two strips of a working width (24 m) wide in a potato field 200 m long, with a 3 m path in between the strips with bare soil surface. Row spacing of the potato ridges was 0.75 m. Potatoes were protected against late blight using the fungicide fluazinam (Shirlan Flow). Two strips received a full dose (0.3 liter ha^{-1} Shirlan) treatment and two strips a 50% dose. Fungicide treatments took place between 31-5-2002 and 3-9-2002 on a weekly basis (13 times). Throughout the season measurements of sprayer boom movement were done as the sprayer moved through the same track in the field. Spray deposition measurements took place on specific areas, and potato leaves were picked to evaluate protection against late blight (*Phytophthora infestans*) repeatedly through the season. A trailed 24 m "Hardi Commander Twin Force" sleeve boom sprayer was used. The sprayer was only used in the conventional, non air-assisted, way. The sprayer boom was equipped with TeeJet DG11004 nozzles operating at 3.0 bar pressure, producing a coarse spray quality (Southcombe *et al*., 1997). The forward speed was 6 km/h, resulting in a sprayed volume of 300 liter ha^{-1}. The sprayer boom height was set to 0.50 m above crop canopy. The trials to measure the deposition were conducted simultaneously with the trials of the biological efficacy measurements at the same plots in the potato crop.

Spray deposition measurements

The trial areas for the deposition measurements were placed in an array above the outside potato ridge next to the bare soil surface strip. The array of collectors was 10 m long and consisted of 20 filter material (Technofil TF-290) collectors each 0.5 m long and 0.10 m wide. Alongside the filter collectors also a 10 m length array of water sensitive paper (Syngenta; 0.5 m long, 0.02 m wide) was placed to visualise the variation in spray deposition along the array of collectors. At different times during the growing season deposition measurements were carried out simultaneously with the fungicide application. A fluorescent dye Brilliant Sulfo Flavine (BSF) was added to the spray agent (0.5 g/l). After the spraying, the dye was extracted from the collectors. Collectors to measure deposition in the crop were chromatography paper strips (Whatman No.1; 20 cm long x 2 cm wide), which were folded around and attached to the leaves with paper clips. The collectors were placed systematically at three leaf heights (top, middle and bottom), four collectors at each height (Zande *et al*, 2000b). Collectors, 1.00 x 0.10 m filter tissues (Technofil TF-290), were placed on the soil surface on and between the potato ridges to examine emission to the soil surface. Above the crop canopy also four filter collectors were placed on both side of the sprayer in the middle of the boom to measure total spray deposition (spray dose). For each measurement a single pass was made. Spray deposition measurements were replicated three times during the growing season (11-7, 1-8 and 5-9). The spray deposit per surface area of the collector was determined by fluorimetry (Perkin Elmer LS30). The measured deposits were expressed as percentage of the application rate of the sprayer (spray dose).

Sprayer boom movement

During spraying the boom position in the field was measured with a system (Jong *et al*., 2000b) consisting of a laser distance indicator (Sick DME200) and an ultrasonic sound (AE, P42-A4N-2D-1C1-130) height sensor. The ultrasonic sensor was connected at the end of the sprayer boom, to measure boom height over the open strip. The data of the ultrasonic was sent wireless (ADAM 4550) to the computer connected to the laser-measuring device. The system checked every 0.1 second the distance and height of the boom tip in the field. The height and the distance, together with the time were synchronised and recorded online. The data of a 10 m strip where the spray deposition collectors were placed were used for further analyses of the sprayer boom movement related to spray deposition and biological efficacy.

Biological efficacy

Simultaneous with the collection of the collectors of the spray deposition measurement potato leaves were picked from the second row of potato plants to evaluate the protection against late blight. From one potato plant at each half-meter of the test lane in the field trial two leaves close under the top were detached and placed in a cooler. Early next day the leaves were stuck in wetted oasis and placed in a plastic container. Five leaflets of each detached leaf were inoculated by placing a droplet (30 µl) of the zoosporangia suspension in the middle of the leaflet.

In this experiment the isolate "IPO-complex" of the fungus *P. infestans* was used. The preservation of this fungus took place on slices of potato tubers and potato leaves (cv. Bintje) under humid conditions at 15°C in the dark. An inoculum suspension of zoosporangia was made by rinsing a one-week-old culture of *P. infestans* with tap water. Inoculum density was assessed by counting the number of zoosporangia/ml with a haemocytometer and was adjusted to 10.000 zoosporangia per ml.

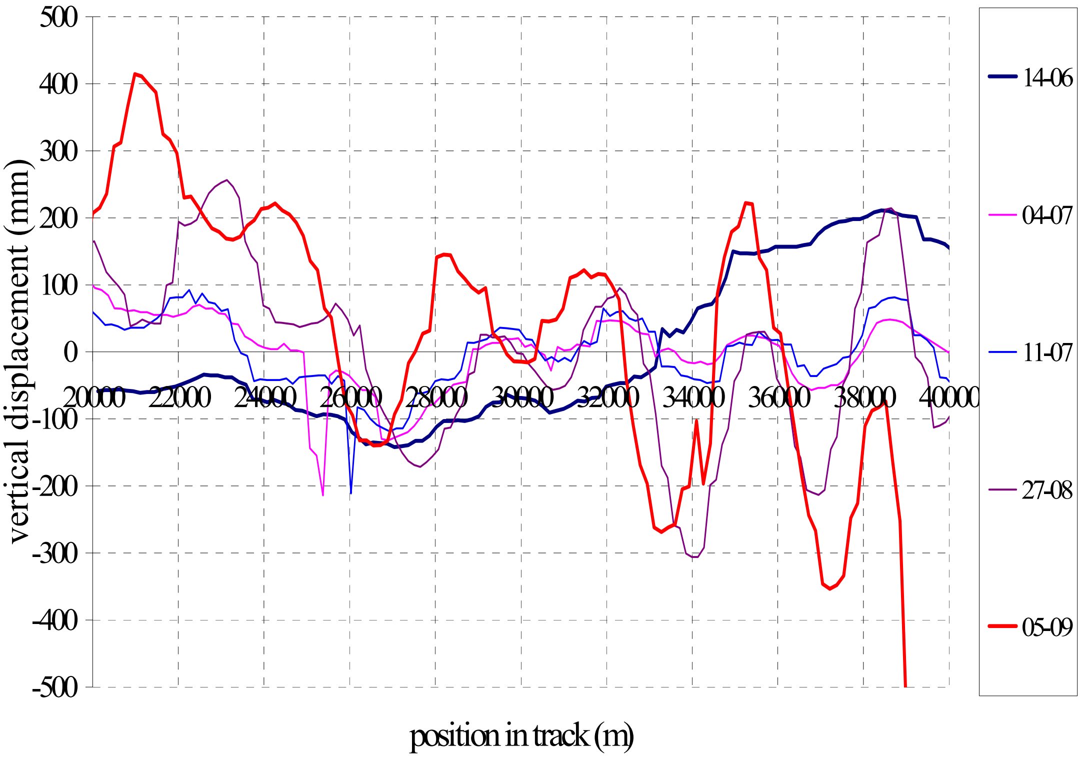
To maintain a high relative humidity during incubation the containers with the leaves were placed in plastic bags and incubated in a climate room at 15°C with a light period of eight hours. Six or seven days after inoculation disease assessment took place. Per treatment the leaflets with a lesion were counted and the percentage of diseased leaflets was calculated. Per leaflet the percentage of diseased area was estimated by using a picture index ranging from 0% up to 100% coverage. The sporulation on the lesions was assessed (yes or no) by naked eye or by using a stereo microscope (40x).

Results

Sprayer boom movements

During spray operations the vertical and horizontal position of the spray boom was measured. In figure 1 the positions relative to boom height and average sprayer speed are presented for different spray applications during the season. Both the vertical as well as the horizontal displacements are on the early spray dates (14-6, 4-7) smaller than further on in the season (27-8) and at (5-9). Early in the season boom movements are within a range of 5 cm where at the end of the season movements up to 50 cm do occur. Specific movements occurring on a certain place on one date do occur again on a next day in the same direction and on the same place. It is as if there exists a self-amplifying effect throughout the season. The rut pattern in the track becomes more pronounced after every pass of a spray application. Especially after a rain shower under moist conditions bumpiness of the track increased.

For the track length (50-60 m) where the deposition measurements were done standard deviation of the vertical and horizontal displacements increased (figure 2) also during the season. During first measurements standard deviation of the vertical movement was around 1-5 cm and at the end of the season 10-30 cm. The variation in boom tip speed also increased in time during the season (figure 2). The standard deviation in boom tip speed early in the season was around 0.15 m s^{-1} whereas at the end of the season it increases to 0.45 m s^{-1}. Average sprayer speed also changed during the season. Early in the season the measured speed was as set 1.6 m s^{-1}. At the end of the season more wheel slip occurred and sprayer speed dropped to 1.4 m s^{-1}. Gear and motor rpm were kept the same throughout the season.



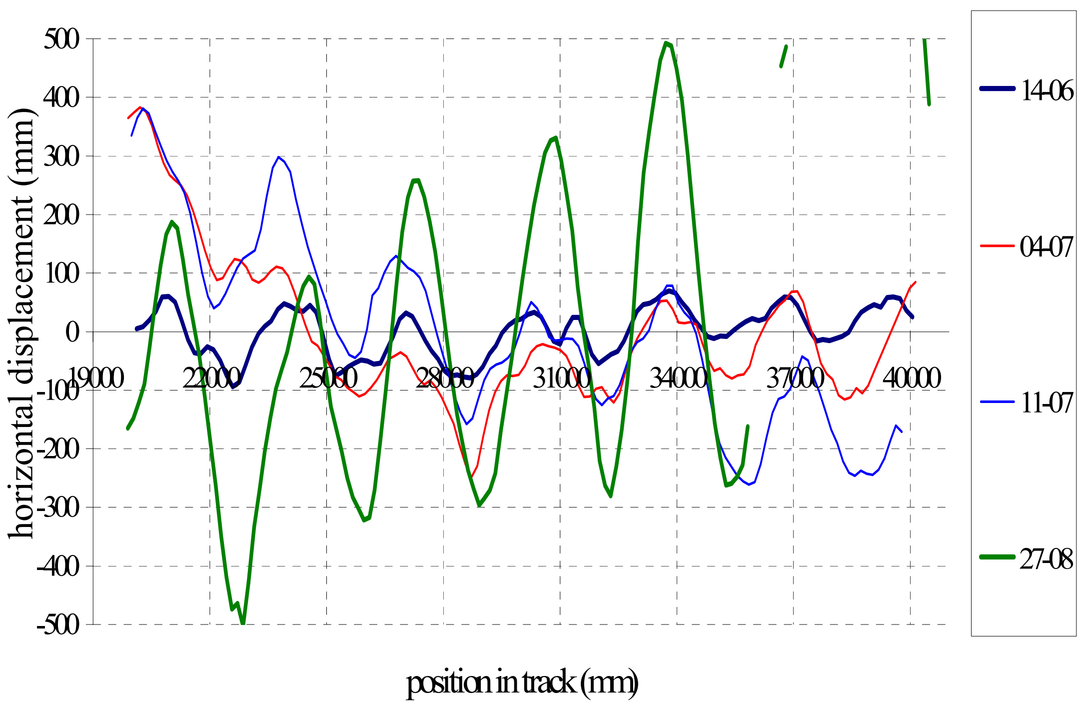
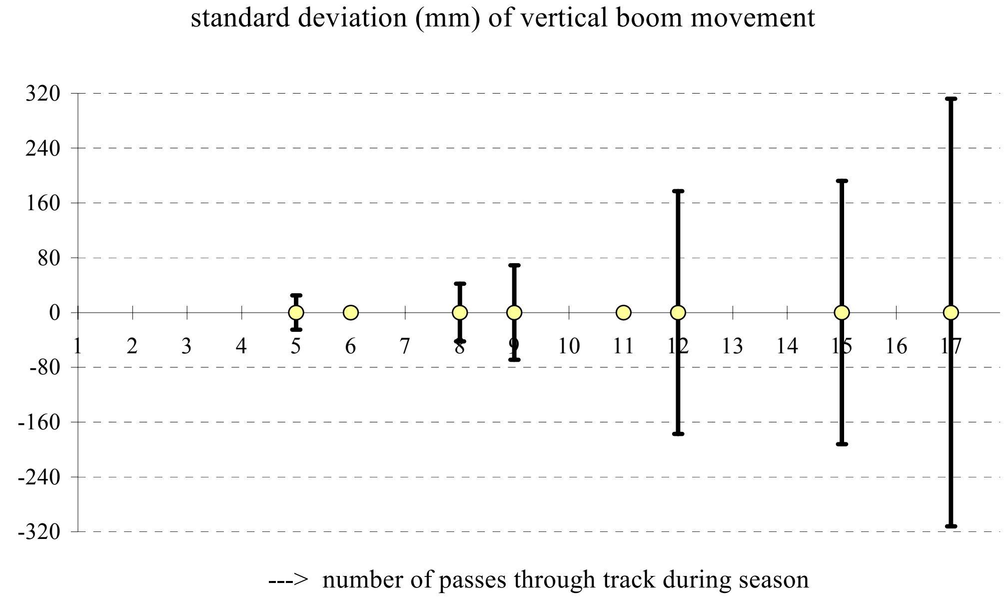


Figure 1: *Effect on vertical (top) and horizontal (bottom) displacement (mm) of the spray boom tip at one place (20-40 m) in the spray track on different spray application dates spraying potatoes*



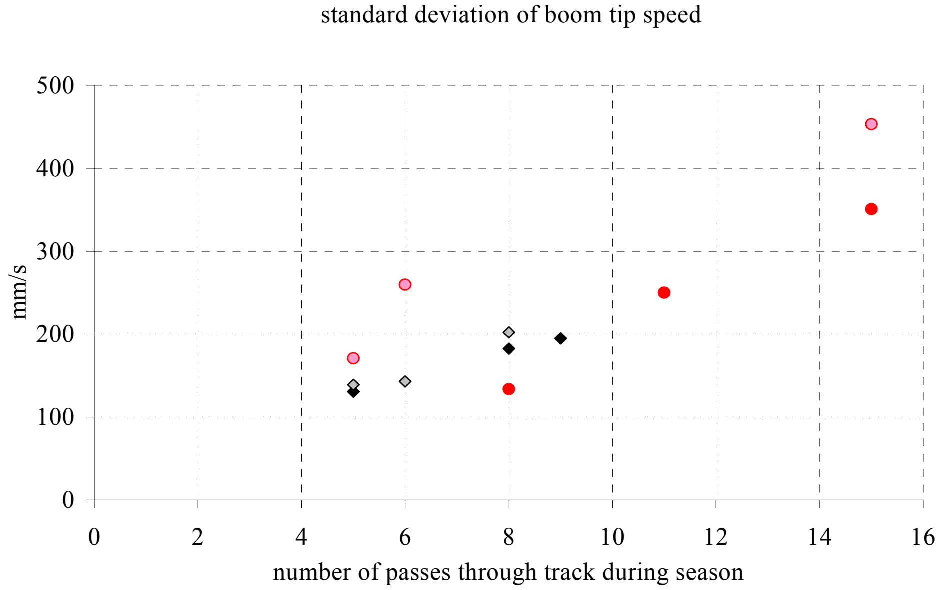


Figure 2: *Effect on variation in vertical boom movement (top, standard deviation; mm) and in boom tip speed (bottom, standard deviation; mm/s) because of repeatedly driving through the same spray track during the growing season, averaged for the four deposition measurement arrays (10 m track length)*

Spray deposition

On dates 11-7, 1-8 and 5-9 spray deposition measurements were performed. Spray deposition underneath the sprayer in the field and on the longitudinal array of 10 m at the boom tip had the same order of magnitude of variation (80-120%) of calculated applied spray volume. The variation in spray deposition at the boom tip is presented in figure 3. High and low values of deposition occurred more or less on the same place every time. Average spray deposit on the 10 m-length array increased during the season from 81% to 104% and 113% of applied spray volume for the respective dates. This change in average deposition can be explained by the decrease in sprayer speed, especially at the end of the season, because of wheel slip. The standard deviation in spray deposition increased for these dates respectively with; 19%, 32% and 35%. Therefore coefficient of variation in spray deposition for these dates changed from 24% to 31%.

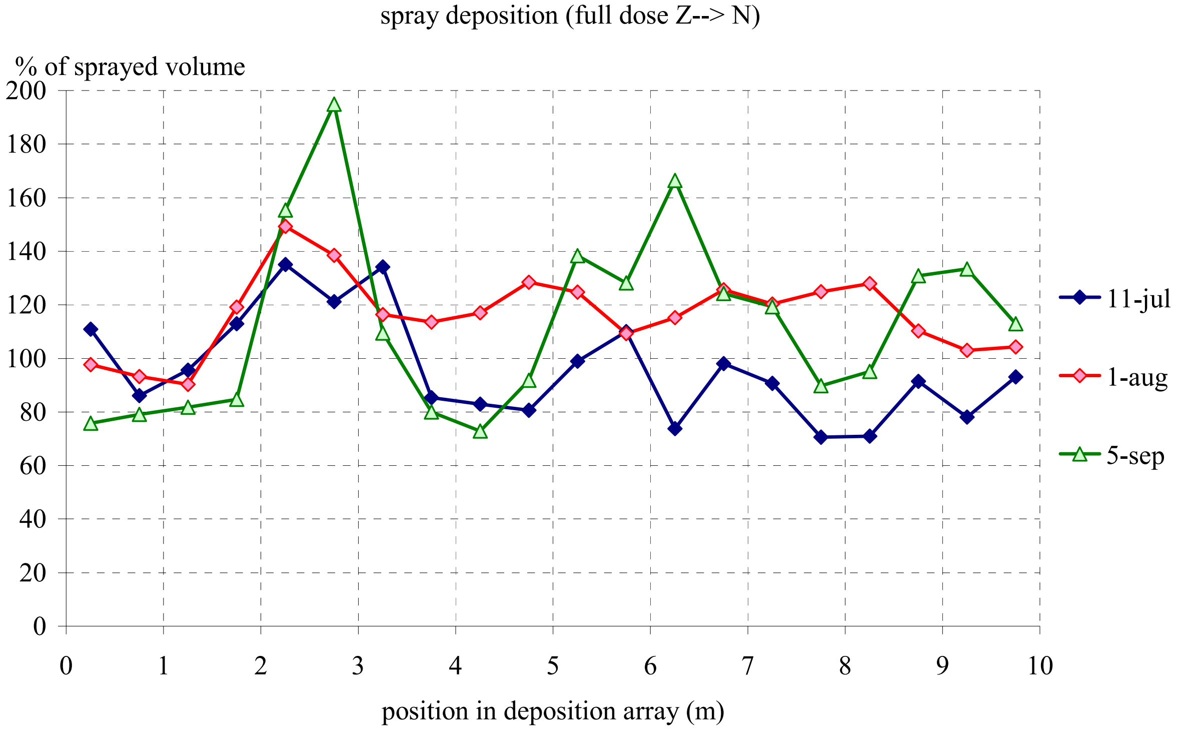


Figure 3: *Spray deposition (% of sprayed volume) measured over the same track length of 10 m (50-60 m) underneath the boom tip on different dates during the growing season when spraying potatoes*

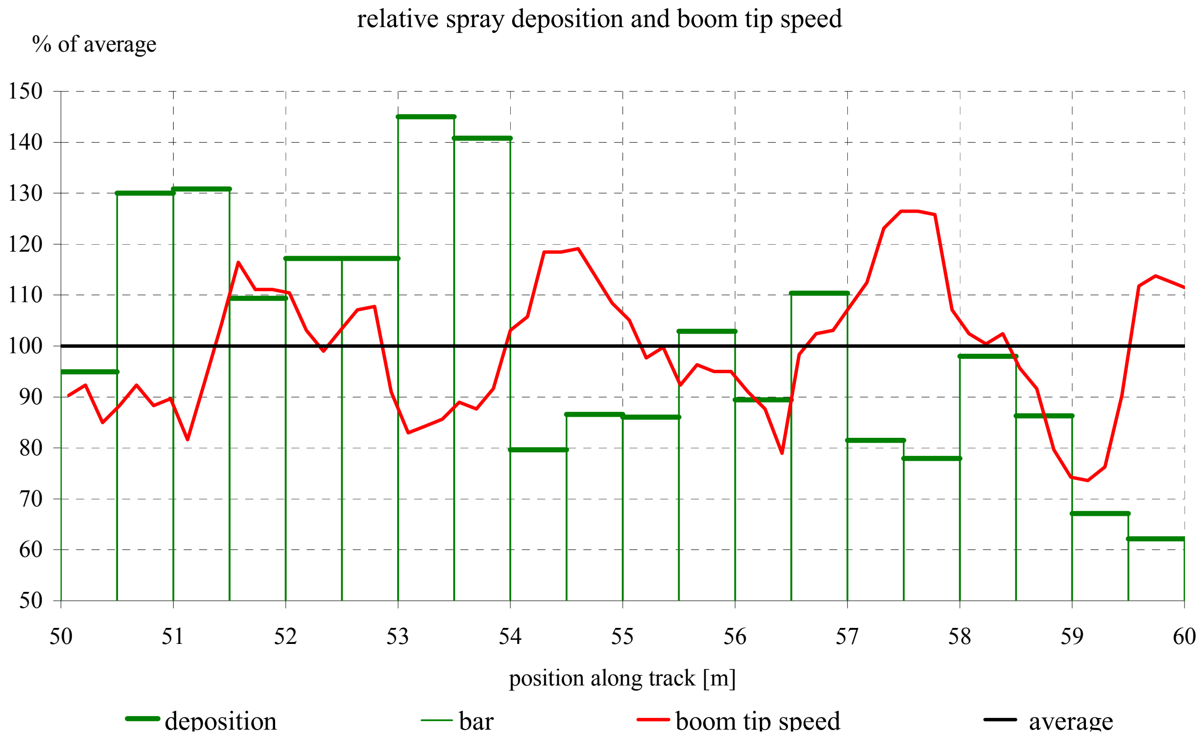


Figure 4: *Relation between the variation in sprayer boom tip speed around average (driving speed) and the variation in spray deposition underneath on top of canopy over a length of 10 m (50-60 m) along the spray track spraying potatoes*

The area underneath the boom with a deviation in spray deposit of 10% of average remained, for

these measurements, the same throughout the season 45%. Spray deposit on 20% of the area was lower than 90% of dose. For 35% of the area spray deposit was higher than 110% of dose. Lowest values of deposition can however be near 60%, and highest values up to 180% of initial intended spray volume.
The variation in spray deposition underneath the boom tip was closely related to variation in boom tip speed. An example is given (figure 4) for a measurement early in the season (11-7) in the half dose field. Higher boom tip speeds resulted in lower levels of spray deposition, as can be seen from the area 54-55.5 m and 57-58 m. Lower speeds resulted in higher levels of spray deposition as shown on the 53-54 m area (figure 4).

Biological efficacy

During spray deposition measurements also leaf samples were taken to evaluate the relation between the spray deposition and the protection against late blight infection. Along the 10 m measuring array 20 potato plants were sampled and the results of the bioassay infection for the measurement of 1-8 are shown in figure 5 for the half dose field. In the full dose field, infection levels were lower than in the half dose field. Large variations do however occur in both dose rates for the 20 plants, over the length of 10 m. Three peaks can be distinguished with higher spray deposition. Two of these high deposition peaks (place 12 and 18) coincide with lower levels of late blight infection. Highest value of infection was 87% with spray deposition being as low as 57% of applied spray volume (place 13). Place 12 has a low infection of 32% with a spray deposition of 145%. Sampled on 0.50 m collectors average spray deposition over 10 m length was 104% of sprayed volume, with a coefficient of variation of 31%. Average late blight infection on top leaves over the same 10 m length was 22% with a coefficient of variation of 39%.

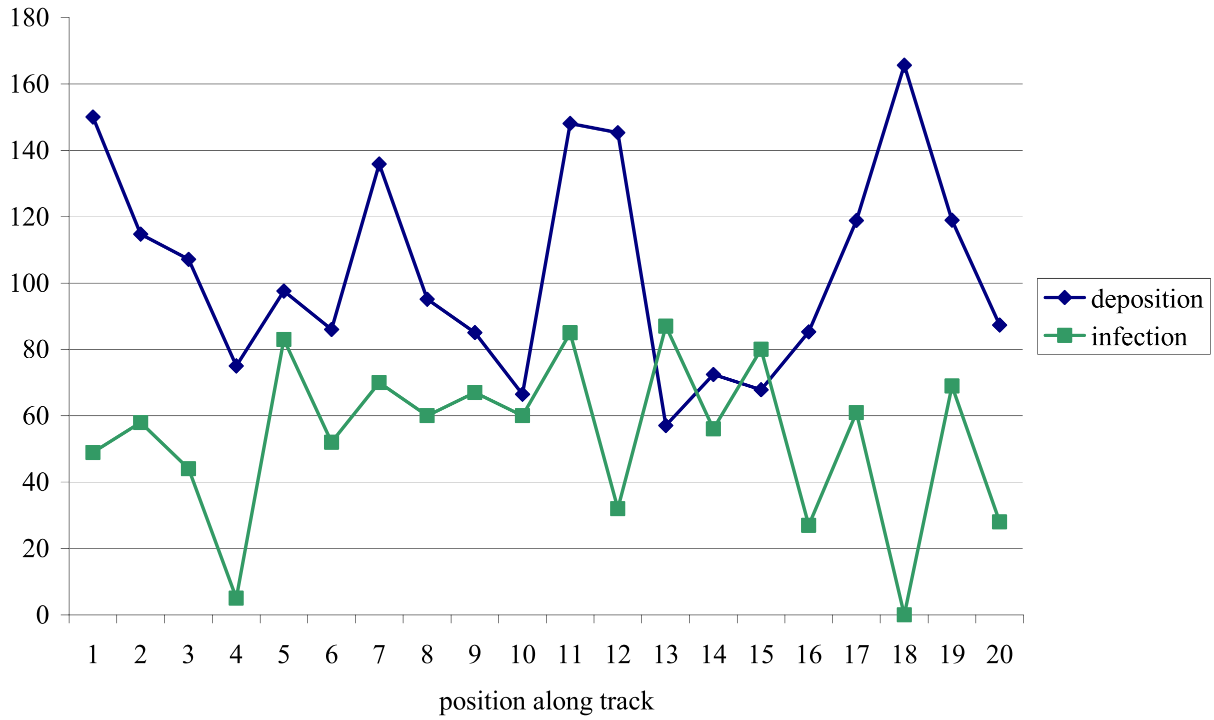


Figure 5: *Spray deposition pattern (% of sprayed volume) on top of canopy and infection of late blight in a bio-assay on leaves of 20 potato plants (% of leaves infected) taken over a length of 10 m along the spray track (50-60 m) spraying potatoes with half (50%) dose of fluazinam (Shirlan 0.3 liter ha^{-1}) with a spray volume of 300 liter ha^{-1}*

These first measurements show that the variation in boom movement and therefore the spray deposition over canopy can be traced back in the level of protection for late blight in the potato leaves. More work is however needed before we can come up with a clear relation, as e.g. a dose-effect curve, to predict the effect of sprayer boom movement on efficacy.

Discussion

Repeatedly driving through the spray track spraying a potato crop creates a bumpy track that increases in severity during the season. As a consequence boom movement increases. Typical boom movements seem to occur in the same way on the same place along the track. Repeatedly over- and under dosing of crop protection products are therefore expected on the same place. It is shown that boom movement, especially the variation in horizontal speed of the tip, is correlated to the spray deposition underneath the boom. Increases in boom tip speed lowered spray deposit. The shown variation in spray deposit underneath the boom was found also in the protection against late blight in the potato leaves.

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