

Effect of sprayer boom curvature on spray distribution: test on spray distribution bench

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Introduction

Since the establishment (1995) of the control of pesticide application equipment in Belgium, the boom curvatures are appreciated only qualitatively. Where there is a doubt, a string is stretched on the extension of the imaginary line of the boom. Until now, limits have been set arbitrarily. So far, a large curvature is the cause of a refusal of the sprayer to control. In front of this lack of accuracy in measurement, pertinence was needed for justification of the sanctions. A study that specifically targeted the effects of boom curvatures on spray quality was missing. Scientific results should help to objectively determinate legal tolerances.

Materials and methods

A boom of 6 meters is used: The structure is suspended above a splitter bench. The nozzles mounted on the ramp are 110 ° slotted nozzles. The "curvature" tested in this test actually is a straight slope of the boom. The 6 m boom is considered a half boom, one end of which corresponds to the center of the spray. The angles of inclination are made into the vertical and horizontal planes. In addition, combinations of the two planes are also tested. The boom is inclined at the angles of 0 °, 1 °, 3 °, 5 ° and 6 °. The working height is fixed at 60 cm. It corresponds to a commonly used height and also to a test height recommended in standard 5682-2. The 0° angle defines the ideal position of the ramp.

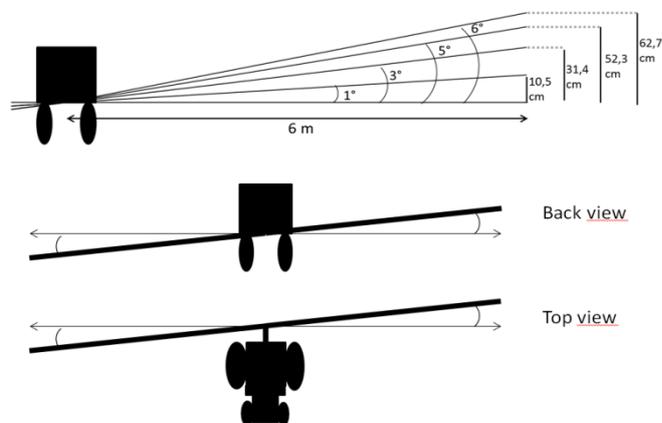


Figure 15 : boom positions into two planes tilts

Spraying is carried out on a static boom, inside a closed room, guaranteeing the absence of wind and a stable ambient temperature and hygrometry. The spray pressure is set at 2 bar. Three theoretical working heights are fixed: The most used height = 60 cm; a lower value = 50 cm; a higher value = 75 cm. The spraying time is 120 seconds. Three repetitions are performed for each measurement.

The total spray width on the bench is 7.5 m for a boom at 60 cm working height on horizontal position. At the ends of the boom there are edge effects of about 1.5 m because the jets of the last nozzles do not benefit from overlays as those of their neighbors. Delimitations were set so that within the range of 4.5 m wide, no edge effects are observed.

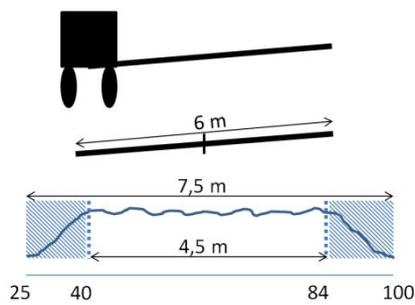


Figure 16 : spray pattern in the 75 collecting tubes. Hatched = edge effect. Numbers under repartition = collecting tube numbers

The 6 m boom is used to simulate a half ramp of a 12 m hypothetical sprayer. At the extremity that represents the theoretical center of the 12 m ramp, the edge effect is not taken into account. Indeed, it is non-existent in the center of a ramp. On the other hand, the edge effect on the extremity that represents the boom end is maintained in the results because it corresponds to a field reality (Figure 16). From all water volumes of collecting tubes, charts are made representing distribution of each measurement. To simplify the reading of these graphs, three points are defined on the ramp: A = nozzle of the left end; B = nozzle of the right end; C = center of ramp (Figure 17). Point C is always fixed at working height. In the case of vertical angles, point A is always pointing downwards and the point B always upwards. These points A, B and C are shown on the distribution charts.

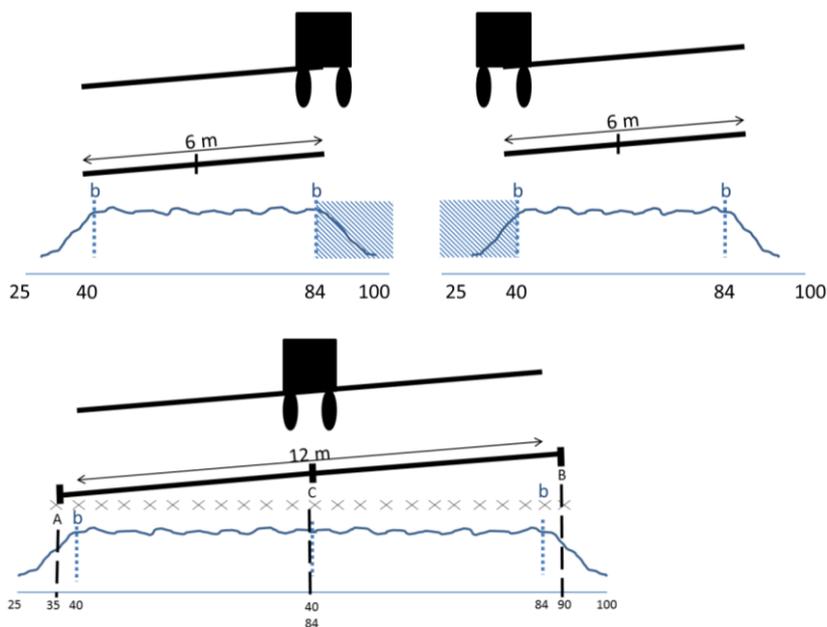


Figure 17 : Simulation of the distribution for a 12 m boom by combination of two half-boom of 6 m. The unwanted edge effects of the center of the boom are removed beyond the tube 84 and before the tube 40. "b" = boundary of the edge effect. Hatched = edge effect deleted from the data. Cross = location of a nozzle

Results and discussion

Coefficients of variation (C.V.)

The coefficient of variation (C.V.) is calculated as the ratio of the standard deviation to the mean and it is expressed as a percentage. In the analysis of C.V., edge effects were deduced.

In theory, for slit nozzles of 110 ° and spaced 50 cm apart, the overlap is double from 35 cm working height and triple from 50 cm working height. The coverage of the jets on the ground increases with the

height of the nozzles. As a result, C.V. decreases with height. Unsurprisingly, C.V. from this work also increases with the amplitude of the vertical angle facing down because the working height decreases. On the other hand, C.V. obtained with vertical angles upward are all similar to each other beyond 60 cm in height. That could be explained by the fact that the recovery reaches its maximum beyond 60 cm. However, the quality of repartition (in term of C.V.) is not affected by any horizontal deviation (until 6°).

Distribution

At a working height of 50 cm, the distribution difference between the horizontal position and 1° of inclination is barely visible. On the other hand, from 3° inclination, the disturbance of the distribution is well marked. It is located at the lower end of the ramp (left on the Figure 18). No effect is observable on the upper part (right), except for a slight increase in the width sprayed at the end. At an average working height of 60 cm, the effect of the inclination 3° is reduced compared to the working height of 50 cm. This is because the nozzles are higher and the overlap is better. On the other hand, spectacular effects are visible as soon as the inclination of the boom is stronger. On chart, the disturbances due to the angles 5° and 6° are visible as of the 5th nozzle starting from the end left.

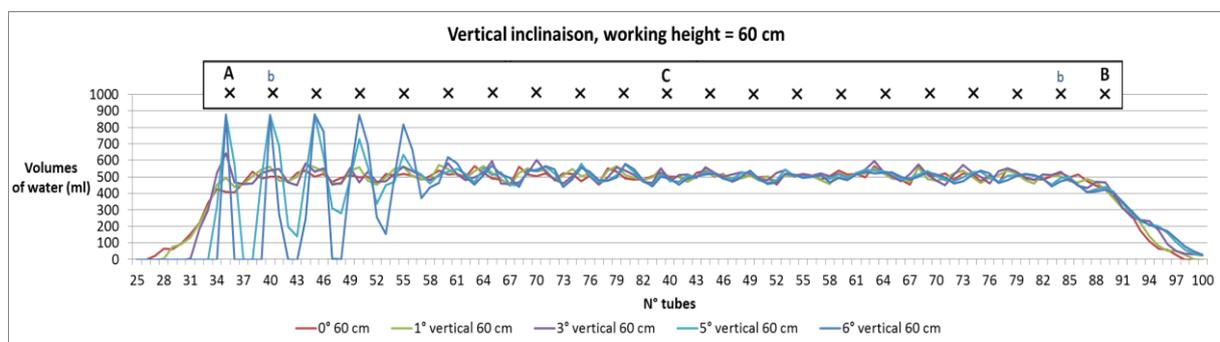


Figure 18 : spray pattern for a ramp inclined vertically. The simulation is carried out from 2 half-ramps of 6 m which meet at point "C" as on Figure 3. "A" = nozzle at the low end. "B" = nozzle at the high end. "b" blue = limits of edge effects. Cross = nozzle location. Working height = 60 cm fixed at point "C"

Similar observations to those of the height 60 cm can be made on the graph of the working height of 75 cm. Again, distribution disturbances are generally reduced by the higher spraying.

By observing these graphs, interesting information emerges about the width of work. This latter increases slightly with the working height. When boom is perfectly horizontal, liquid is projected beyond the end nozzles ("B" points). The additional widths are 70 cm, 80 cm and 100 cm for the respective working heights of 50 cm, 60 cm and 75 cm (Figure 18). If the boom is tilted downwards, working widths are lost. In this test these lost are similar regardless of the working height, but variations are observable according to the angles.

Effects of back and forth on field

The following charts simulate sum of two boom-end sprays crossings on field, for side-by-side or for back and forth. The example is given for a working height fixed at 60 cm on the half-boom of 6 m. Between 1 and 3 degrees of angular amplitude, only one occasional accident appears in the distribution for side-by-side passage (Figure 19): a slight underdosing and a slight overdose.

From 5° angle amplitude, the effects are clearly observable. Since a vertical angle is directed downwards, the over- and under-dosages are spectacular despite the summation of the two passes. Already when passing side by side a boom that is deformed upwards and another deformed downwards, the distribution quality is reduced by about 2.5 m wide (Figure 19). During the passage of two deformed booms downwards side by side, some areas are not treated at all and the occasional overdose peaks are doubled over a total width of nearly 4.5 m (Figure 20). On the contrary, when two upward booms pass side by side, the distribution quality is almost undisturbed (Figure 21).

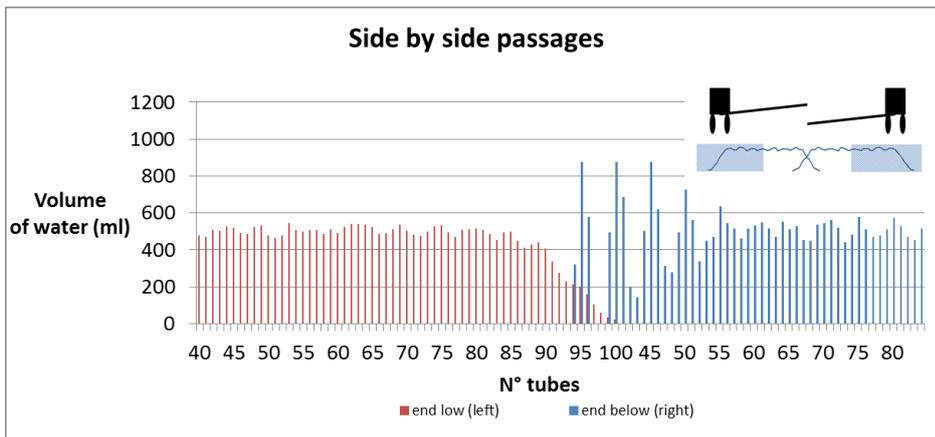


Figure 19 : sprays at the boom ends during two side-by-side passages: chart shows the decomposition of the liquid sprayed by each of the two passages. Half booms are inclined 5 ° upwards and downwards respectively. Working height = 60 cm

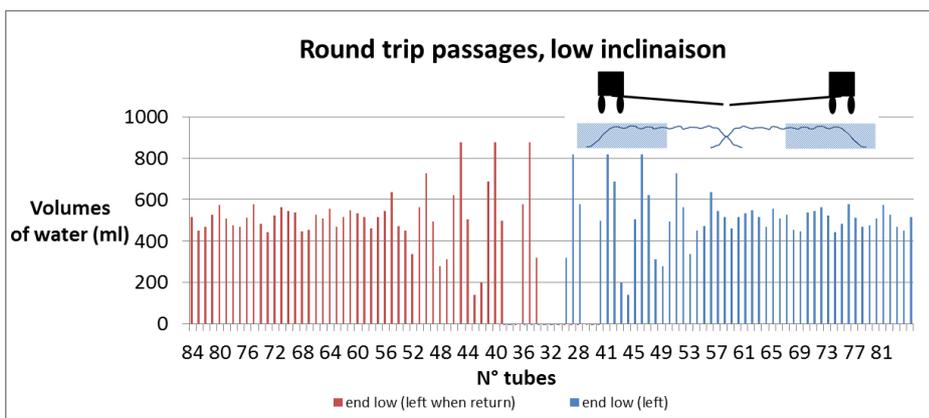


Figure 20 : sprays at the boom ends during two round trip passages: chart shows the decomposition of the liquid sprayed by each of the two passages. Half booms are inclined 5 ° downwards. Working height = 60 cm

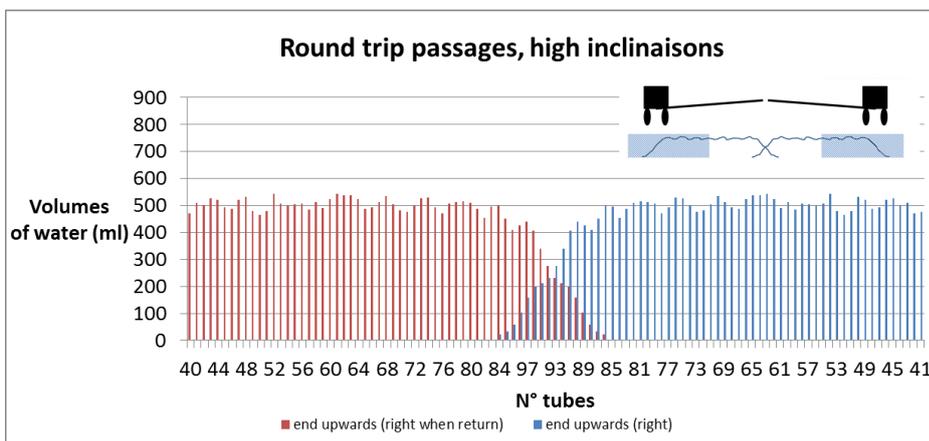


Figure 21 : sprays at the boom ends during two round trip passages: chart shows the decomposition of the liquid sprayed by each of the two passages. Half booms are inclined 5 ° upwards. Working height = 60 cm

Conclusion

Results of this study provide quantitative information on the effects of boom inclination. The main conclusions are the following:

- Inclinations of the boom in horizontal plane from the angle of 1° to 6° have no effect on spray distribution. This criterion considered in the context of mandatory control could therefore be re-evaluated.

- Inclinations of the boom in vertical plane induce different effects following it is directed upwards or downwards.

Upwards, even the strong inclination (63 cm of deflection for a 6 m of boom length), does not affect the distribution out of edge effects. At the boom end, only a very slight increase in the distribution area is observable. This causes a negligible effect on the crop by the round trip of the tractor in the field.

Oriented downwards, the inclination of the half ramp of 6 m induces significant disturbances from an angle of 3° . The importance of these disturbances does not only depend on the deviation that is measured at the control, but depends on the initial working height, the angle and the length of the boom. This work shows that the disturbances of the distribution are in reality strongly dependent on the height of the nozzles at the end of the boom. A too low height induces a lack of covering sprays and a decrease of surface sprayed by each nozzle. The return of the tractor in the field on the neighboring pulverized strip reduces the distribution fault for parallel passages but increases it for round-trip passages. In addition, it should be noticed that the study was performed in a laboratory in a static situation. In the field, distribution is inevitably strongly variable: the boom moves continuously by effect of ground irregularities and the wind modifies sprays of droplets. So, it can be retained from all results that downward inclination is an important point in the control of the sprayers. However, the way of measuring it and the way of setting the acceptable limits could be reconsidered.