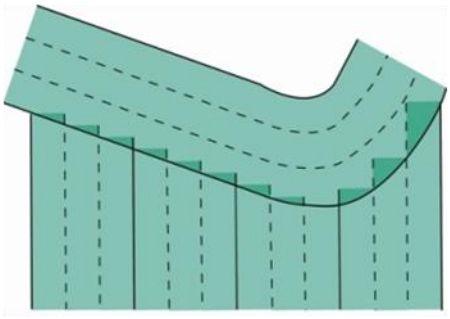
GPS on the sprayer

How much is gained from shutting off sections of the spray-boom?

Shutting off sections of the spray-boom with the assistance of GPS can improve the quality of the work by optimising overlaps in the headland or with zones already sprayed. It is very convenient for the user compared with the traditional method.

Operating principal for shutting off sections of the spray boom *(Figure 1)*



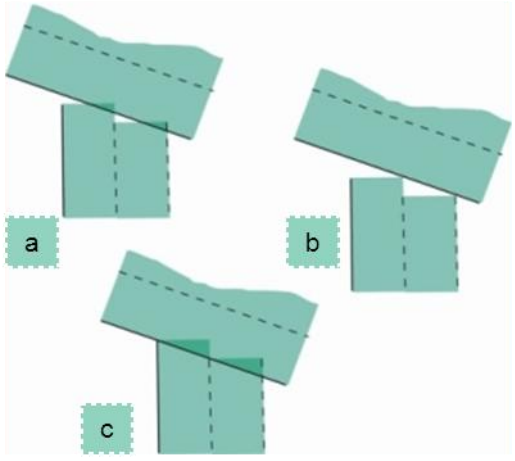
The objective of the system is to optimise the overlaps (and the unsprayed areas) with the zones already treated.

More and more to be found on farms, GPS (Global Positioning System) allows fields to be surveyed or yields to be mapped. It is mainly used to guide tractors in fields in order to optimise overlaps between passes. More recently, systems for shutting off sections of spray-booms under GPS control have appeared.

Here also, the aim is to reduce overlaps (or gaps) with the zones already treated (headlands for example, *figure 1*). The farmer can choose the degree of overlap *(figure 2)* depending on the operation and the risk he is prepared to take. The spray-boom is divided into sections whose number is specific to the model. When the GPS module detects that one of the boom sections is above a zone which is already treated, it sends an electrical signal to the solenoid on that section which is closed without any action by the driver. Similarly, when the boom leaves the treated zone, the GPS module instructs the solenoids in the appropriate sections to open.

The solenoids of the boom sections are controlled directly by the GPS.

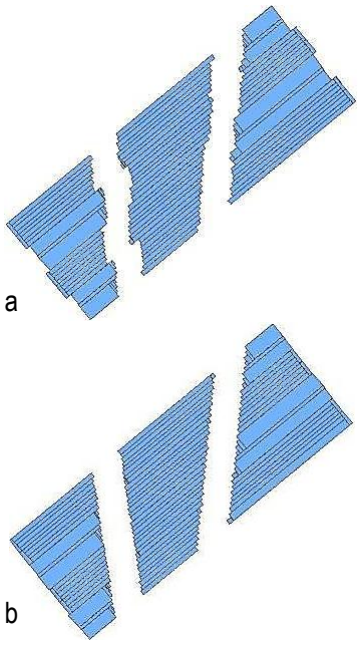
Adjusting the percentage overlap from the console *(Figure 2)*



The farmer can choose the percentage of overlap he wants with the zones already sprayed, from 100% (a) to 0% (c).

The greater the number of spray-boom sections, the smaller the area of overlap.

Area sprayed when the boom sections are shut off manually (a) or by GPS (b) *(Figure 3)*



The boundary between the zones already sprayed is more even when the sections are shut off by the GPS. The overlaps are visually less obvious.

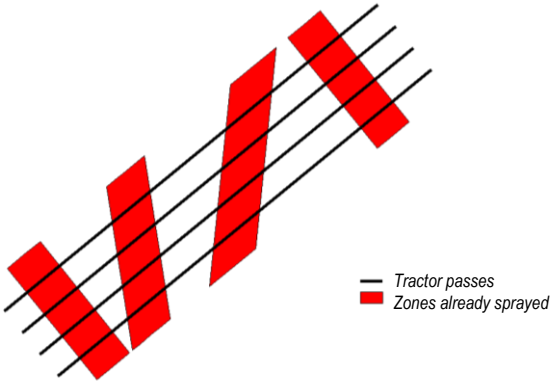
In order to evaluate the gains obtained from shutting off boom sections with GPS, we tested three systems on the experimental station at Boigneville (91 – South of Paris), equipping a towed sprayer, a tractor-mounted sprayer, and a rear-mounted self-propelled sprayer. The objective was to compare the treated zones when the boom sections are shut off by the driver with those obtained when they are shut off by the GPS *(figure 3)*.

The length of the field is a determinant criterion for calculating the area gains. The fewer the U-turns, the fewer will be the errors.

The experiment *(figure 4)* is made up of zones corresponding to the zones already treated (in red), simulating headlands with a right angle or angles of 30° or 45°. The passes were made by different drivers at several speeds - 8, 12, 16 et 20 km/h. In order to avoid mistakes (misses or overlaps) other than those caused by the management of the boom sections, the tractor (with the exception of the self-propelled sprayer) had a homing guidance (2-5 cm precision).

It is this correction which guides the systems for shutting off the boom sections. One should note that these are more precise than most of the corrections normally used in GPS systems. The different consoles were set so that the overlap was 100 %. The overlap errors determined on each angle of the experiment made it possible to calculate the area errors for « typical » fields for angles of 90°, 30° or 45°.

Experiment laid out to evaluate the systems for shutting off sections with the aid of GPS *(Figure 4)*

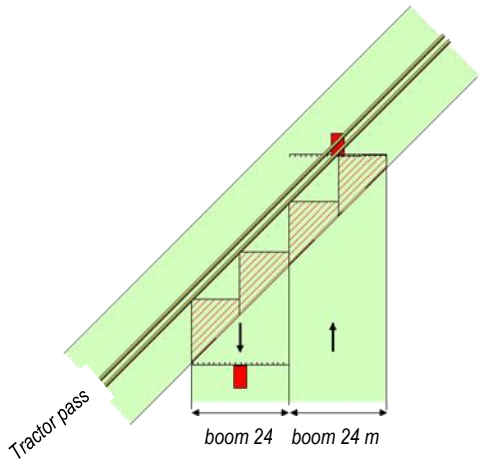


The experiment can simulate the overlap errors made with a headland at right angles or at an angle of 30° or 45°

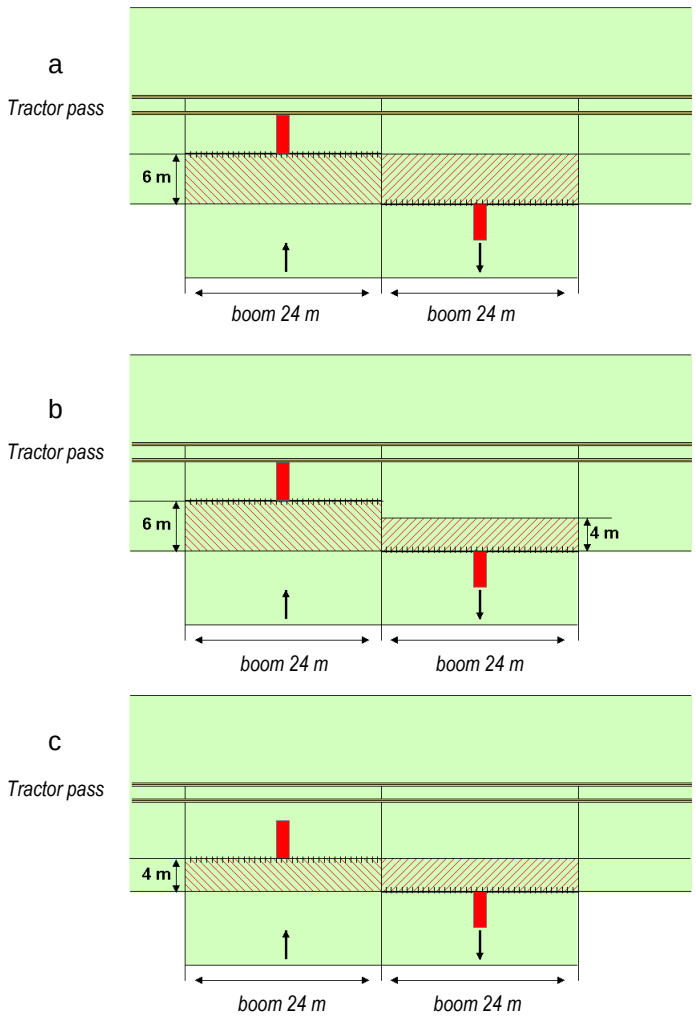
What is the maximum error one can make when the boom sections are shut off manually?

We made a simulation for a tractor fitted with a mounted sprayer with a 24 m boom. We assumed that the wheelings on the headlands serve as a visual reference for the driver. In hypothesis 1, for a rectangular field, the driver shuts off the complete boom when the front wheels of the tractor cross the first wheelmark on the headland. Because of the type of machine under consideration (a mounted sprayer), this means making a double treatment over a length of about 6 m *(figure 5a)*. We assume that he makes the same error when closing and opening the spray nozzles. Hypothesis 2 keeps the same scenario at the closure of the nozzles, but the driver waits longer before switching the boom back on. In this case he makes an overlap of 6 m at the closure and 4 m at reopening *(figure 5b)*. With the last hypothesis, the driver anticipates the closure in relation to the wheelings in the headland. Thus he makes 4 m of overlap when opening and closing the boom *(figure 5c)*. In the field with two angles of 45º, the driver differentiates between two sections of the boom (right and left): he closes or opens when the tip of the boom reaches the first wheel-mark in the headland *(figure 6)*.

Maximum overlaps on a field with two angles of 45°° With manual control, the overlaps are big *(Figure 6)*

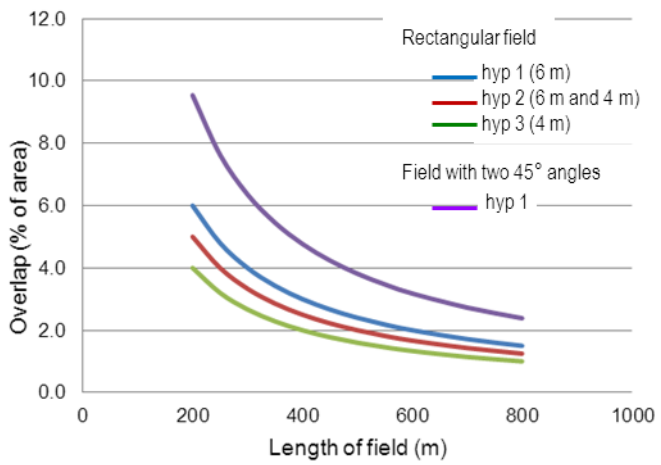


Maximum overlap on a rectangular plot under various hypotheses *(Figure 5)*



If the driver shuts off the whole boom when the front wheels of the tractor cross the first wheeling in the headland, there will be a double treatment over a length of about 6 m.

Maximum overlaps calculated for a rectangular field and one with two 45° angles *(Figure 7)*



On the average rectangular French field, 300 m long, the maximum overlap is 4 %.

Maximum errors

To take account of the consequences of late shutting off of the sprayer on the headland, different scenarios were considered. The first hypotheses were applied to a rectangular field (angle 90°/90°); then to a field with two angles of 45° at its extremities (45°/45°) (see previous page).

At each U-turn, overlaps occurred with the zone already treated in the headland. For a given area, the longer and narrower the field, meaning fewer passes of the sprayer, the fewer were the errors on the field. The length of the plot is a determinant criterion for calculating the area gains and must be greater than the width. Hence a field 300 m long cannot have an area of more than 9 ha (table 1). On a typical rectangular field (on average, 300 m long in France) the overlap varies from 4 to 3 % depending on the overlap assumption *(figure 7)*. On smaller fields, this percentage reaches 6 % at the maximum and remains below 2 % for fields over 600 m long.

Losses from overlaps are less in a rectangular field.

Shutting off boom sections with the GPS would reduce the overlaps at the upper end of these percentages if one could control each nozzle individually, which is not the case. For the field with two angles of 45°, the overlaps are bigger: 6.5 % for a field 300 m long and less than 3 % for a field more than 600 m long *(figure 7)*.

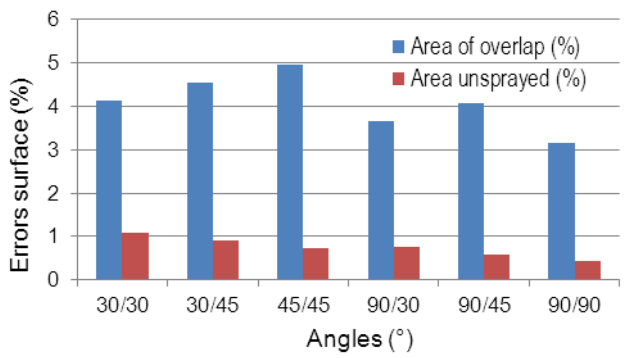
Display of the work on the console.

Table 1 : Maximum area of fields as a function of their length.

Length (m)	Area (ha)
200	4
300	9
350	12.25
400	16
500	25

The length of a field cannot exceed its width.

Errors (unsprayed or overlap) measured when the boom sections are shut off manually *(Figure 8)*



Rectangular fields have a smaller percentage of errors (overlaps or unsprayed areas).

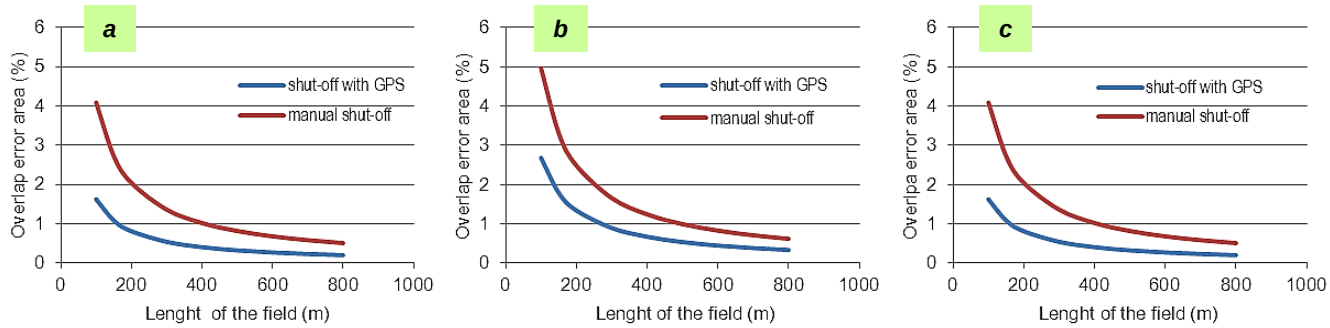
Measured overlaps

With manual shutting off of boom sections, the overlap area represents on average 4.1 % of the area, whereas the untreated areas occupy 0.7 %. On the more restrictive field (with two angles of 45°) the overlap is 5 % of the area *(figure 8)*. The field with the least overlap is the rectangular one (3 %).

The other fields (one angle of 30° and another of 45°, or two angles of 30° etc) had intermediate overlaps. As to the untreated areas, they represent less than 1 % of the area over all the fields and are smaller on the rectangular fields (0.4 % against 1 % for the highest). There is little effect of speed: 4 % overlap on average at 8 or 20 km/h.

For a given area, the longer the field, the fewer the number of passes is. The use of GPS is thus distinctly more beneficial for fields of 100 m of long.

Measured overlap area (with and without GPS) on three types of field : average (a), with two angles at 45º (b) and rectangular (c) *(Figure 9)*



The gain in area due to the use of GPS is greater on the rectangular plot, being 2.7 % for a field 100 m long.

On average, *(figure 9a),* the use of GPS to shut off boom sections can reduce overlap zones from 4 to 1.6 % (i.e. a reduction of about 2.5 % in the sprayed area) for a field 100 m long. This percentage reduction in area sprayed thanks to GPS is 0.8 % for a field 300 m long (the average in France) and 0.3% for a field 800 m long. For the field identified as being the most restrictive with manual shut-off (two angles at 45º), the management of the boom sections by GPS reduced the overlap area from 5 % with manual shut-off to 2.7 % for a field 100 m long *(figure 9b)*. From 300 m upwards, the gain becomes less than 1 % of the area. This gain is slightly greater for the rectangular plot *(figure 9c)*.

Although the gains may appear small for certain fields, shutting off boom sections with GPS is very convenient for the farmer. In particular it can optimise spraying in all sorts of visibility conditions: fog, night etc. Together with a self-steering system, (2 % gain in area, Perspectives Agricoles n° 367 May 2010) using an aerial and a common GPS receiver, the gain in area per field should be 2.8 % for a typical field 300 m long.

GPS can optimise the whole field when boom section shut-off is combined with homing guidance.

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