Oilseed rape mechanical weed control as an alternative or a complement to chemical weed control

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Abstract

For agronomic, economic and environmental reasons, weed control in farming systems can no longer only rely on selective herbicides. In this context, mechanical weed control can be an alternative or a complement to herbicides. Trying to reduce the production costs and solving weeding problems that herbicides cannot solve are the two main reasons that lead farmers to adopt these techniques, but they also express fears about the high sensitivity to the climate and the work time these techniques require. Three tools have been tested in a network of 15 farmers' fields since 2003, alone or combined with herbicides: the in-row hoe, the finger weeder and the rotary hoe, in different types of soils and on different weeds. The selectivity has been assessed for each tool: the in-row hoe can be used from stage 3 leaves of the oilseed rape until the moment when the oilseed rape covers the inter-row ; the finger weeder at pre-emergence stage and then from stage 3 leaves ; the rotary hoe from pre-emergence to stage 4-5 leaves, including cotyledon stage. The efficacy of the finger weeder and the rotary hoe are very dependant on the development stage of the weeds: it strongly decreases when the weeds have more than 3 leaves. Efficacy rates of 80% and more have been reached in the trials in optimal conditions (weeds stage, soils, climate, etc…). Mechanical weed control is efficient against weeds that are hard to destroy with herbicides (crucifer weeds for example). One technique consists in spraying herbicides only on the row when sowing, and then using the in-row hoe to destroy weeds between the rows. The quantity of herbicides is thus reduced by 60% since only a part of the surface is treated. In-row hoeing without any herbicides is usually not efficient enough. Decision grids have been built to guide farmers in the use of these tools, according to the stage of the crop and the weeds, the soil humidity etc…An economic assessment has been made, that shows that mechanical weed control can be profitable thanks to the saving in herbicides costs, but the profitability of these techniques is very dependant on the number of hectares on which they are used.

Key-words: oilseed rape, weeds, in-row hoe, finger weeder, rotary hoe, selectivity, efficacy, economic assessment

Introduction

Mechanical weed control has been used for a long time in sunflower and soybean crops but it is a recent technique as far as oilseed rape is concerned. Three main components of the agricultural context have led French farmers to get interested in these techniques. First, herbicides take the main part in production costs (about 30% of the total production cost), so that farmers want to reduce it to remain competitive. Moreover, the herbicides aren't always efficient enough to destroy all the weeds farmers have to face, especially geraniums and crucifer weeds (*Calepina irregularis*, *Sinapis arvensis* for example). Third, the environmental criteria will have to be more and more taken into account when reasoning agricultural practices, and herbicides usually represent the main molecules that are found in the water. For these reasons, weed control can no longer only rely on selective herbicides, and mechanical weed control can be an alternative or a complement to herbicides. In this context, the CETIOM launched in 2003 a program to study these techniques. The priority was to study their agronomic performances: selectivity and efficacy. This paper mainly deals with the results on these two aspects, but also shows an economic analysis.

Materials and Methods

From 2003 to 2006, three tools have been tested in a network of 15 farmers' fields, alone or combined with herbicides, in different types of soils and on different weeds. The in-row hoe cuts the roots of the weeds between the rows of the crop. The tool can work on 6 to 12 inter-rows. Another technique has been tested which consists in spraying herbicides only on the row when sowing, and then using the in-row hoe to destroy weeds between the rows; with this combined technique, weeds can be destroyed on all the surface of the field. The finger weeder is composed of many long metallic teeth whose vibrations uproot the weeds, on the row and between the rows. The width goes from 9 m to 24 m. The rotary hoe is composed of wheels laid out on two lines, each wheel carries teeth that hit the soil at a high speed and tear off the weeds on the rows and between the rows. The width of this tool can vary from 4.70 m to 9 m.

Different combinations of these tools and herbicides have been tested, in comparison with a reference (pre-sowing and pre-emergence herbicides):

- pre-sowing herbicide (trifluraline) followed by one to four mechanical weeding with the finger weeder or the rotary hoe;
- pre-sowing herbicide followed by one to two interventions with the in-row hoe;
- pre-sowing herbicide on all the surface, pre-emergence herbicide only on the row and then in-row hoeing between the rows;
- combinations of the finger weeder or rotary hoe and the in-row hoe.

Two main measurements have been made: efficacy and selectivity, by counting the plants (oilseed rape and weeds)

before and after the tools have been used.

Results and Discussion

Selectivity. Figure 1 compares the selectivity of the finger weeder and the rotary hoe (the selectivity is good when the oilseed rape plants (or seedlings) losses are low). The rotary hoe is systematically more selective than the finger weeder. The rotary hoe is selective from pre-emergence stage to stage 2-4 leaves: the losses are inferior to 10%. On the other hand, the losses caused by the finger weeder are unacceptable from cotyledon stage to stage 2 leaves. This tool can be used at pre-emergence and then from stage 3 leaves.

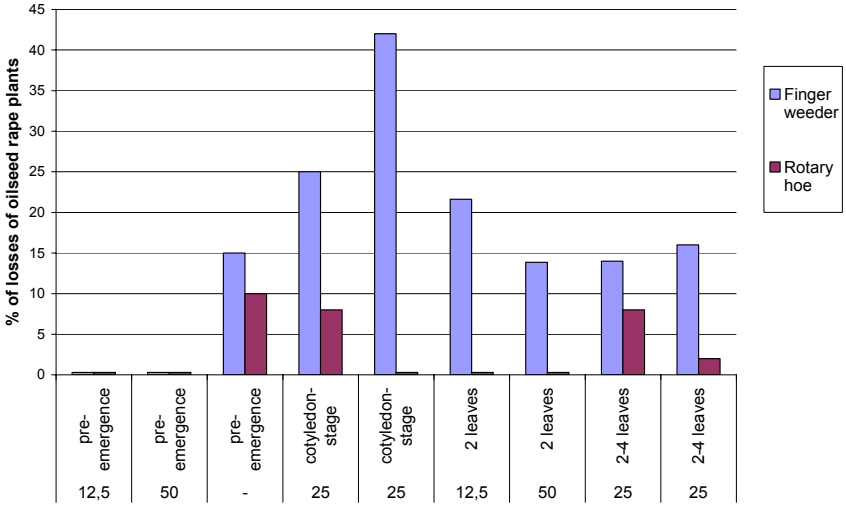

Figure 1: Selectivity of the finger weeder and the rotary hoe for different oilseed rape stages and inter-row spacings

The selectivity of the in-row hoe is less problematic because it only works between the rows: it can be used from stage 3 leaves until the moment when the crop covers the entire surface. The results about selectivity allowed us to build the following table which shows at what stages of the crop the different tools can be used.

Table 1: Selectivity of the tools according to oilseed rape stage

	Pre-emergence	Cotyledon	2 leaves	3 leaves	4 leaves	5 leaves
Finger weeder	+++	- - -	- - -	+++	+++	+++
Rotary hoe	+++	+++	+++	+++	-	- -
In-row hoe	- - -	- - -	- -	+++	+++	+++

Legend:

Possible use, good selectivity	+++
Possible use, the selectivity is reduced	-
Possible use but the selectivity starts to decrease	- -
Not recommended use, the selectivity is unsufficient	- - -

Efficacy of the finger weeder and the rotary hoe. The finger weeder is more efficient than the rotary hoe for the same conditions of intervention (weeds stage, soil humidity, climatic conditions). This greater aggressiveness of the finger weeder also has repercussions on the selectivity (see above). The efficacy is very dependant on weeds stage: it strongly decreases after 2-3 leaves for the rotary hoe, and after 4 leaves for the finger weeder. The precocity of the intervention is thus the first factor of success for these tools. The efficacy of one passage is never 100%, it varies according to weeds stage, soil type and humidity, climatic conditions before and after the intervention etc. For this reason, the interventions have to be repeated two or three times with the same tool for example or a combination of the two tools (finger weeder – rotary hoe – finger weeder). Such strategies are also necessary to control the repeated emergence of certain weeds (for example *Alopecurus myosuroides*). As shown on figure 2, the global efficacy of a chemical-mechanical combined program can be as good as the reference (pre-sowing and pre-emergence herbicides). This figure also shows that mechanical weed control can be efficient against weeds that are hard to destroy with herbicides (crucifer weeds for example, here *Sinapis arvensis*), but only if the weed density is not too high (this density threshold is dependant on the weed species).

Efficacy of the in-row hoe. Figure 3 compares the most frequent herbicides program among French farmers (pre-sowing – pre-emergence, here trifluraline-metazachlore), with two other methods including the in-row hoe. The method that consists in spraying herbicides only on the row when sowing, and then using the in-row hoe is as efficient as the chemical reference after the in-row has been used. In-row hoeing alone is not efficient enough: the weed coverage level decreases after the intervention of the tool, but grows again after. In this case, it is important to preserve the pre-sowing herbicide (trifluraline) for its efficacy against grass weeds in particular.

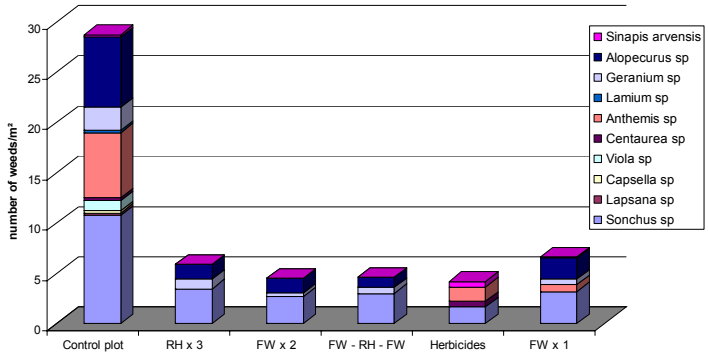

Figure 2: Global efficacy of different combinations of weed control

(RH = Rotary Hoe, FW = Finger Weeder, Herbicides = pre-sowing – pre-emergence program)

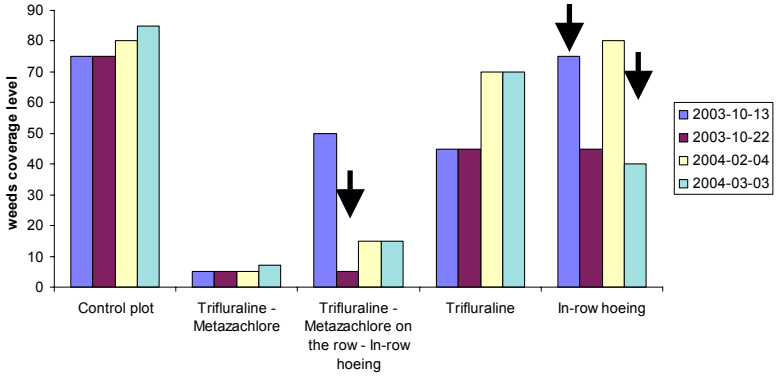

Figure 3: Efficacy of different combinations of weed control including in-row hoeing

(The arrows symbolise the in-row hoe interventions. Weeds: *Geranium* sp., *Raphanus* sp., *Anagallis* sp., *Papaver* sp., *Lolium* sp.)

Economic assessment. Five strategies have been compared. The total cost of the mechanical-chemical combined techniques is systematically lower than the reference, thanks to the saving in herbicides costs (pre-emergence herbicide only sprayed on the row for one technique, the two other techniques only using the pre-sowing herbicide). The main limit of the mechanical techniques is the greater working time they require. This assessment is very dependant on the hypothesis made about the cost of use of the tools, which vary a lot according to the number of hectares on which they are used.

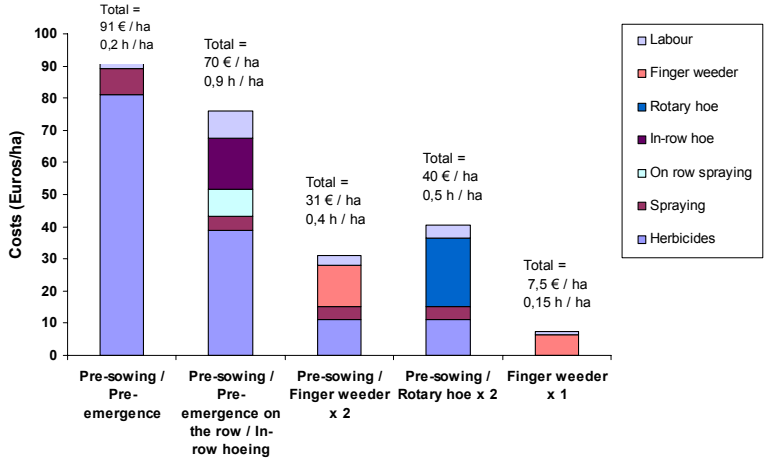

Figure 4: Comparison of the costs of different weed control strategies

(Two-wheel drive tractor: 8.7 €/h / Field crop sprayer 24 m: 3.3 €/hectare, 10 hectares/h / On row sprayer: 3600 € writing off 7 years, 60 hectares/year = 8.6 €/hectare / In-row hoe 6 rows: 7.2 €/hectare, 1.3 hectare/h / Rotary hoe 4.70 m, 9 €/hectare, 5 hectares/h (140 hectares/year) / Finger weeder 12 m, 5.2 €/hectare, 7 hectares/h (200 hectares/year) / Labour: 7.6 €/h)

Conclusions

As an alternative or a complement to herbicides, mechanical weed control strategies:

- are selective enough for oilseed rape if they are used in appropriate conditions (crop stage, soil humidity, adjustments of the tools);
- can be as efficient as herbicides but this efficacy is more irregular and strongly dependant on weed development stage;
- can be economically competitive but require more working time.

These techniques can thus be an answer to some of the new requirements of the agricultural context but their adoption by farmers still faces important difficulties, especially the sensitivity to climatic conditions and the need of high technical skills. Introducing these techniques in a farm requires a deep change of state of mind that many farmers are not ready to make.

These results enabled us to build several decision support tables (for example table 1), which describe in particular the selectivity of the tools according to the crop stage, the efficacy according to the weeds stage, the different soils in which the tools can be used. These tables will guide farmers who want to implement these techniques.