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Contrasted maize based cropping systems influence weed dynamics and impact maize productivity

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Introduction

Conventional Maize Monoculture (MM), a dominant cropping system in south-western France, is now questioned for water quality reasons due to a high use of herbicide, mineral nitrogen and irrigation water (Stoate *et al.*, 2001). To reduce the use of inputs without reducing the productivity of agro-ecosystems, an integrated approach needs to be considered. Indeed, since no individual alternative technique levels with the effectiveness of synthetic herbicides, a cropping system approach, including a wide combination of weed management tools with partial effects through Integrated Weed Management (IWM), needs to be considered in order to achieve defined multi-criteria objectives (Chikowo, 2009).

Materials and Methods

Four cropping systems were designed then experimented in field from 2011 to 2015:

- a conventional intensive Maize Monoculture (MM_{Conv}) that aimed at maximizing the gross margin with ploughing, a bare soil in winter and a chemical weed control;
- a low pesticides, fertiliser and irrigation water monoculture (MM_{LI}) that implemented ploughing, mechanical weeding and a rye grass-crimson clover as a relay cover crop;
- a low-fuel monoculture (MM_{CT}) with maize direct-sowing and a faba bean cover crop sowing after maize harvest. For this system, weeds were chemically controlled.
- a three-year rotation of maize-soybean-soft wheat (MSW rotation) designed to reduce herbicide, water and nitrogen inputs by 50% compared to MM_{Conv}.

These cropping systems were compared for crop production (yield) and weed management (biomass and Potential of Infestation, PI). Weed-free zones, hand-weeded weekly, were also implemented in the experiment in 2014 and 2015 to evaluate the impact of residual weeds on yield.

Results and Discussion

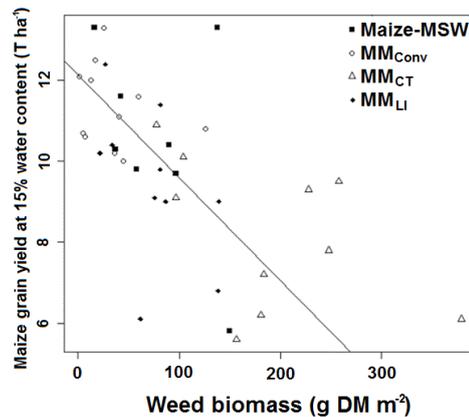
Table 1: Mean biomass (g DM m⁻², mean±sd) of weed species presenting differences among the cropping systems at maize maturity. For each weed species, mean values followed by the same letter are not significantly different according to ° Tukey's HSD or + Wilcoxon tests

| Weed Species | Cropping systems | | | | P-value |
|-------------------------------|--------------------|------------------|------------------|-----------|---------------------|
| | MM _{Conv} | MM _{CT} | MM _{LI} | Maize-MSW | |
| <i>Convolvulus arvensis</i> | 1±1 b | 4±3 a | 2±3 ab | 2±3 ab | <0.01 ⁺ |
| <i>Digitaria sanguinalis</i> | 0 b | 4±6 a | 1±1 ab | 0±0 ab | <0.01 ⁺ |
| <i>Echinochloa crus-galli</i> | 6±7 b | 140± 114 a | 25±29 ab | 14±21 b | <0.001 [°] |

A principal component analysis showed that weed communities drastically changed from one cropping system to another. Maize-MSW had low scores and the lowest dispersion due to low and stable PI across years. Weed biomasses and PI were higher in MM_{CT}, especially for spring grasses and perennials (Table 1). The ploughed cropping systems (MM_{LI}, MM_{Conv}, Maize-MSW) presented similar PI of broadleaf species.

MM_{Conv} (11.3 T ha⁻¹) and MM_{LI} (10.6 T ha⁻¹) had higher grain yields than MM_{CT} (8.2 T ha⁻¹). At maize maturity, a negative linear correlation was identified between weed biomass and grain yield ($\rho=-0.62$, $p<0.001$) (Figure 1). However, no differences in grain yield between weed-free zones and the rest of the plot were observed for the four cropping systems since the maximum loss was 0.9 T ha⁻¹. The potential yield of MM_{CT} in the absence of weed flora (9.9 T ha⁻¹) was at least 2 T ha⁻¹ lower than those of the other three cropping systems.

Figure 1. Correlation between maize harvested grain yield (15% water content) and weed biomass assessed at maize maturity stage. The line corresponds to the regression line between both variables.



Conclusions

Weed communities were drastically different from one cropping system to another. However, even with high weed abundances, low-input cropping systems were sufficiently efficient to manage weeds and ensure crop productivity. Weed-free zones also indicate that residual weeds were not the main factor to explain yield reductions, especially on MM_{CT}.

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