# SOYBEAN-RAPESEED SUCCESSION AS TOOL FOR WEED MANAGEMENT IN BRAZILIAN SAVANNAH CROPPING SYSTEMS

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## ABSTRACT

We aimed in this study to evaluate the potential of rapeseed planted following soybean, in terms of its ability to inhibit the occurrence of weed species under Brazilian Savannah cropping systems. The long-term experiment was installed in 2010 at Dourados-MS, Brazil, using the completely randomized blocks design with five replications with 12 x 24m plot size. For three consecutive years (2010/11, 2011/12 and 2012/13), soybeans were planted in all the area by October/November being harvested in February/March, when previously marked plots were planted with rapeseed (*Brassica napus*) or kept under fallow – no plantation after soybeans. In all years the same crop was repeated at the same plots, with no crop rotation. Phytosociological characterization of weed species was carried out in winter (after oilseeds harvest), pre-planting and post-emergence of soybean during the three seasons. Relative density, frequency and dominance, as well as the importance value for each species, was obtained. Rapeseed grown in winter definitely contribute for sustainable weed management as a cultural tool. The most important weeds infesting rapeseed in the Savannah-like region of Brazil were *Hybanthus parviflorus*, *Richardia brasiliensis* and *Amaranthus hybridus*. Weed management in soybean-rapeseed succession areas should, thus, focus in suppressing these species.

**Keywords:** phytosociology; oilseed crop; sustainability.

## INTRODUCTION

Soybean is one of the most important crop grown in Brazil, with about 27.7 million hectares planted in the 2013/2014 cropping season. Soybean yields in Brazil had significantly increased in the last decades, and current Brazilian average yield is 3,035 kg $ha^{-1}$ (CONAB, 2014). Among the factors which limit the yield of this crop, the occurrence of weed species which can be highlighted as one of the most relevant facts (SILVA et al., 2013).

One of the main management practices which contribute to the reduction in weeds infestation is the continuous maintenance of straw on the soil surface (CECCON, 2013), which limits weeds access to light. In addition, some plant species produce chemicals which usually exudate to soil through the root system, inhibiting germination and/or growth of other plant species. This phenomenon is called Allelopathy (GULZAR & SIDDIQUI, 2014).

Rapeseed (*Brassica napus*) is promising for producing biofuels (CHAMMOUN, 2009), being a good profitable choice for the second crop while keeping soil protected during fall/winter; it can be planted later than corn, developing well even when planted after march 10$^{th}$, which is a deadline for corn planting in the Brazilian Savannah (CECCON, 2013).

Beyond being a profitable option to replace corn after soybean, rapeseed presents potential to suppress the occurrence of weed species in areas of rotation with soybeans what need to be assessed. Rapeseed could demand additional herbicide application in the cropping system throughout the year for not suppressing weeds, or reduce the herbicide demand supposing the most important weed species are being suppressed – the latter would be the side-effect desired.

This study aimed to evaluate the potential of rapeseed planted following soybean, in relation to its ability to inhibit the occurrence of weed species under Brazilian Savannah cropping systems.

## MATERIAL AND METHODS

The long-term experiment was installed in 2010 under field conditions at Embrapa Western Agriculture, Dourados city, Mato Grosso do Sul State, Brazil, at coordinates 22º 16' S and 54º 49' W at 408 m above sea level. The experiment was installed in completely randomized blocks design with five replications and plot size of 12 x 24m.

For three consecutive seasons (2010/11, 2011/12 and 2012/13), soybeans were planted by October/November, being harvested in February/March of the following year. After each soybean crop, previously marked plots of the experiment was planted in April according to the treatment as follow: (1) rapeseed (*Brassica napus*); (2) fallow – no plantation after soybeans. In all years rapeseed was repeated at the same plots, without crop rotation.

Soybean was planted, fertilized and conducted according to the official Brazilian Recommendations for Soybean Crop in Cerrado (Savannah). Rapeseed was planted in rows spaced by 0.4 m, at plant densities of 25 plants $m^{-1}$ in the row. Fertilization was accomplished applying 347 kg $ha^{-1}$ of NPK 08-20-20 in the seeding furrow. No further management (fertilization or pest control) was accomplished.

The amount of straw (in terms of dry mass) left by rapeseed and its resultant percentage of soil covered were evaluated right after rapeseed harvest each year. Data for these parameters were presented in histograms as a function of means and standard errors.

Phytosociological characterization of weed species was carried out every year for all areas in three periods. “Winter” evaluations were accomplished right after harvest of the winter oilseed crops, by July/August; “Pre-Planting” evaluations were accomplished about 30 days after chemical burndown (no residual herbicides were used) prior to planting soybean, usually by end of September or beginning of October; “Post-Emergence” evaluations occurred about 25 days after soybean emergence, in November. For that, the Random Quadrats method (BARBOUR et al., 1998) was used and 5 areas of 0.50 x 0.50 m were sampled in each plot (25 quadrats per treatment in each evaluation). All the emerged seedlings inside each quadrat were identified by species, collected and stored in paper bags, being dried in oven with continuous air circulation for posterior dry mass determination. Sampling precision was estimated according as follows:

$$Pr = \frac{1}{s^2}$$

where $s^2$ = variance of sample means.

Estimations of relative density (based on number of individuals), relative frequency (based on the distribution of the species in the area) and relative dominance (based on the ability of each species to accumulate dry mass) were done for each species found. The Importance Value (I.V.), which ranks species in terms of importance within the studied area, was also determined (PANDEYA et al., 1968; BARBOUR et al., 1998), with the following equations:

$$rDe = \frac{I}{TI} * 100 \qquad rFr = \frac{Q}{TQ} * 100$$

$$rDo = \frac{DM}{TDM} * 100 \qquad IV = \frac{rDe + rFr + rDo}{3}$$

where rDe = relative density (%); rFr = relative frequency (%); rDo = relative dominance (%); I = number of individuals of species *x* in the area *r*; TI = total number of individuals in the area *r*; Q = number of quadrats assessed in area *r* where species *x* is present; TQ = total number of quadrats assessed in area *r*; DM = dry mass of individuals from species *x* in the area *r*; TDM = total dry mass of weeds in the area *r*.

At the phytosociological analysis, rapeseed was analyzed against the area under fallow both as a function of cropping season (average of Winter + Pre-planting + Post-emergence, Table 2, upper section) and evaluation season (average of 2011+2012+2013, Table 2, lower section), being presented for each area only the 10 most important weed species, according to the IV (Table 2). Data presented at this study is results from a pool analysis from three years and three evaluations per year.

## RESULTS AND DISCUSSION

The precision of the sampling proved most areas were accurately sampled, as according to the demanded by BORDEAU (1953) and GOLDSMITH & HARRISON (1976), who stated that the variance of sample means increases as number of sampled quadrats per area decreases. BARBOUR et al. (1998) finally proposed the inverse of the variance as indicator of precision. Only dominance of rapeseed in Winter was considered not reliable (Table 1), being considered with restrictions in the further analysis.

**Table 1**. Sampling precision as a function of season, crop and parameter evaluated. Embrapa Western Agriculture, Dourados-MS, Brazil, 2014.

| | **Winter** | | **Pre-Planting** | |
|---|---|---|---|---|
| **Area** | **Pr.De.** | **Pr.Do.** | **Pr.De.** | **Pr.Do.** |
| **Rapeseed** | 1134 | 0.8 | 19 | 493 |
| **Fallow** | 148 | 152 | 37 | 62 |
| | **Post-Emergence** | | **Pooled** | |
| **Area** | **Pr.De.** | **Pr.Do.** | **Pr.De.** | **Pr.Do.** |
| **Rapeseed** | 51 | 1054 | 32 | 523 |
| **Fallow** | 36 | 54 | 152 | 61 |

Precision was obtained as 1/(variance of sample means), according to Barbour et al. (1998), based on 25 sampled quadrats per area.

The percentage of soil surface covered by straw resulting from the winter crops, as well as crops stubble dry mass, is shown in Figure 1. There was a direct relationship between volume of dry mass produced by each crop/management and the respective percentage of soil covered by this stubble (Figure 1) (Pearson correlation = 82.5%*). On the other hand, there were only weak relationships both between percentage of soil covered and number of plants of weed species, and between soil covered and dry mass of weeds, which were not significant.

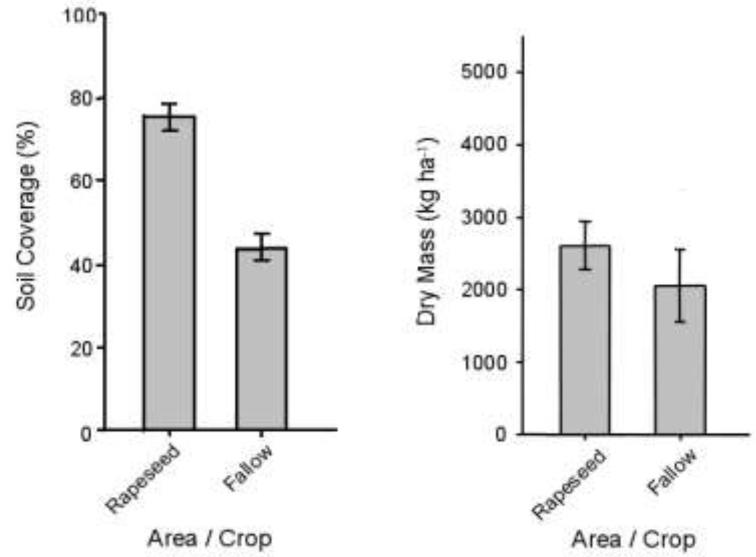


**Figure 1**. Soil covered (%) and dry mass (kg $ha^{-1}$) accumulated by rapeseed in winter, evaluated right after harvest. Embrapa Western Agriculture, Dourados-MS, Brazil, 2014.

When areas were compared among them, considering the average of three years with three assessments per year (Table 2), *R. brasiliensis* and *A. hybridus* were respectively observed as the second and third most important weeds in both rapeseed and fallow areas. *H. parviflorus*, was the most important weed in rapeseed, although it is not a traditional weed species but its importance is increasing at the Center-West region of Brazil. This species is not efficiently controlled by glyphosate or 2,4-D, the main burndown herbicides used prior to planting soybean. Atrazine, the most used herbicide in corn planted in succession to soybean, is also fairly efficient (CONCENÇO et al., 2013).

*A. hybridus* and *R. brasiliensis* are reported as the most dominant weed species in rapeseed, highlighting its ability to accumulate dry mass and compete for physical space with the crop. *H. parviflorus* was also the most dense one in both rapeseed and fallow areas (Table 2).

**Table 2. Phytosociological parameters of the 10 most important weeds infesting winter oilseed crops and fallow, as average of three years (2011/2012/2013) with three evaluations per year (Winter, Pre-planting and Post-emergence of soybean). Embrapa Western Agriculture, Dourados-MS, Brazil, 2014.**

| | | Rapeseed | | | | Winter Fallow | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Species** | **Common name** | **De** | **Fr** | **Do** | **VI** | **De** | **Fr** | **Do** | **VI** |
| *A. deflexus* | Pigweeds, Low amaranth | 6.2 | 0.1 | 2.9 | 3.0 | 1.2 | 2.1 | 5.8 | 3.0 |
| *A. hybridus* | Smooth pigweed, red amaranth | 5.6 | 6.4 | 20.7 | 10.9 | 5.6 | 9.3 | 10.5 | 8.5 |
| *B. pilosa* | Beggar's tick, black-jack | - | - | - | - | 4.7 | 0.5 | 11.1 | 5.4 |
| *E. colona* | Awnless barnyard grass, jungle rice | 0.2 | 5.5 | 8.0 | 4.5 | - | - | - | - |
| *E. indica* | Goosegrass | - | - | - | - | - | - | - | - |
| *E. hieraciifolius* | American burnweed | 0.1 | 12.8 | 0.1 | 4.3 | 0.1 | 16.4 | 0.1 | 5.5 |
| *H. parviflorus* | Violetilla | 40.6 | 5.5 | 12.0 | 19.4 | 10.3 | 4.3 | 9.2 | 7.9 |
| *I. nil* | Morningglory | 0.1 | 26.0 | 0.1 | 8.7 | 0.3 | 17.1 | 0.1 | 5.8 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *L. nepetifolia* | Lion's tail, bald head | 8.1 | 13.2 | 4.9 | 8.7 | 39.1 | 10.9 | 11.9 | 20.6 |
| *L. sibiricus* | Motherwort | 0.6 | 0.1 | 15.2 | 5.3 | - | - | - | - |
| *L. virginicum* | Peppergrass, Virginia pepperweed | - | - | - | - | 5.1 | 0.1 | 5.8 | 3.7 |
| *R. raphanistrum* | Wild Radish | - | - | - | - | - | - | - | - |
| *R. brasiliensis* | Brazilian calla-lily, Brazil pusley | 19.0 | 0.1 | 15.9 | 11.7 | 16.6 | 0.1 | 19.6 | 12.1 |
| *S. cordifolia* | Country mallow, heart-leaf sida, flannel weed | 8.2 | 0.5 | 5.6 | 4.8 | 9.7 | 0.1 | 8.7 | 6.2 |
| *S. rhombifolia* | Common sida | - | - | - | - | - | - | - | - |
| Other species | - | 11.7 | 30.1 | 14.8 | 18.9 | 7.4 | 39.4 | 17.2 | 21.3 |

## CONCLUSIONS

- Rapeseed grown in winter contribute for weed management as a cultural tool. The most important weeds infesting rapeseed in the Savannah-like region of Brazil were *Hybanthus parviflorus*, *Richardia brasiliensis* and *Amaranthus hybridus*.
- Weed management in soybean-rapeseed succession areas should, thus, focus in suppressing these species.

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