EVOLUTION OF WEED OCCURRENCE IN SOYBEAN AREA PLANTED OR NOT WITH RAPESEED IN WINTER – A LONG-TERM TRIAL

Germani Concenço[1], Cesar José da Silva[1], Rodolpho F. Marques[2], Sabrina A. dos Santos[3], Waggner G. Palharini[3], Maxwell E. S. Alves[3], Air Lisbôa Fróes[3]

[1]Agronomist, Researcher at EMBRAPA Western Agriculture. Dourados, MS, Brazil. E-mail: germani.concenco@embrapa.br
[2]Federal University of Grande Dourados, Dourados, MS, Brazil.
[3]Trainee at EMBRAPA Western Agriculture, Dourados, MS, Brazil.

ABSTRACT

We aimed with 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, in 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 in April with rapeseed (*Brassica napus*) or left in fallow – no plantation after soybeans. In all years rapeseed was repeated at the same plots, with no crop rotation. Phytosociological characterization of weed species was carried out in winter (after rapeseed harvest), pre-planting and post-emergence of soybean for the three years. Relative density, frequency and dominance, as well as the importance value for each species, was obtained for every year. The most important oilseed crop weeds in the Savannah-like region of Brazil were *Amaranthus hybridus*, *Richardia brasiliensis*, *Lepidium virginicum*, *Leonotis nepetifolia* and *Hybanthus parviflorus*. After three years of repetitive crop succession, some weeds were selected, and rotation in Winter is advised at least every two or three years.

Keywords: phytosociology; oilseed crop; sustainability.

INTRODUCTION

Recent GMO technologies have aimed to employ herbicide resistance to soybean varieties. Misuse of such technologies, however, led to the selection of weed species tolerant or resistant to the herbicides applied with these technologies. The demand for partial or total substitution of petroleum-based fuel oil for biofuels has become a topic of strategic security for many countries (BEHRINGER et al., 2010). Rapeseed (*Brassica napus*), among other winter oilseed crops, are promising for producing biofuels (CHAMMOUN, 2009), being also good choice for a profitable second crop while keeping soil protected during fall/winter.

Even being a profitable option to replace the often used corn after soybean, rotation, the potential of rapeseed to suppress the occurrence of weed species in areas where these are rotated with soybeans need to be assessed. This crop could either demand additional herbicide application in the cropping system throughout the year for not suppressing weeds, or reduce herbicide demand supposing the most important weed species are properly suppressed – the latter would be a highly desired side-effect.

This study aimed 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.

MATERIAL AND METHODS

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

For three consecutive years (2010/11, 2011/12 and 2012/13), soybeans were planted in all the area of the experiment by October/November, being harvested in February/March of the following year. After each soybean crop, half of the area of the experiment was planted in April with rapeseed (*Brassica napus*) being the other half left as winter fallow – no plantation after soybeans. In all years rapeseed and fallow were at the same plots, with no crop rotation.

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

Phytosociological characterization of weed species was carried out every year for all areas, at 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.

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 present. The Importance Value (I.V.), which ranks species in terms of importance within the studied area, was also determined (BARBOUR et al., 1998).

At the phytosociological analysis, oilseed crops were pool 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).

RESULTS AND DISCUSSION

Number of weed individuals and dry mass of weeds per area was lower in areas planted with rapeseed compared to fallow, for all seasons (Figure 1a,b,c,d). In Winter (Figure 1a), about 19 plants m-2 were observed in rapeseed while 108 plants m^{-2} were observed at the fallow area, immediately after harvest. The same was observed for dry mass, where 30 g m^{-2} were observed in the oilseed crop areas against 83 g m^{-2} at the fallow area. This translated to about 23% and 36% of the infestation, respectively for number of weed individuals and dry mass accumulated, for the area planted with rapeseed compared to that under fallow (Figure 1a).

At the pre-planting of soybean (Figure 1b), infestation was kept at low levels in the area planted with rapeseed. While 21 plants m^{-2} were observed for the area previously planted with rapeseed, 71 plants m^{-2} at the fallow area. Similar behavior was observed for dry mass (Figure 1b).

At post-emergence of soybean (Figure 1c), there was still effects of the winter management on the level of weeds infestation, where the area previously planted with rapeseed was always less infested than the area under fallow. Weed dry mass was about 13 g m^{-2} at the area previously planted with rapeseed, against 40 g m^{-2} at the area under fallow. Although weed dry mass accumulation was not pronounced at the fallow area by the time of evaluation – probably due to the coupled effect of soybean shading and glyphosate application, the high number of individuals at this treatment indicated that weeds were smaller than the observed at the area under rapeseed, but the latent infestation was high.

The season-pooled analysis (Figure 1d) showed that rapeseed performed well in inhibiting the occurrence of weed species, and winter fallow should not be adopted in areas where soybeans are to be cropped. When number of weeds and its respective dry mass are compared in Pre-Planting (Figure 1b) and Post-Emergence (Figure 1c), it is possible to infer that weeds were smaller compared to the ones present at the other areas, thus with delayed emergence. This delayed emergence of weeds in rapeseed, is most probably a consequence of the time needed for seeds forced to a quiescent or dormant state to restart their metabolism and allow germination (SEVERINO, 2005). In practical terms, weed infestation at this area would be less severe when a given crop is planted due to the time needed for plants of the weed species to establish themselves, allowing the crop to have good advantage in development and causing its canopy to shade seedlings of the weed species blocking their development (PUTNAN & DeFRANK, 1983).

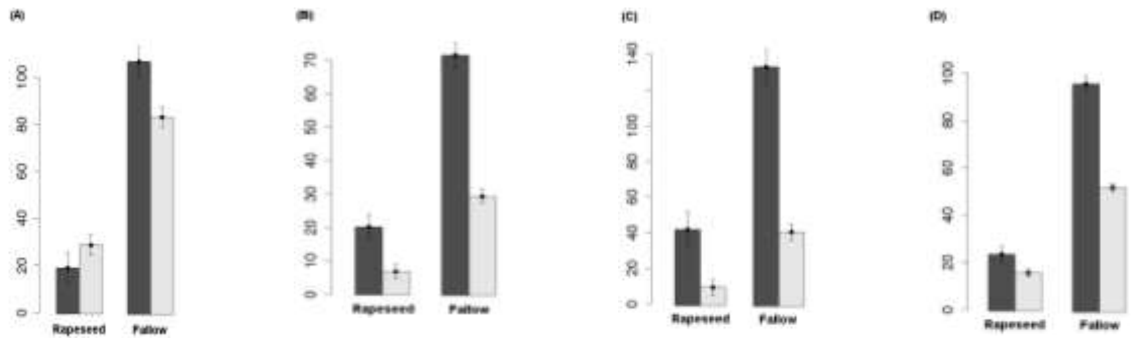

Figure 1. Number of plants of weed species (nº m^{-2}) and dry mass (g m^{-2}) of weeds as a function of crop grown in winter in savannah-like region of Brazil. Embrapa Western Agriculture, Dourados-MS, 2014. (A) = winter; (B) = pre-planting; (C) = post-emergence.

The evolution of weed occurrence from the assembly of the trial (Table 1, upper section) showed that species changed from the first to the third year of the trial both for the oilseed crop and fallow areas. At the area with oilseed crop, in 2011 *R. brasiliensis* and *A. hybridus* were the most important weed species, which accounted for 36.4% of the Importance Value (IV); in 2012 part of the IV from *R. brasiliensis* was shifted to *A. hybridus*, but both were still the most important weed species. At the third year of the experiment, *R. brasiliensis* and *L. virginicum* were the most important ones.

While *R. brasiliensis* was important all throughout the trial, accounting for 16.1 - 32.6% of the IV, *L. virginicum* started as a weak weed species which jumped from IV = 0.3% at the first year to IV = 26.7% at the third year (Table 1). This greatly highlights weed management in areas often planted with oilseed crops should focus on controlling these two weeds if they are present, besides *A. hybridus*, *H. parviflorus* and *L. nepetifolia* which were also important in years where climatic conditions favored its occurrence. *L. nepetifolia* (klip dagga) is a common, but low competitive weed, which is usually either easily controlled with herbicides or suppressed by other plant species.

For the area under fallow (Table 1), *H. parviflorus* was responsible for about 15% of the IV at the first and third years, while *R. brasiliensis* also ranged from 16.1 to 25.7% in IV. At the first year infestation was more balanced, with five weed species presenting IV of about 10 - 15%; at the third year, however, *L. nepetifolia* and *R. brasiliensis* suppressed most weed species, representing together 53.6% of the overall infestation in the area under fallow (Table 1).

Besides the IV, *H. parviflorus*, *L. nepetifolia*, *L. virginicum* and *R. brasiliensis* are highlighted for its numerous offspring (De), each species solely representing, in most cases, more than 20% of the individuals accounted at the experiment (Table 1). In the same way, *A. hybridus*, *L. virginicum* and *R. brasiliensis* were the most vigorous weed species as their Dominance (Do) was often higher than 20% (Table 1).

When the evaluation season is considered (Table 1, lower section), it is noted that the most important weed species in the system were present all throughout the year. For the area grown with the oilseed crop, *R. brasiliensis* was the most important one from Winter to Post-Emergence, followed by *A. hybridus* in Winter and Post-Emergence. At the intermediary assessment, *L. virginicum* surpassed *A. hybridus* in importance. For the area under fallow, *R. brasiliensis* was also the most important and persistent weed species, but contrary to the observed for the oilseed area, *L. nepetifolia* surpassed *L. virginicum* and *A. hybridus* as the second most important species in Winter and Pre-Planting, and *H. parviflorus* was the second most important one in Post-Emergence (Table 2). Overall, there was no weed species most present in a certain season; important weed species were the ones with year-round occurrence (Table 2).

CONCLUSIONS

- Cultivation of rapeseed in Winter do contribute for lower weed infestation levels in the subsequent soybean crop;
- Infestation composition changes among years. Some weed species start to be selected in the absence of crop rotation;
- *Amaranthus hybridus, Richardia brasiliensis, Lepidium virginicum, Leonotis nepetifolia* and *Hybanthus parviflorus* are highlighted as weed species with most potential to infest areas grown with rapeseed;
- In the Savannah-like region of Brazil, areas often grown with soybean in summer, should have its winter crop rotated with rapeseed to avoid weed selection, at least every two or three years.

REFERENCES

BARBOUR, M. G.; BURK, J. H.; PITTS, W. D.; GILLIAM, F. S.; SCHWARTZ, M. W. **Terrestrial plant ecology**. Menlo Park: Benjamin/Cummings, 1998. 688 p.

BEHRINGER, T.; LUCHT, W.; SCHAPHOFF, S. Bioenergy production potential of global biomass plantations under environmental and agricultural constraints. **Global Change Biology Bioenergy**, v. 3, n. 4, p. 299-312, 2010.

CHAMMOUN, N. **Properties, performance and economics of *Raphanus sativus* (Oilseed Radish) Biodiesel**. Msc. Thesis, University of Georgia, Athens, 2009.

PUTNAN, A. R.; DEFRANK; J. Use of phytotoxic plant residues for selective weed control. **Crop protection**, v. 2, n. 2, p. 173–181, 1983.

SEVERINO, F. J.; CARVALHO, S. J. P.; CHRISTOFFOLETI, P. J. Interferências mútuas entre a cultura do milho, espécies forrageiras e plantas daninhas em um sistema de consórcio. I - Implicações sobre a cultura do milho (Zea mays). **Planta daninha**, v. 23, n. 4, p. 589–596, 2005.

Table 1. Phytosociological parameters of the 10 most important weed species, as a function of year (average of Winter/Pre-Planting/Post-Emergence evaluations), and cropping season (average of years 2011/2012/2013). Embrapa Western Agriculture, Dourados-MS, Brazil, 2014.

	Winter Oilseed Crop				**Winter Fallow**				**Winter Oilseed Crop**				**Winter Fallow**				**Winter Oilseed Crop**				**Winter Fallow**			
Weed Species	**De**	**Fr**	**Do**	**IV**	**De**	**Fr**	**Do**	**IV**	**De**	**Fr**	**Do**	**IV**	**De**	**Fr**	**Do**	**IV**	**De**	**Fr**	**Do**	**IV**	**De**	**Fr**	**Do**	**IV**
	------------------------ **2011** ------------------------								------------------------ **2012** ------------------------								------------------------ **2013** ------------------------							
A. deflexus	17.7	8.1	19.1	15.0	3.9	5.6	14.1	7.9	6.9	7.3	4.4	6.2	0.4	1.7	0.8	0.9	0.2	0.7	0.0	0.3	0.7	5.2	9.4	5.1
A. hybridus	18.0	13.5	15.4	15.6	14.3	11.2	9.3	11.6	18.5	12.1	33.8	21.5	11.8	11	14.2	12.3	2.7	4.3	17.9	8.3	0.4	2.2	4.7	2.4
B. pilosa	3.7	7.6	3.8	5.0	15	10.1	6.5	10.5	4.1	6.1	2.9	4.4	7.9	6.8	18.9	11.2	1.5	3.6	3.3	2.8	0.4	0.9	0.5	0.6
C.benghalensis	2.8	3.8	1.6	2.7	1.7	6.7	1.6	3.3	2.9	4.0	4.0	3.7	1.9	7.6	6.4	5.4	0.0	0.0	0.0	0.0	0.9	4.7	1.5	2.4
E. heterophylla	-	-	-	-	1.3	4.5	9.9	5.2	-	-	-	-	1.2	2.5	4	2.6	-	-	-	-	-	-	-	-
H. parviflorus	22.2	6.0	4.9	11.0	15.9	11.2	18.1	15.1	2.0	1.6	0.5	1.4	1.5	1.7	0.5	1.2	19.2	11.2	6.9	12.4	12.3	15.5	18.9	15.6
L. nepetifolia	2.0	3.8	0.8	2.2	24.8	12.4	6.9	14.7	13.9	10.1	9.5	11.2	17.3	10.2	14.4	13.9	4.3	7.9	0.7	4.3	52.3	21.1	10.5	27.9
L. virginicum	0.2	0.5	0.1	0.3	-	-	-	-	1.0	1.2	0.6	0.9	4.3	5.9	6.8	5.7	36.7	22.3	21.0	26.7	6.9	10.3	7.4	8.3
R. brasiliensis	16.3	21.1	24.9	20.8	7.4	12.3	20.3	13.4	17.2	17.7	13.2	16.1	11.7	12.7	10.3	11.5	28.2	31.7	38.1	32.6	21.3	21.1	34.8	25.7
R. raphanistrum	5.8	6.0	6.8	6.2	-	-	-	-	5.4	4.4	5.3	5.1	-	-	-	-	0.1	0.4	0.2	0.2	-	-	-	-
S. cordifolia	1.9	3.8	0.9	2.2	5	6.7	1.6	4.4	19.3	16.1	6.4	13.9	32.6	15.2	12.5	20.2	0.9	0.7	0.0	0.5	1.5	7.3	6.2	5.1
Other species	9.5	26.0	21.7	19.1	10.4	19.1	11.5	13.7	8.8	19.4	19.4	15.8	9.3	24.6	11	14.9	6.3	17.3	11.9	11.8	3.2	11.6	5.9	6.9
	----------------------- **Winter** -----------------------								------------------- **Pre-Planting** -------------------								----------------- **Post-Emergence** -----------------							
A. deflexus	14.8	6.8	14.4	12	2.0	5.9	6.3	4.7	5.8	6.8	5.5	6.1	1.0	5.6	7.6	4.7	-	-	-	-	-	-	-	-
A. hybridus	4.6	7.3	32.8	14.9	1.8	4.3	11.8	5.9	3.1	4.4	13.8	7.1	0.8	3.5	5.9	3.4	30.9	19.1	21.7	23.9	18.6	13.9	12.7	15.1
B. pilosa	3.9	5.5	2.8	4.1	1.8	3.7	15.9	7.1	2.2	5	3.7	3.6	0.7	1.4	0.6	0.9	2.7	6.1	3.5	4.1	15.2	9.3	8.4	11.0
C. benghalensis	1.3	3	4.3	2.8	1.6	5.9	5.9	4.5	-	-	-	-	0.9	4.2	1.1	2.1	4.2	5.1	1.5	3.6	1.3	8.3	1.3	3.7
H. parviflorus	2.3	4.3	0.3	2.3	5.8	7.5	2.4	5.2	21.5	8.9	5.7	12.1	14.6	15.4	17.6	15.8	21.4	5.5	6.5	11.1	12.4	11.1	24.5	16.0
L. nepetifolia	7.9	10.3	5.4	7.9	38.6	18.1	14.2	23.6	10.4	10.1	6.1	8.8	48.0	18.9	7.8	24.9	0.3	1.1	0.4	0.6	28.1	10.2	9.2	15.8
L. virginicum	23	14.9	7.1	15	7.2	10.1	7.6	8.3	20.9	11.2	8.2	13.4	6.2	8.4	4.6	6.4	-	-	-	-	-	-	-	-
R. brasiliensis	23.9	24.7	8.3	19.1	19.2	18.1	14.3	17.2	23.4	25.4	34.1	27.6	20.0	19.6	27.8	22.5	16.3	21.2	35.1	24.3	7.4	12.0	28.2	15.9
R. raphanistrum	-	-	-	-	-	-	-	-	0.3	0.7	0.5	0.5	0.1	0.7	0.4	0.4	10.9	10.6	17.9	13.1	4.2	5.6	6.9	5.5
S. cordifolia	12.8	8.5	2.6	7.9	17.2	9.6	7.3	11.4	3.8	6.1	5.6	5.2	2.3	8.4	15.3	8.7	3.3	6.1	0.1	3.2	6.6	10.2	3.3	6.7
Other species	5.5	14.5	22	14.1	4.9	17.1	14.2	12.1	8.6	21.5	16.8	15.6	5.3	14.1	11.4	10.3	10.1	25.3	13.2	16.2	6.3	19.4	5.6	10.4

Winter Oilseed Crop: rapeseed; **Winter Fallow**: planted with soybean, no crops in winter; **De** = density; **Fr** = frequency; **Do** = dominance; **I.V.** = importance value; (**-**) = species absent from the area. **Evaluations**: "*Winter*" = right after harvest of the winter oilseed crops, by July/August; "*Pre-Planting*" = about 30 days after no-residual chemical burndown prior to planting soybean, by September/October; "*Post-Emergence*" = about 25 days after soybean emergence, in November.