POPULATION DYNAMICS OF CATERPILLARS ON THREE COVER CROPS BEFORE SOWING COTTON IN MATO GROSSO (BRAZIL)

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SUMMARY

Direct seeding mulch-based cropping systems under a preliminary cover crop such as millet are common in some areas of Brazil. Lepidopteran pests that damage cotton, soybean and maize crops can proliferate on cover crops, so preventive chemical treatments are necessary. Very little data is available on these pests on cover crops. This paper presents the dynamics of *Spodoptera frugiperda*, *S. eridania*, *Mocis latipes* and *Diatraea saccharalis* caterpillars monitored at Primavera do Leste, Mato Grosso state (Brazil) during the of 2005/2006 and 2006/2007 cropping seasons on four cover crops, i.e. finger millet (*Eleusine coracana*), pearl millet (*Pennisetum glaucum*), sorghum (*Sorghum bicolor*) and ruzigrass (*Brachiaria ruziziensis*). The pests were visually counted on plants within a 1 m^2 transect (wooden frame). Caterpillars were reared to facilitate identification of collected species and parasitoids. Many *S. frugiperda* caterpillars were observed on millet in 2005, with a maximum of 37 caterpillars/m^2. On sorghum, we found 30 caterpillars/m^2, or 0.83 caterpillars/plant. The *Diatraea* borer attacked sorghum later than the other pests. *M. latipes* was also observed on millet. The millet cover crop had to be dried for at least 1 month before direct drilling the main cotton crop in order to impede *S. frugiperda* infestations on cotton plantlets, thus avoiding the need for substantial resowing. The comparative methodological aspects are discussed.

Key words: *S. frugiperda*, millet, *Brachiaria*, cover crops, caterpillars.

INTRODUCTION

Direct seeding mulch-based cropping systems have been highly developed in Brazil (Séguy *et al.*, 1996, 1998). In Mato Grosso state, under this technique single- or multi-species cover crops are sown after the first rains fall in October. As pearl millet (*Pennisetum glaucum*, Poaceae) can be readily knocked down and dried by herbicide treatments, it is the main cover crop species used in the savannah region (*cerrados* bioma). Other species such as finger millet (*Eleusine coracana* (L.) Gaertn, Poaceae), along with several *Brachiaria* species, have been studied in terms of their agronomic features prior to being recommended. *Crotalaria* species (Fabaceae) were also recommended for the purposes of reducing nematode populations. Some short-season soybean varieties can also serve as cover crops prior to sowing a main crop such as cotton, thus making two crop harvests a year possible on the same fields. Residue of the dried cover crop thus serves as a mulch layer into which the main crop is sown. The main crop is direct seeded using machinery designed specially to cut the mulch layer (millet straw). The expanding widespread use of this technique likely promoted development of the noctuid moth *Spodoptera frugiperda* (J.E. Smith), which is one of the main maize pests in the Americas. When farmers

notice that these caterpillars are proliferating on their millet crops before heading, they often conduct up to three pesticide control sprays (pyrethroids) so as to eliminate the pests before the main crop is sown.
The biology of insects living on these cover crops has seldom been studied by agricultural scientists. We thus decided to carry out a series of experiments based on monitoring insects present on cover plants in order to determine the advantages and disadvantages associated with the use of these plants (Silvie, 2005; Silvie *et al.*, 2005).
The dynamics of lepidopteran caterpillar populations thriving on various cover crops was studied during the 2005/2006 and 2006/2007 cropping seasons at the research station of the COODETEC cooperative at Primavera do Leste, a town located in Mato Grosso state, in central western Brazil.

MATERIALS AND METHODS

The effects of three different cover crops (Poaceae) on the development of caterpillar populations were monitored:

- Cover 1 (C1): pearl millet (*Pennisetum glaucum* (L.) R. Br.)
- Cover 2 (C2): finger millet (*Eleusine coracana* (L.) Gaertn)
- Cover 3 (C3): ruzigrass (*Brachiaria ruziziensis* R. Germ. and C.M. Evrard), in association with sorghum (*Sorghum vulgare* Pers.). Here the *B. ruziziensis* cover crop continued growing after the sorghum crop had been harvested.

Cover crop experimental design

There were nine test plots, 35 m wide x 40 m long, aligned in a linear pattern, with three replications per cover crop. In 2005/2006, the linear distribution of cover crops in the nine plots was as follows: C3, C2, C1, C2, C1, C3, C3, C1, C2.
In 2005, untreated finger millet (*E. coracana*) seeds were obtained from a nearby farm where this species had been propagated. Untreated pearl millet (*P. glaucum*, cv ADR 500) was supplied by the *fazenda* Adriana. Sorghum (*S. vulgare*, cv SARA), supplied by the Agroceres company, was monocropped since it was a very timely process to get the ruzigrass (*B. ruziziensis*) cover crop to grow properly. The sorghum seeds had been treated with the insecticides K-Obiol 25 CE (deltamethrin) and Actellic 500 CE (pyrimifos-methyl) and the fungicide Captan 750 TS (Captan).
The first cover crops were sown on 4 October 2005 with a Jumil seeder set to sow 6 seeds/m for sorghum and 16 seeds/m for pearl millet and finger millet. The spacing between rows was 0.45 m.
On 21 December 2005, almost 3 months after sowing, the cover crops were dried out by a glyphosate herbicide spray (Polaris at 3.5 l/ha, with the adjuvant Agral at 0.0045 l/ha). The pesticide Lannate (methomyl) was added (1.5 l/ha).
Cotton (cvs CD 406 and CD 409, from COODETEC) was planted on 11 January 2006, only on plots mulched with dried finger millet and pearl millet.
In 2006, ruzigrass and sorghum (cv Dow 740, supplied by DowAgro Sciences) were sown on 3 March 2006 in the same plots as the previous year (C3) after the residue had been chopped with a rotary slasher followed by a fertilizer application (300 kg/ha NPK 08-28-16). Spot glyphosate treatments (Polaris at 3 l/ha) were carried out the same day to knock down weeds and thus facilitate cover crop growth. Following the sorghum harvest, ruzigrass continued growing in plots where it had been sown (C3).

Cotton crops that had been sown on mulched cover crops C1 and C2 were harvested in July 2006 and then the residue was chopped with a rotary slasher. Weeds growing on these cotton plots were knocked down by a herbicide treatment (2.4 D at 0.3 l/ha) on 22 August 2006, and again on 26 October 2006 (2.4 D at the same dosage, and glyphosate (Roundup) at 1.5 l/ha).
In 2006, plots that had been sown with finger millet in 2005 were then sown with pearl millet, and *vice versa*. In 2006/2007, the linear distribution of cover crops on the nine plots was thus as follows: C3, C1, C2, C1, C2, C3, C3, C2, C1.
The sowing dates for these two crops were staggered, i.e. 26 October 2006 (finger millet) and 3 November 2006 (pearl millet), in order to obtain uniform development and heights. These crops were broadcast sown (30 kg seeds/ha). The seeds were buried by a light disc ploughing.
In the second year, the cotton crop was sown late (1 February 2007) and only on plots with *B. ruziziensis* cover (C3). The high dry biomass produced by this cover species (7.2, 14.7 and 10.9 t/ha on average for each plot/replication) was hard to destroy. The ruzigrass was therefore dried out with a glyphosate herbicide spray (Polaris at 3 l/ha) on 8 January 2007 and then chopped with a rotary slasher a week later.

Pest monitoring

Pests were quantified on each plot on a weekly basis during the following periods:

- from 1 November to 12 December 2005 (prior to herbicide treatments) and from 11 to 17 January 2006 on dried out finger millet and pearl millet covers;
- from 5 April to August 2006 in plots that had been sown with ruzigrass (growth phase);
- from 6 September 2006 to 11 January 2007, just on ruzigrass cover. Because of the late sowing and poor germination of seeds that had been sown in late 2006, plots with heterogeneous finger millet and pearl millet cover could not be properly monitored.

Identified caterpillars were counted within a 1 m^2 transect (wooden frame) that was randomly placed in the plots at a frequency that varied depending on the monitoring period (Table 1), the difficulty (high plant density) and the time required to find the caterpillars. In 2005/2006, as the sorghum crop had been planted in rows, the counts were carried out along 4 m row sections before 26 December. From 26 December 2005 to 2 January 2006, 30 randomly selected plants were monitored. The number of caterpillars counted was averaged per plant and per unit area (1 m^2).

Table 1. Area monitored per plot and cover crop according to monitoring dates

Monitoring dates	Area monitored (m^2) per elementary plot
1 and 4 November 2005	6
9, 14, 17 and 29 November	2
6-7; 12-13 December	4
11 and 17 January 2006	5
5 April 2006 and the following dates: 12, 19, 26 April; 3, 10, 17, 24, 31 May; 7, 14, 21, 30 June; 5, 11, 18, 25 July; 2, 9, 16, 24, 30 August 2006	4
6 September 2006 to 11 January 2007	4

Caterpillars collected and allowed to feed on same plants from which they had been collected were monitored until they moulted into adults—the species identifications were done at this stage. Some caterpillars could not be reared to the adult stage. Parasitoids sometimes emerged during this rearing period.

RESULTS AND DISCUSSION

Climatic constraints were recorded in 2005/2006. Total rainfall for the month of October 2005 was under 100 mm. This was followed by a very harsh drought in January 2006, which hampered rapid growth of the cover crops. Total rainfall for the period between early September 2005 and the end of April 2006 was nevertheless 1555 mm. Rainfall was more regular during the last 3 months of 2006. 444.5 mm of rainfall was recorded from September to the end of December 2006.

Four major caterpillar species were identified on the monitored cover crops: three Noctuidae species, i.e. *Spodoptera frugiperda*, *Mocis latipes* (Guenée, 1852) (or *curuquerê-dos-capinzais* in Portuguese) and *S. eridania* (Stoll), and one Crambidae species, i.e. *Diatraea saccharalis* (F.), which is a major sugarcane pest.

The following species was also identified after rearing caterpillars collected on low plants growing under the dried cover crops: *Pseudaletia sequax* Franclemont (Noctuidae), which is a known wheat pest in southern regions of Brazil, and others Noctuidae as *Elaphria deltoides* (Möschler), *E. agrotina* (Guenée), *E. hyposcota* (Hampson), *Phalaenosphana eudorealis* (Guenée) and *Leucania rivorum* Guenée, these three last species on *Brachiaria*.

The parasitoids identified are listed in Table 2. Tachinidae and Braconidae of the genus *Aleiodes* and probably *Microplitis* still have to be identified. Bodies of dead *S. frugiperda* caterpillars infected with entomopathogenic fungi (especially *Nomuraea rileyi* (Farlow) Samson) were also identified. It was not possible to estimate the percentage of parasitism because of the high caterpillar mortality rate after collection.

Table 2. Host/parasitoid relationships

Insect Host	Development stage	Parasitoids/hyperparasitoids
Spodoptera frugiperda	Ex nymph ex larva	? Tachinidae (sp.1)
	Ex larva	? Tachinidae sp.2
	Ex larva	*Euplectrus* sp. (Eulophidae)
	Ex larva	*Campoletis* sp. (Ichneumonidae)
Mocis latipes	Ex larva (mumified)	Braconidae Rogadinae (*Aleiodes* sp.)
	Ex larva	Braconidae Microgastrinae (? *Microplitis* sp.)
	Ex larva	*Conura* sp. (Chalcididae)
	Ex nymph ex larva	? Tachinidae sp.2
	Ex larva	? Tachinidae sp.2

Table 3 and 4 give the mean populations of these caterpillar species on pearl millet, sorghum and finger millet. During the 2005/2006 crop season, the extent of caterpillar infestations was associated with the degree of development of each cover crop.

S. frugiperda caterpillars were found on all cover crops and their population numbers varied according to the crop and period. On pearl millet, a maximum of 37 caterpillars/m² was recorded during two consecutive surveys in mid-November 2005, suggesting that this species had a slight preference for this cover crop species. The colour of *S. frugiperda* caterpillars on pearl millet differed from that of caterpillars noted on maize and cotton—their biotype also differed from that of caterpillars that thrive on maize and cotton (Nagoshi *et al.*, 2007). On pearl millet cover crops, *S. frugiperda* represents an incredible resource for predatorial insects living on the soil surface. The Carabidae species *Calosoma granulatum* is the most commonly reported representative of these predators because it is very easy to monitor, despite the fact that there are many other species (Cividanes, 2002). *S. frugiperda* also had attacked the sorghum crop to a substantial extent in November 2005. As of early April 2006, *S. frugiperda* caterpillars were again noted on the sorghum crop sown in March (Table 4), but at lower densities (4-7 caterpillars/m²) than recorded in November 2005 (20-30 caterpillars/m²). Moreover, very high densities were noted on ruzigrass crops grown at other locations, with bare pupae sometimes even found on the ground, along with very high pupae densities, i.e. 55 pupae/m² (Silvie, unpublished data). These results are in line with the findings of other research studies recently carried out in Brazil (de Sá, V.G.M. *et al.*, 2006).

D. saccharalis was only found on sorghum, from late November and during December 2005, following the *S. frugiperda* infestation. This species has different biological features because the caterpillars remain within the plant stems. A maximum of 0.6 caterpillars per plant were noted on 12 December 2005.

Table 3. Variations in mean numbers (n°) of caterpillars observed on sorghum, finger millet and pearl millet cover crops (first crop season, 2005/2006)

	S. frugiperda				*D. saccharalis*		*M. latipes*			*S. eridania*
	Sorghum		Pearl millet	Finger millet	Sorghum		Sorghum	Pearl millet	Finger millet	Sorghum
Dates	n°/m²	n°/plant	n°/m²	n°/m²	n°/m²	n°/plant	n°/m²	n°/m²	n°/m²	n°/m²
1/11/05	2.45	0.2	0.11	0						0
4/11/05	4.8	0.43	1.33	0.33						0
9/11/05	19.8	0.53	7.7	0						0
14/11/05	29.8	0.83	36.8	29						0.42
17/11/05	17.2	0.57	36.8	24.8				2.5		0.42
29/11/05	2.3	0.07	2.2	3.8	2.2	0.07		0.5	2.2	0.33
6/12/05	1.75	0.06	4.75	9.5	12.5	0.44		0.33	0	0
12/12/05	0.25	0.009	2.6	0.42	15.3	0.58	0.33	0	8	0.7
26/12/05		0.01			13.7	0.46				0.9
29/12/05		0			6.3	0.2				0
2/1/06		0			6.3	0.2				0
11/1/06	0.07		0.07	0.13			0.87	1.07	0.2	0
17/1/06	0.9		0.2	0.53			0.87	0.47	0.4	

Table 4. Variation in mean numbers (n°) of *S. frugiperda* and *M. latipes* caterpillars on sorghum and ruzigrass cover crops (from 30-06-2006)

	S. frugiperda	*M. latipes*		*S. frugiperda*
Dates	n°/m²	n°/m²	Dates	n°/m²
5/4/06	4.4	0	20/9/06	0.00
12/4/06	6.8	0	27/9/06	0.08
19/4/06	6.2	0	5/10/06	0.08
26/4/06	5.8	0.17	11/10/06	0.00
3/5/06	4.25	0	17/10/06	0.25
10/5/06	0.25	0	26/10/06	0.17
17/5/06	1	0	1/11/06	0.58
24/5/06	0	0	9/11/06	1.42
31/5/06	0.17	0	16/11/06	1.67
7/6/06	0.75	0.08	23/11/06	6.42
14/6/06	0.92	0	30/11/06	8.25
21/6/06	0.33	0	11/12/06	6.67
30/6/06	0.08	0.08	22/12/06	6.92
5/7/06	0.00	0.25	5/1/07	2.50
11/7/06	0.00	0	11/1/07	0.33

M. latipes was observed on finger millet crops on 12 December 2005, with a maximum of 8 caterpillars/m² detected. During the sorghum monitoring period from April to June 2006, the number of *M. latipes* caterpillars was insignificant in comparison with that of *S. frugiperda*. Outbreaks of this species are also often detected on pearl millet crops. Parasitoid-infected caterpillars by *Aleiodes* sp. (Braconidae Rogadinae) found on millet heads may be mistakenly taken for sclerotia of millet pathogens. Low populations of this species were noted at Primavera do Leste, and its population pattern was irregular between years.

Spodoptera eridania was observed only on the sorghum crop at very low densities (less than 1 caterpillar/m²). Live caterpillars, including *Pseudaletia* species, were found under mulched plants that had been knocked down by herbicide sprays, indicating that the pesticides applied during the drying out phase were partially inefficient.

This study highlighted the importance of the method to be implemented and the problems that have to be solved in this type of comparative assessment:

- uniform soil coverage is a priority—homogeneous covers may be obtained by using top quality seeds (purity and germination) and carefully adjusting seeder discs. We encountered this problem at the beginning of the growth period during the 2005/2006 crop season. Mixtures of finger millet and pearl millet seed complicated monitoring of the finger millet crop;
- access to the first lepidopteran adults studied on crops of the same height and even biomass. The sowing dates should be adjusted to take the sown cover crop growth rates into account.

Finally, two other aspects could be the focus of future studies, i.e. the stand density, which may be an important parameter for soil borne predators, and the chemical attractiveness of different types of biomass. *Brachiaria ruziziensis*, for instance, emits a strong typical odour that likely influences the behaviour of phytophagous insects.

CONCLUSION

We found a very high number of caterpillars on cover crops under the direct seeding mulch-based cropping technique. We thus recommend, prior to pesticide sprays, sampling the cover crop using 0.5 m^2 transects (wooden frames), especially since it is hard to monitor these pests under densely sown Poaceae cover crops such as *Brachiaria ruziziensis*.
On the basis of the study findings and additional observations, we also recommend that cotton should not be sown on dry mulch formed by the residue from plants that have been knocked down by a herbicide spray less than a month before. If necessary, depending on the rainfall constraints, the cover crops should be knocked down earlier and the biomass should then be reduced mechanically.

ACKNOWLEDGEMENTS

The authors are very grateful to Alexander Specht (Caxias do Sul University) and Vitor Becker (Instituto Uiraçu) for the lepidopteran identifications, Gérard Delvare for the hymenopterous identifications, Osmar Faria Barbosa, Rodrigo de Araujo Dutra, Marcelo Sebastião da Silva (UNIC University) and Thiago Pereira Vieira (COODETEC) for their help with the monitoring operations. The study was funded by FACUAL (2005/06) and COODETEC (2006/07).

REFERENCES

CIVIDANES F.J. (2002). Efeitos do sistema de plantio e da consorciação soja-milho sobre artrópodes capturados no solo. *Pesquisa agropecuaria brasileira*, 37(1):15-23.

DE SÁ V.G.M., FONSECA B.V.C., BOREGAS K.G.B. AND WAQUIL E.J.M. (2006). Sobrevivência e desenvolvimento larval de *Spodoptera frugiperda* (J.E.Smith) (Lepidoptera: Noctuidae) em hospedeiros alternativos. *Congresso Milho e Sorgo*, agosto 2006, CD-ROM.

NAGOSHI R.D., SILVIE P., MEAGHER R., LOPEZ J. AND MACHADO V. (2007). Identification and comparison of fall armyworm (Lepidoptera: Noctuidae) host strains in Brazil, Texas, and Florida. *Annals of the Entomological Society of America*, 100(3):394-402.

SÉGUY L., BOUZINAC S., TRETINI A. AND CORTES N.A. (1996). L'agriculture brésilienne des fronts pionniers. *Agriculture et développement*, 12:1-76.

SÉGUY L., BOUZINAC S., MAEDA E. AND MAEDA N. (1998). Brésil: semis direct du cotonnier en grande culture motorisée. Agriculture et développement, 17:3-23.

SILVIE P. (2005) Avaliação entomológica dos sistemas de cultivo do algodoeiro. *Anais do V Congresso brasileiro de algodão*, Salvador, BA, Brasil, 2005. CD-ROM

SILVIE P., BELOT J-L., MARTIN J., SEGUY L., BOUZINAC S., DA SILVA M.R.P. AND MARQUES A. (2005). Entomological observations on cover crops in cotton cropping systems in Mato Grosso state: first results. *Anais do V Congresso brasileiro de algodão*, Salvador, BA, Brazil, 2005. CD-ROM.

Silvie Pierre, Menzel C.A., Mello A., Coelho A.G. (2010).

Population dynamics of caterpillars on three cover crops before sowing cotton in Mato Grosso (Brazil).

In : Spanoghe P. (ed.), Vanderkerkhove B. (ed.) International symposium on crop protection : proceedings.

Communications in Agricultural and Applied Biological Sciences, 75 (3), 329-336. International Symposium on Crop Protection, 62., Gent (BEL), 2010/05/18. ISSN 1379-1176