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Can an anti-erosive *Andropogon gayanus* live hedge help regulate millet stem borer infestation in neighbouring millet fields?

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From 2008 to 2010, the effect of a wind erosion-alleviating practice, that is, planting of windbreaks of the perennial grass *Andropogon gayanus* Kunth on the populations of millet stem borer (MSB) *Coniesta ignefusalis* (Hampson) (Lepidoptera: Pyralidae) and the damage induced by this pest to pearl millet, was studied at Sadore (Niger). The extent of bored stems in the *A. gayanus* hedge bordering millet plots (23% on average) was significantly lower than in the millet plots (76% on average), with no MSB larva recovered, compared to an average of 2.2 larvae per stem in the millet plots over the three years. *Andropogon* grass was thus ruled out as a trap crop for MSB management. Under the conditions of this study, a pest regulation service by *Andropogon* grass hedges, synergistic with a potential wind erosion alleviating service, cannot be put forward.

Key words: *Coniesta ignefusalis*, *Andropogon gayanus*, trap cropping, wind erosion, Niger.

INTRODUCTION

In the Sahel, there is a major soil erosion problem due to windy conditions that commonly occur at the time of the dry season to rainy season shift (Rajot et al., 2009). The winds can also have a destructive effect on millet crops sown in sandy soils. Several agroecological management practices have been implemented or proposed to alleviate this erosion and thus contribute to soil conservation and pearl millet crop protection. In earlier studies conducted by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Niger, borders of the perennial grass *Andropogon gayanus* Kunth were shown to efficiently protect millet against violent winds (Renard and Vandenbelt, 1990), although there were also contradictory reports (Michels et al., 1998).

A. gayanus was also found to be an alternate host of several cereal stem borers in Africa (Gounou and Schulthess, 2004), including the millet stem borer (MSB),

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Abbreviations: **ICRISAT**, International Crops Research Institute for the Semi-Arid Tropics; **MSB**, millet stem borer.

Table 1. Millet (cultivar ICMV IS 99001) and *Andropogon gayanus* stem damage by stem borers (Sadoré, 2008, 2009 and 2010).

Parameter	Bored stems (%)		
Year	2008	2009	2010
Millet	81.7[a]	67.6[a]	78.1[a]
Andropogon	23.8[b]	25.6[b]	17.7[b]

Means followed by the same letter in the same column are not significantly different at the 5% threshold in a bilateral means comparison test.

Coniesta ignefusalis (Hampson) (Lepidoptera: Pyralidae), a major pest throughout Sahelian countries (Youm et al., 1996).

The use of this grass as a 'trap crop' for stem borer management was thus suggested, and promising results were obtained in preliminary studies conducted in southern Mali (INTSORMIL, 2008). We therefore conducted trials in Niger from 2008 to 2010 to confirm whether the use of a *A. gayanus* border as a soil conservation measure, that is, an essential ecosystem service, could also have a diversionary effect on the MSB, resulting in "killing two birds with one stone".

MATERIALS AND METHODS

In 2008 and 2009, at the Sadore ICRISAT research station in Niger (13°15'N, 2°17'E), two rows of four experimental millet plots were planted at the onset of the rainy season. Millet plot dimensions were 12.8 × 12.8 m, with alleys of 1.6 m. They were located north of a 53.6 m long × 2 m wide perennial *A. gayanus* hedge, which had been planted more than 10 years before. The southern sides of millet plots were parallel to this border, at distances of respectively 28.8 and 43.2 m for the two rows. Within the plots, pearl millet grain cultivar ICMV IS 99001 (Ministère de l'Agriculture de la République du Niger, 2012) was planted at a spacing of 0.80 × 0.40 m, at approximately 6-8 seeds per hill (namely approximately 3.5 kg/ha). Plots were fertilized via broadcast application of calcium-ammonium nitrate at 100 kg/ha at the time of thinning, according to the research station recommendations.

Both years, at millet harvest, two samples of approximately 20 millet stems (each corresponding to an area of 1 m², or six millet hills) were randomly taken in the central part of each millet plot, and compared to eight samples of 40 stems randomly taken along the *A. gayanus* hedge. Stems were observed for the presence of stem borer holes and, after dissection, the number of stem borer larvae and pupae (*C. ignefusalis* or others) were recorded. Larvae were tentatively identified using the key reported by Meijerman and Ulenberg (1996).

In 2010, the section immediately north of the *A. gayanus* border (from 2.0 to 27.2 m) was sown with pearl millet fodder cultivar Souna 3 (Ministère de l'Agriculture de la République du Niger, 2012). Four strips were set up orthogonally to the *A. gayanus* border in which five subplots of six millet hills, that is, 1 m² with each located respectively 2, 5, 10, 20 and 25 m from the border, along with a subplot of 30 stems in the *A. gayanus* hedge, in the prolongation of each strip. Each millet six-hill subplot corresponded to approximately 30 stems, due to the higher tillering ability of fodder cultivar Souna 3 as compared to grain cultivar ICMV IS 99001. In every strip, all stems in each subplot were dissected at harvest, and numbers of bored stems and stem borer larvae or pupae were recorded as in 2008 and 2009. Data were analyzed using the XLSTAT t-test module (Addinsoft, 2011).

RESULTS

In all three years from 2008 to 2010, the extent of bored stems in the *A. gayanus* hedge bordering millet plots was significantly lower than on the millet plants (Table 1). Not a single *C. ignefusalis* larva was recovered in *A. gayanus*, compared to averages of 1.8, 1.6 and 3.1 larvae per millet stem, in 2008, 2009 and 2010 respectively.

All three years, the lepidopteran (pyralid) caterpillars responsible for stem boring on *A. gayanus* could not be reared to adulthood for identification, but, based on the key reported by Meijerman and Ulenberg (1996) they were clearly not *C. ignefusalis*.

Furthermore, no trends were noted in the infestation and damage levels on pearl millet according to the distance to the *A. gayanus* hedge, which could have reflected a positive or negative effect of this hedge on the MSB (Table 2).

DISCUSSION

MSB pressure at Sadore during the study period was high, at the same level as that reported in 1996 both at this site with a MSB susceptible pearl millet cultivar (Drame-Yaye et al., 2003; Sastawa et al., 2002) and, for damage rate, as that reported from farmers' fields (on supposedly local pearl millet cultivars) in the Upper East Region of Ghana, and for MSB infestation, from the Upper West Region (Tanzubil and Mensah, 2000), and higher than the damage rate observed in 2010 to 2011 at Maiduguri in Northern Nigeria, with a MSB-susceptible pearl millet cultivar (Degri et al., 2014). Pearl millet cultivar Souna 3 infestation and damage by MSB observed in 2010 at Sadore were higher and more variable than those observed on the same site on cultivar ICMV 99001 (Ratnadass et al., 2014).

A. gayanus was thus ruled out as a trap crop for MSB management under the conditions of Sadore from 2008 to 2010, contrary to preliminary results reported earlier from Mali (INTSORMIL, 2008). On the other hand, the

Table 2. Millet (cultivar Souna 3) stem damage and infestation (means ±standard deviations) by MSB according to the distance from the *Andropogon gayanus* hedge (Sadore, 2010).

Distance from *A. gayanus* hedge	2	5	10	20	25
Bored stems (%)	52.9 ±33.4	49.3 ±20.9	43.2 ±27.2	58.2 ±24.0	49.9 ±28.3
No. MSB larvae/stem	3.9 ±4.1	3.8 ±1.0	1.6 ±1.7	4.1 ±2.3	3.5 ±2.8

only parameter reported from that earlier study was percent dead hearts, and *A. gayanus* was planted as a perimeter trap crop surrounding millet. In addition, *A. gayanus* was specifically planted for the purpose of the study, while the *A. gayanus* hedge at Sadore had been planted more than 10 years before. Actually, one considers that it requires one year before *A. gayanus* can act as a windbreak (Renard and Vandenbelt, 1990). In addition, both in this study and in that of Mali, Andropogon hedges were much narrower than those reported to actually act as wind breaks (Renard and Vandenbelt, 1991; Bielders et al., 2004), except the study by Michels et al. (1998), which revealed that a 2 m tall to 3.5 m wide windbreak of *A. gayanus* reduced annual soil flux by 6 to 55%. Also, differences in the results obtained in Niger as compared to those of Mali could be partly due to varietal differences. Actually, the dominant variety used in the relatively humid Sudanian zones of both Mali and Burkina Faso, where wind erosion is less of a problem, is cultivar *bisquamulatus*. Conversely, the only variety adapted to the Sahelian zone, e.g. that of Sadore in Niger, where wind erosion is a crucial problem, is cultivar *tridentatus* (Kaboré-Zoungrana et al., 1994).

In our study, the Andropogon hedge was not ideally planted, neither for wind erosion alleviation purposes, nor for pest regulation purposes via trap cropping effect, since it was displayed parallel to dominating wind direction. There was no “control” millet field (without Andropogon border) either, for comparison purposes. However, the fact that not a single MSB larva was recovered from the Andropogon border, and that there was no effect/trend of the distance from this border on MSB infestation and damage across the millet field (unlike what was found in the case of sugarcane with an Erianthus border: Nibouche et al., 2012), are sufficient to reject a trap cropping potential of *A. gayanus* vis-à-vis *C. ignefusalis*.

The previously reported stem borer reduction from Mali could also have been due to a barrier effect, since *A. gayanus* surrounded millet plots, or to top-down control by natural enemies sheltered in the *A. gayanus* hedge. Regarding the bottom-up trap cropping effect, further to the role of attractant volatile organic compounds (Khan et al., 2010), it is interesting to note that the most emblematic cases of successful use of trap plants for stem borer control pertain to Napier grass (*Pennisetum purpureum*) and vetiver grass (*Vetiveria zizianoides*) for *Chilo partellus* management on maize (Khan et al., 2006; Van den Berg et al., 2006), while the results are less clear-cut for *Busseola fusca* (Khan et al., 2007; Van den Berg et al., 2006). The two maize stem borer species could be distinguished by the fact that *C. partellus* females lay their eggs on the leaf surface, while those of *B. fusca* insert them under the leaf sheath, like those of *C. ignefusalis* which seldom deposits them on the leaf surface (Youm and Gilstrap, 1994). This could explain why, based on this behavioral trait, *C. partellus* is a better candidate than either *B. fusca* or *C. ignefusalis* for regulation via trap cropping. Also, while *C. partellus* is indeed a polyphagous species, both *B. fusca* and *C. ignefusalis* are rather oligophagous (Le Ru et al., 2006; Youm et al., 1996).

The results reported here highlight the importance of documenting the impact of agroecological management options on all factors likely to influence crop yields, in both the short and long run, including soil erosion and pest damage. However, they do not question the advantage of *A. gayanus* borders for anti-erosion control, and for protecting pearl millet seedlings from sand and wind damage. Furthermore, *A. gayanus* has some value as a fodder (Kaboré-Zoungrana et al., 1994), and it could be partly used as such without affecting its anti-wind erosion function. Moreover, although erosion alleviation and pest regulation services were not found to be synergistic in this case, at least they were not found to be antagonistic, unlike in the case of anti-erosion techniques based on stem residue management (Ratnadass et al., 2014).

Conflict of Interest

The authors have not declared any conflict of interest.

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