

Strategies for controlling the degradation of grasslands invaded by *Sporobolus indicus* (L) R. Br

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Results of studies conducted in the Institute of Animal Science of the Republic of Cuba with an integral and multidisciplinary approach are presented. The topic developed is related with the applied strategies to control the degradation of grasslands invaded by wire grass (*Sporobolus indicus*). Other researches conducted with this weed in different tropical and subtropical regions considering the biological characteristics of this species are also considered. Reproduction methods of wiregrass and of seeds production are also dealt with. The negative effect of this weed on the economy and biomass production of an improved grassland is analyzed. The infestation level of wiregrass and the pureness percentage of the improved pasture are considered, as well as the application of recovery alternatives throughout new sowings or rehabilitation. It is proved that planting species of the *Pennisetum* genus by the plowing method or the traditional method are effective ways of control that also favor the recovery of completely damaged grasslands. The recovery or rehabilitation with the use of plowing plus harrowing, in combination with the chemical and organic fertilization, is a promising alternative to recover the energy of the grassland and an option to minimize the population of this weed and reestablish the productivity of the agroecosystem. A good animal and agrotechnical management is suggested after these labours, in order to achieve the sustainability of the improved pastures. The knowledge described will make possible to design a program for the integral control of the weed and the recovery of improved grasslands ecosystems invaded by wiregrass.

Key words: *Sporobolus indicus*, weed, sowing, rehabilitation.

INTRODUCTION

The degradation of improved pastures is a first-order problem in the world. Generally, the development of cattle production brings about the loss of the soils natural fertility and the invasion of weed species. These conditions provoke great environmental and economical losses due to the diminishing of cattle productivity, affections present in 680 millions of hectares in the world (Brown 2003). Several scientists affirm that grassland degradation is the anteroom of desertification. In Cuba, 14 % of the territory is affected by this phenomenon.

Therefore, tackling this problem, related with the climatic change in fragile ecosystems as the small island states, is important.

Wiregrass is one of the undesirable species affecting the most the improved pastures in Cuba and other tropical regions, as it has similar physiological characteristics to those of the cultivated grasses (C_4 photosynthetic pathway, perennial life cycle and low nutritive quality). Besides, it is not an intake source for animals. In a short period of time, this weed may cause a high invasion and infestation degree in different agroecosystems, provoking huge losses in the plant biomass yield.

From the conceptual perspective, grasslands recovery in degraded and weed-invaded areas is based on two strategies. One comprises the recovery through renewal or new sowings, when the undesirable species are over 65 %, or when there is need of replacing the existing species by others with higher productivity and nutritive value, when the pasture state does not allow any other option. Another alternative consists on the recovery or rehabilitation of the grassland through the replacement

of its productive capacity, per area unit and animal, until reaching acceptable ecological and economical levels.

The rehabilitation term supposes the presence of one or more desirable forage species, with conditions to be preserved, stimulated or complemented. For this purpose, it is necessary that the desirable species have an acceptable botanical composition (40-60 %) when applying recovery labors. A possible guide to achieve this could be that suggested by Andrade *et al.* (2006) to define the deterioration level of a grassland: productive, slight, moderate and advanced degradation, with values of 0-10; 11-35; 36-60 and of 61-100 % of invasion, respectively.

The knowledge of the weed biology and the application of difference control methods are integrated in this study. The analysis will be based on assessing what occurs when there is an excluding competitions between the weed and improved pasture, with benefits for this last: agroecosystems of stable grasslands from the biological and economical point of view.

The general objective of this study was to expose reviewed information about the biology of *Sporobolus indicus* and offer practical tools to achieve the grasslands recovery from the use of cultural labors. Besides, it intends to offer knowledge to generate and apply integral programs to make easy the reduction of this weed population at inferior levels to the economical damaged and, at the same time, make possible the recovery of the degraded grasslands.

BIOLOGICAL STUDIES

A deep biological knowledge of the species to be controlled is needed when desiring establish weed control integrated systems. This will allow to adequate the agricultural labors to the self biological characteristics of the species to be eliminated from the grassland.

The biological studies conducted by Febles *et al.* (2010) indicate that this plant produces seed almost during the whole year, except in February and August. It has dormancy, with germination increase from the six months after the seed was formed. The seed viability was of at about two years, and it was not abruptly lost. It is known that a plant may produce 10 panicles and 11000 seeds/plant, which do not germinate when they are covered with a soil layer superior to 0.5 cm. The germination percentage varies, depending on when the seed is produced and on the storage time. Seeds harvested in September, for example, reach up to 53.2 % from six months of storage on (Padilla *et al.* 2005a). The seed production potential and the germination level alert the danger of wiregrass to invade the improved pastures. Knowing the biology of a weed may be a practical guide to plan the mechanical and cultural labors for its control and develop further studies on this respect.

The formation period of the panicles up to the seeds maturation goes from week six to 12. This means that the vegetative cycle of wiregrass during the dry season is of 84 d, and of 65 d in the rainy one (Sardiñas 2009). This indicates the need of starting labors to prepare the soil before wiregrass ends its reproductive cycle. This way, the increase of the seed bank could be avoided and therefore, the diminishing of this weed in the agroecosystem.

It was evidenced in a phenological study that the highest height (40.2 cm), yield per plant (12.20 g), DM production (3.99 t/ha), as well as the lowest CP percentage (4.27 %) occur when plants are harvested

after the seeds threshing. However, the best option in respect to quality (5.46 % of CP), was achieved when the plant was in the vegetative development, having also higher content of calcium and phosphorous (Padilla *et al.* 2010).

When studying the effect of the wiregrass population density (0, 2, 4 and 6 plants/m²), it was demonstrated that the increase of the number of plants of this weed reduced the guinea grass height, from 87 to 64 cm. The percentage of the covered area was from 100 to 67 %, and the yield of basis pasture was reduced to 33 % of its potential. It decreased from 2.16 t DM/ha/cutting, when there was not wiregrass, to only 0.69 t DM/ha, when the population increased to 6 plants/m². The cost of produced DM in t/ha increased from 25.21 to 78.63 Cuban pesos (table 1). There was not defined effect between the nutrients content of the soil and the wiregrass population. However, OMD of guinea grass, as well as CP and P in wiregrass, were inferior when the population of this weed was higher (Padilla *et al.* 2012).

This last result showed clear tendencies and informed, for the first time in Cuba, the negative, technical-economical influence of this plant in improved pastures. Besides, the hypothesis that this weed may be a whip for the improved pastures in many tropical and subtropical regions of the world was confirmed.

The researches concerning biology and those related with measuring the technical-economical effect of this weed in improved pastures, are referred in final report of the Project conducted at the Institute of Animal Science, ended in 2005. These researches integrated and deepened in essential aspects to establish a control program of the weed. The scientific-practical bases needed to design and apply a scheme of multidisciplinary researches about the proper methods for controlling wiregrass and recover the degraded pastures were established (Padilla *et al.* 2010).

Table 1. Biomass production and costs, according to the invasion degree of wiregrass

Wiregrass, plants/m ²	Wiregrass, tDM/ha	Guinea grass, tDM/ha	Cost, t DM/ha
0	-	2.16 ^a	26.21 ^a
2	0.18 ^a	1.76 ^b	31.28 ^b
3	0.51 ^b	1.23 ^c	48.81 ^c
6	0.91 ^c	0.69 ^d	78.63 ^d
SE ± sig	0.05***	0.09***	0.08***

^{abc} Values with different letters per column differ at P < 0.05 (Duncan 1955)

***P < 0.001

RENEWAL OR NEW SOWINGS

The recovery of grasslands by the renewal or new sowings is an alternative, when the deterioration level of the grassland is such that, due to its low presence in ecosystem, it cannot have its vigor back. It has to

be substituted then by a new one through the sowing labors.

The establishment of pastures by renewal with complete soil preparation has been the most studied

and spread option in Cuba. It is one of the most expensive investments for livestock, as it implies fuel, labor and machinery expenses. This occurs because, before conducting the sowings or plantations, leveling operations and those of soil preparation, harvesting and seed transportation need to be carried out, apart from elaborating the material for the plantation. This expensive investment is recovered only when conducting a good sowing and the useful and productive life of the grasslands are increased (Padilla 2008). Recovering the degraded area invaded by wiregrass through the sowing of improved pastures species of aggressive growth was the first step in this study. This way, an invading weed like wiregrass could be removed from the grassland ecosystem (Sardiña *et al* 2011).

In previous studies to that referred by Padilla *et al.* (2005b), the combination of an aggressive-growth pasture, such as the clone Cuba CT-115, and the plantation by the plowing method was assessed. The results indicated that these two cultural practices, knowing their biology, could favor the control of this weed. In respect to the conventional method, the superiority of planting Pennisetum varieties by the plowing method was demonstrated. With these studies, the firsts on this topic, the need of planting their clone after conducting, at least, a minimum tillage to the soil, contrary to that made by some technicians, was demonstrated. Clearing up this confusion would avoid spending resources in the livestock enterprises.

The cited authors recommended the plowing method at the beginning of the rainy season (June) to diminish the wiregrass population. It was confirmed that the integration of the preparation beginning and the minimum soil tillage, with an aggressive species and of upright growth like Cuba CT-115 pasture, reduces the wiregrass population on time, from 7.82 to 0.19 plants/m² (Padilla *et al.* 2004) (table 2).

This experiment and others conducted from this same topic (Padilla *et al.* 2004, Padilla *et al.* 2005a and Padilla *et al* 2005b), allowed counting the technical-economical

advantages. Important practical rectifications were also conducted in different Cuban livestock enterprises, which allowed proposing an original simple and practical methodology about the plantation of *P. purpureum* with the plowing method, with minimum soil tillage, generalized in the whole country. This technology propitiates higher biomass production (9.49 and 9.22 t/ha of DM) and lower cost/t of DM and GM (4.63 and 16.25 Cuban pesos). Besides, when reducing the number of labors from six to three, 50 % of the oil and machinery expenses per planted hectare are reduced as well as the total expenses in 39.91 Cuban pesos (Padilla *et al.* 2005b). The wiregrass populations decreased to inferior values to those of the critical threshold where this weed may affect the improved pastures.

In another study, where five varieties of improved pastures of the genera *Cynodon*, *Brachiaria*, *Panicum* and *Pennisetum* were assessed in the control of wiregrass (Lorenzo *et al.* 2013), the variety Cuba CT-115 of *Pennisetum* and those of the genus *Panicum* (*Guinea cv. Mombaza* and *Likoni*) controlled the wiregrass invasion, reduced the wiregrass invasion from 5 to 0.52 plants/m², and achieved the highest percentages of the grassland pureness (98 %). There was no positive response to the wiregrass control with *Cynodon* and *Brachiaria*.

An important result was the study related with the wiregrass control throughout the sowing of four varieties of *P. maximum* that transformed the floristic composition of the agroecosystem (Sardiñas *et al.* 2011). The infestation percentage of the weed was reduced in this study from at about 52 to 5 %, and the covering percentage of the desired pasture was increased from 20 to 89 % at the end of the research. The availability of total biomass, initially of 2.8 tDM/ha/rotation and mostly corresponding to wiregrass was increased with the application of the treatments up to 4.6 tDM/ha/rotation, and decreased in the last year of assessment. Besides, the population density of the invader was reduced from 5 to 0.52 plants/m² during the experimental period.

Table 2. Influence of the beginning of soil preparation and the sampling date on the number of plants/m² of wiregrass

Factors	Beginning of soil preparation					SE±
	April	May	June			
Plants/m ²	1.31 ^a (2.12)	1.23 ^a (1.92)	1.48 ^b (2.52)			0.05**
	Different moments of conducting the sampling					
	Beginning	September	October	November	February	SE±
		12, 2001	10, 2001	15, 2001	27, 2002	
Plants/m ²	2.84 ^c (7.82)	1.03 ^b (0.94)	1.04 ^b (1.03)	1.05 ^b (1.03)	0.72 ^a (0.19)	0.06**

^{abc} Values with different letters within the same row differ at P < 0.05 Duncan (1955).

** P < 0.01

() Real values

RECOVERY OR REHABILITATION.

Due to the economical and productive impact for the primary sector, a not less important situation was the recovery or rehabilitation of grasslands. Using this, the grassland agroecosystem can be recovered without making new sowings. Other studies were conducted, consisting of the application of different reaper systems (by impact with a weeder machine CH 60, by saber E-281 and disc with Soviet reaper) for controlling wiregrass and its effect on the biomass production of the basis pasture (Padilla *et al.* 2005 a).

It was proved that the cutting by impact weeding did not favor either the control of wiregrass nor the recovery of guinea grass, as it reduced the height and biomass production of the basis pasture (guinea grass). There was not defined response to the cutting systems in the control of wiregrass, but in the worst case, the impact weeding increased the yield and the population /m² of the weed. This performance seems to be specific for wiregrass, as it favors its propagation by the impact cutting, as other weeds of this genus can be reduced with these cultural practices, as the case of *Paspalum virgatum* (Martínez *et al.* 1984).

Studies of Crespo and Fraga (2005) showed that the application of cattle manure did not influenced on the yield and biomass production of guinea grass and wiregrass. The highest guinea grass yield (3.43 tDM/ha) was obtained when applying plowing and harrowing only, coinciding with the lowest population wiregrass (1.0 -1.2 bunches/m²). The guinea grass population increased from 37 to 80 %.

In respect to the percentage of wiregrass in the grassland ecosystem, the chemical fertilization propitiated higher guinea production, when differing from the treatments without fertilization. The combination plowing and harrowing and fertilization may be an option for the recovery of grasslands of guinea grass invaded by the wiregrass (Crespo and Fraga 2005 and Sardiñas *et al.* 2011).

Another research conducted was that related with the

animal management and its influence on the population performance of wiregrass and guinea grass. Padilla *et al.* (2005c) assessed two resting times (15-30 d in rainy season and 45-55 d in dry season) or grazing every 30-40 d in the rainy and 60-70 in the dry season, with or without fertilizer (0 and 500 kg/ha of complete formula) at the beginning of the rainy season. Increasing the botanical composition in favor of the improved pasture was achieved, as well as the appearance frequency and density of guinea grass and the diminishing of wiregrass in the agroecosystem. It was proved that prolonging the resting time and applying maintenance fertilization is a strategy for guinea grass grasslands in degradation.

Regarding the use of chemical methods of control (Sardiñas *et al.* 2011), the effect of two herbicides (Diurón and Solar) was assessed with three application dosages on the control of wiregrass. Better control was achieved when applying dosages of 5 L/ha of the Solar herbicide, with 99.94 % of affectation in the weeds bunches. After 20 d of application, there was a recovery of the wiregrass, suggesting the need of a second application.

Studies of Valenciaga *et al.* (2007) demonstrated the existence of phytofagous insects associated to wiregrass. These authors found five fungi species on the seeds, considered as possible potential pathogens, highlighting *Fussarium roseus*. In a grasses grassland invaded by wiregrass, insect-plagues and phytopathogen microorganisms were found as possible natural enemies of this weed. These results show that there is a total 20 phytofagous species associated to wiregrass, highlighting the orders Hemiptera-Homoptera, as those with the highest presence of insects-plague. However, the insects of highest frequency and population were *Empoasca sp.* and *Ormenaria rufifascia*, both with superior values during the dry season (1.36 and 1.09 insects/m²), which are not enough for a beneficial effect on these plants. These results are considered the basis for further studies on this topic.

CONCLUSIONS

It is concluded that wiregrass is a weed that produces gamic seed, with high percentages of germination. It has dormancy up to six months after being formed. It is capable of producing up to 12 thousand seeds, which do not germinate if cover them with more than 1 cm of soil.

When the wiregrass population reaches 6 plants/m² influences negatively on the improved pasture. This is shown in the reduction of its biomass production and the increase of DM production costs.

The grasslands recovery through the plantation of Pennisetum species, by the plowing method or the traditional sowing of Panicum varieties, may be an effective strategy for controlling wiregrass and the

recovery of grasslands with advanced deterioration stage.

The rehabilitation with plowing and harrowing, combined with fertilization as a way to recover the vigor of the degraded pasture invaded by wiregrass, could be an option to minimize the population of this weed and re-establish the productivity of the agrosystem.

A proper animal and agrotechnical management is necessary so the renewal or rehabilitation effects last in time and, therefore, the sustainability of improved pastures may be achieved.

Knowing the biology, as well as the infestation level of the weed and the degradation stage of the grasslands,

together with the application of different alternatives, favor the design of programs for the integral control of this weed.

It is also necessary to control the causes provoking the grasslands degradation and keep a proper agronomical and animal management to achieve the sustainability of these agrosystems in time.

There is necessary knowledge for technicians and producers identify properly the degradation of a pasture from the infestation of wiregrass, as well as the pureness percentage of the improved pasture. With this information, the strategies for its recovery from renewal (new sowings or rehabilitation) could be determined.

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Received: October 19, 2012