Differences in seed longevity between quinclorac-resistant and susceptible barnyardgras

AL Pereira[1], , N Saldain[2], C Marchesi[3], M Oxley[4] and A Pimienta[5]
[1] Instituto Nacional de Investigación Agropecuaria, Treinta y Tres, Uruguay, apereira@inia.org.uy
[2] Instituto Nacional de Investigación Agropecuaria, Treinta y Tres, Uruguay, nsaldain@inia.org.uy
[3] Instituto Nacional de Investigación Agropecuaria, Treinta y Tres, Uruguay, cmarchesi@inia.org.uy
[4] Instituto Nacional de Investigación Agropecuaria, Tacuarembó, Uruguay, moxley@inia.org.uy
[5] Instituto Nacional de Investigación Agropecuaria, Treinta y Tres, Uruguay, apimienta@inia.org.uy

ABSTRACT

The objective of this research is to quantify the longevity of seeds of biotypes resistant and susceptible to the herbicide quinclorac, verifying if there are differences between them, when seeds are on the soil surface or buried at 15 cm of depth. The experiment was installed on April 2013. Enough seeds of quinclorac resistant- and susceptible-biotypes were placed in PVC pipes buried at 15 cm depth and at the surface for a sampling period of five years. Extractions were made every three months, corresponding to each season of the year during the first three years, and every six months extractions in the last two years. The viability and dormancy of the seeds were studied through germination and tetrazolium tests, respectively. The experimental design consisted on a completely randomized block design with sub-sub-divided plots, and six replicates. The plots corresponded to the year of extraction (2013 to 2018), the sub-plot the soil depth (0 and 15 cm), and the sub-sub-plot the biotype (susceptible and resistant to quinclorac).Regardless biotypes, seed viability was reduced in the successive extractions, being the reduction greater for the seeds deposited on the surface than those buried. Resistance to the herbicide quinclorac did not affect the viability of the seed or modify the seasonal dormancy cycles of *Echinochloa crus-galli* at any depth studied. After 5 years of seeds burying at 15 cm depth, they continue having high potential for re-infestation, when they come back to the soil surficial horizons by means of soil tillage.

Key words: *Echinochloa crus-galli*, viability, dormancy, seed bank

1. Introduction

Approximately 40% of the rice acreage in Uruguay is sown each year on rice stubble, and the rest of the area in rotation with pastures or idle land for two or more years. In these systems, herbicides have been an effective tool in integrated weed management. However, the continued use of the same active ingredients determined selection pressure in the populations towards individuals that tolerate herbicides. Herbicide resistance is a result of the selection for traits that allow weed species to survive specific management practices which would otherwise cause mortality (Powles, 1994). Quinclorac is a highly selective herbicide that has had an important use in most regions where rice is grown. Resistance in weeds to this herbicide has been reported in various rice producing regions. In the eastern part of Uruguay, Saldain and Sosa (2015) reported resistance of barnyardgrass biotype to quinclorac, showing a new aspect to be considered in the integrated management of weeds in rice cultivation in Uruguay.

Weeds when evolved herbicide resistance sometimes lose or diminish some of their survival abilities (Gressel, 2009). Since the longevity of the seeds is a characteristic of great importance in the survival capacity of weed species, this could be affected by the acquisition of herbicide resistance. Some authors mention that the longevity of the seeds depends critically on the dormancy mechanisms that prevent completely embedded seeds from germinating (Cook, 1980), however, Baskin and Baskin (2001) stated that the only type of dormancy that can be a great cause for the persistence of the seeds is physical dormancy (hard seeds). On the other hand, knowing the dynamics of the viability and dormancy of the seeds of these species becomes relevant in the management of rice cultivation. The objective of this work is to quantify the longevity of seeds of biotypes resistant and susceptible to the herbicide quinclorac, verifying if there are differences between them, when placed on the soil surface and buried at 15 cm depth.

2. Material and Methods

A field experiment was carried out in the Experimental Unit Paso de la Laguna of the Instituto Nacional de Investigación Agropecuaria in Treinta y Tres state, Uruguay. It was installed on April 28, 2013. The seeds of *Echinochloa crus-galli* were collected in the eastern region of Uruguay, being biotypes quinclorac-susceptible and another quinclorac-resistant. Both biotypes presented zero percent of germinated seeds at the time of the trial installation, and a viability of 96.5% for the resistant and 96.8% for the susceptible biotypes, respectively. These seeds were deposited on the soil surface or buried at 15 cm, for a period of five years. Extractions were made every three months corresponding to each season of the year during the first three years, and every six months in the last two years. The viability was calculated as the product of the percentage of seeds recovered and their respective percentage of viability. In each repetition, 100 seeds placed in PVC open tubes of 10 cm diameter, buried at 15 cm soil depth were used, and the tubes corresponding to the surface seed were buried halfway, distributing the seed in the area of the tube. Ninety-six cylinders were buried per treatment. The unearthed tubes were taken to the laboratory where the seeds were recovered. Initially live and dead seedlings were counted and then the earth was crumbled looking for the seeds visually. Seeds that were not visually damaged were placed to germinate on paper with alternating temperatures of 20-30° C. Seeds germinated on the fourteenth day and the number of seedlings born in the field constituted the portion of viable quiescent (non-dormant) seeds. The experimental design consisted on a completely randomized block design with sub-sub-divided plots, and six replicates. The plots corresponded to the year of extraction (2013 to 2018), the sub-plot the soil depth (0 and 15 cm), and the sub-sub-plot the biotype (susceptible and resistant to quinclorac). The statistical analysis of variables was done using proc Mixed (SAS Institute, v9.4) and the comparison of means using the Tukey test ($P < 0.05$).

3. Results and Discussion

The viability of the seeds is presented in Figure 1, In this, the changes that occurred in the successive extractions for the two biotypes and depths under study can be observed.

In fall 2013, when the trial was installed, the seeds had 97% viability (100% corrected). The viability of the seeds was reduced in the successive extractions, being significantly lower for the seeds deposited on the surface ($P < 0.05$). The difference in longevity of the seeds at different depths has already been verified by many authors for several species, where the seeds buried deeper have greater longevity (Miller and Nalewa, 1990; Noldin et al 2006).

Viable surface seeds showed an abrupt drop in the first year, obtaining average values of around 20%. These seeds did not remain viable by the third summer, finding viability percentages less than 10% in this last year. On the contrary, seeds buried at 15 cm maintained a high percentage of viable seeds until the third year, 56% on average for both biotypes. At the fall of the fifth year, 21% of viable seeds remained in the soil on average. Seeds can remain 100% viable for 6-8 years in dry condition (Maun and Barrett 1986); longevity in soil varies according to soil texture. Echinochloa species, specifically barnyardgrass, were reported to remain viable up to 13 years in sandy loam soil when buried at 20 cm depth with 3% of viability (Dawson and Bruns 1962).

Soil and climate, according to Bekker et al (1998) can influence these longevity differences, however, this influence is not decisive, since persistence is above all a characteristic of the seed, which may or may not be modified by environmental conditions (Fenner and Thompson, 2005). Interaction between depth at different moments of extraction was found for viability. The number of seeds of the total deposited decreased over time, especially on the surface. These losses are given, among other factors, by the germination of the seeds on the surface, the action of the microfauna, and greater exposure to climatic factors.

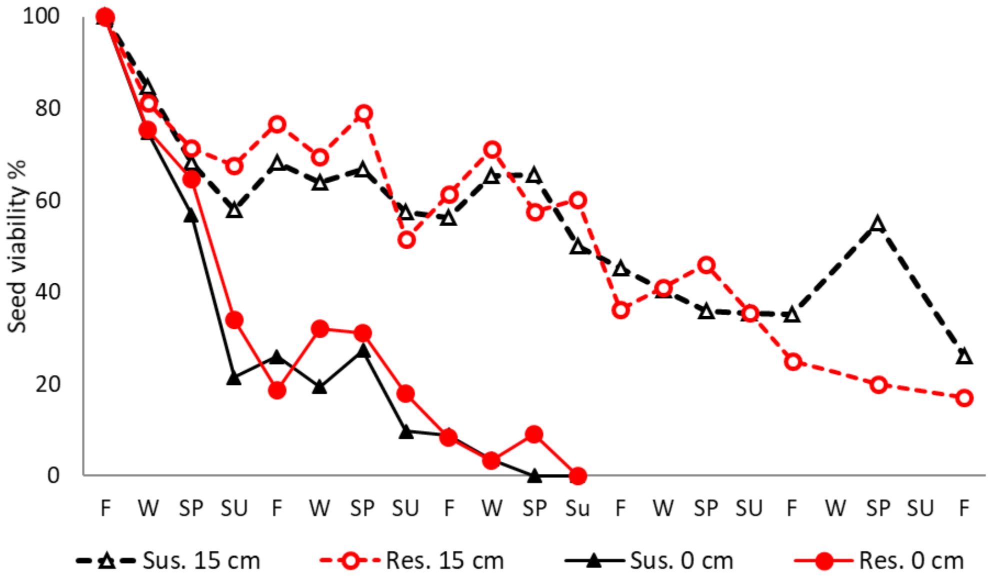

Figure 1. Evolution of the seed viability (%) of resistant (Res) and Susceptible (Sus.) biotypes. Seeds of *Echinocloa crus-galli* buried at 15 cm and on the surface (0 cm) were seasonally extracted (F = fall; W= winter; SP = spring; SU = summer); experiment began in the fall of 2013. P <0.05%.

In the viable seeds obtained in each season of the year there were changes in the proportions of dormant and quiescent. Figure 2 shows the evolution by season of dormancy and quiescence of seeds of the two biotypes and at both depths. At the end of April 2013, less than two months after harvest, seeds were 97% dormant and 0% quiescent.

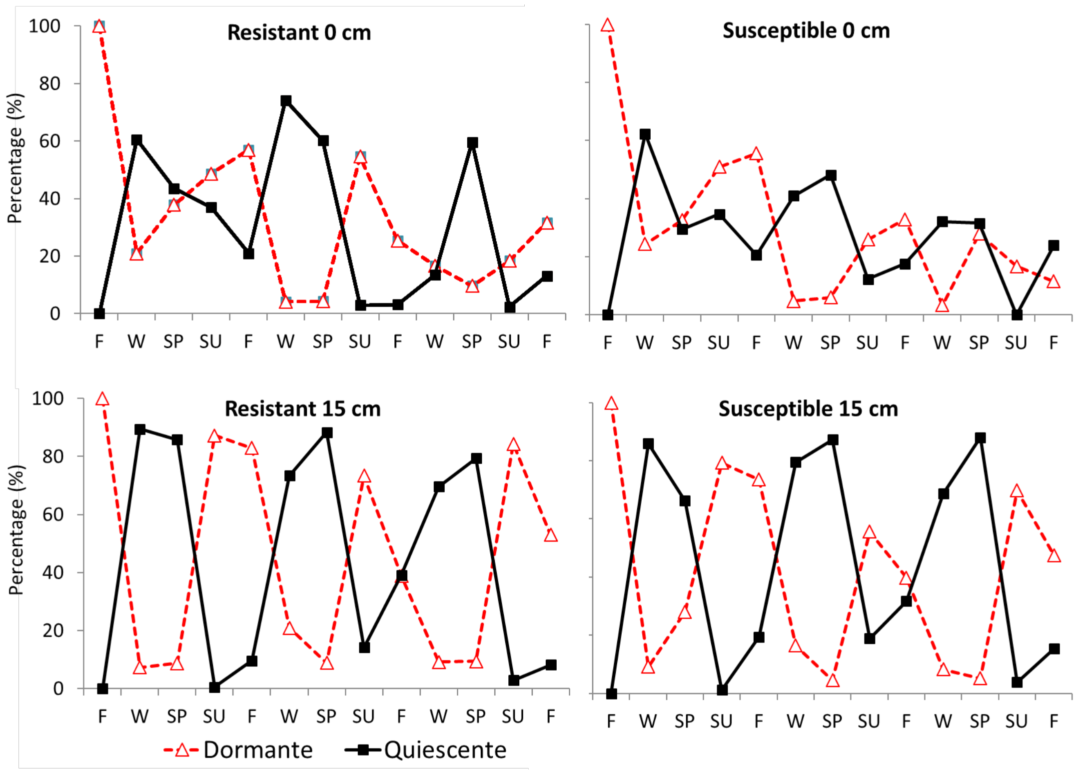

Figure 2. Evolution percentage of dormant and quiescent seeds of resistant and susceptible biotypes *Echinocloa crus-galli* on surface (0 cm) and buried at 15 cm in seasonal extractions from fall 2013 to 2018 (F=fall; W=winter; SP=spring; SU=summer).

Three months later, in the winter, dormancy was overcome and most of the seeds passed to a quiescence condition. This difference is greater in the seeds buried at 15 cm, presenting an average of almost 90% quiescence, the seed being more affected by the variations in soil and climate conditions. In spring, this situation began to be reverted slowly, increasing the number of dormant seeds and decreasing the quiescent ones until reaching a maximum of dormancy in the summer. This cyclical behavior was repeated the other years for both depths and biotypes.

Between the biotypes, no differences were found in the proportions of dormant and quiescent seeds, with a similar behavior at both depths. Between the depths, however, there are differences in both the percentage of dormant and quiescent seeds. There were differences in the percentage of dormant and viable seeds in the average of the different moments of extraction.

Conclusions

Seeds buried deeper had greater viability than those on surface, for biotypes resistant and susceptible to quinclorac. Resistance to the herbicide quinclorac did not reduce the viability of the seed or modify the seasonal dormancy cycles of *E. crus-galli* at both depths evaluated. After five years buried at 15 cm, seeds continue with a high potential for re-infest rice fields if they are taken to the surface.

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