DOI: 10.5965/223811712332024448

Revista de Ciências Agroveterinárias 23 (3): 2024
Universidade do Estado de Santa Catarina

Viability of black oat seeds in the soil as a function of burial time

Viabilidade de sementes de aveia preta no solo em função do tempo de enterrio

Kassiana Kehl [1(ORCID 0000-0002-2493-2131)], Ivan Ricardo Carvalho [2(ORCID 0000-0001-7947-4900)], Deivid Sacon [3(ORCID 0000-0002-9690-8528)], Mauro Antonio Rizzardi [4(ORCID 0000-0002-4042-6431)], Nadia Canali Langaro [4(ORCID 0000-0002-2031-5152)], Jaqueline Novakowiski Huzar [4(ORCID 0000-0003-1037-2396)], Murilo Vieira Loro [5(ORCID 0000-0003-0241-4226)], Francine Lautenchleger [6(ORCID 0000-0003-0219-6062)]

[1]Fundação Pró-Sementes, Matriz Passo Fundo, RS, Brazil.
[2]Universidade Regional do Noroeste do Rio Grande do Sul, Ijuí, RS, Brazil. *Author for correspondence: ivan.carvalho@unijui.edu.br
[3]Universidade Federal de Viçosa, Viçosa, MG, Brazil.
[4]Universidade de Passo Fundo, Passo Fundo, RS, Brazil.
[5]Universidade Federal de Santa Maria, Santa Maria, RS, Brazil.
[6]Universidade do Centro-Oeste, Guarapuava, PR, Brazil.

Submission: 07/08/2023 | Acceptance: 30/03/2024

ABSTRACT

This work aimed to verify if there is a temporal effect on the viability of black oat seeds under natural conditions after harvesting, under burial. The treatments were arranged in a bifactorial scheme, with five black oat genotypes and eight exhumation periods (90; 180; 270; 360; 450; 540; 630 and 720 days after burial), distributed in four repetitions of one hundred seeds buried at 10 cm deep. After each exhumation, seeds separation and count, those that did not germinate, did not rot, or were predated were considered as whole seeds, which underwent a process of asepsis and disinfection to verify viability through the germination test and vigor through the tetrazolium test (live seeds). The genotypes showed a decreasing percentage of seeds over time, Agro Planalto showed the lowest percentage at 360 days after burial, Agro Esteio at 450 days, Agro Coxilha, Agro Quaraí and Agro Zebu at 540 days. The percentage of live seeds differed between the genotypes only in the third period of exhumation (270 days after burial), the lowest percentages of live seeds were identified in the genotypes Agro Esteio and Agro Planalto at 360 days after burial, in Agro Coxilha and Agro Quaraí at 450 days and Agro Zebu at 540 days. Black oat seeds remain viable in the soil for a period of 450 days after burial.

KEYWORDS: survival; seed bank; soil; germination; tetrazolium.

RESUMO

Este trabalho teve como objetivo verificar se há efeito temporal na viabilidade de sementes de aveia preta em condições naturais após a colheita, sob enterro. Os tratamentos foram arranjados em esquema bifatorial, com cinco genótipos de aveia preta e oito períodos de exumação (90; 180; 270; 360; 450; 540; 630 e 720 dias após o enterro), distribuídos em quatro repetições de cem sementes enterradas a 10 cm de profundidade. Após cada exumação, separação e contagem das sementes, aquelas que não germinaram, não apodreceram ou foram predadas foram consideradas como sementes inteiras, que passaram por processo de assepsia e desinfecção para verificação da viabilidade pelo teste de germinação e vigor pelo teste de tetrazólio. Os genótipos apresentaram percentual de sementes decrescente ao longo do tempo, Agro Planalto apresentou o menor percentual aos 360 dias após o enterro, Agro Esteio aos 450 dias, Agro Coxilha, Agro Quaraí e Agro Zebu aos 540 dias. A porcentagem de sementes vivas diferiu entre os genótipos apenas no terceiro período de exumação (270 dias após o enterro), os menores percentuais de sementes vivas foram identificados nos genótipos Agro Esteio e Agro Planalto aos 360 dias após o enterro, em Agro Coxilha e Agro Quaraí aos 450 dias e Agro Zebu aos 540 dias. As sementes de aveia preta permanecem viáveis no solo por um período de 450 dias após o enterro.
PALAVRAS-CHAVE: sobrevivência; banco de sementes; solo; germinação; tetrazólio.

INTRODUCTION

Black oat is an annual Poaceae (grass) from western Mediterranean, with its center of diversity located in the northwest of the Pyrenees, in the Iberian Peninsula (Spain and Portugal) (FREY 1991). Its aptitude occurs in several ways: green forage, hay and straw production for direct sowing of summer crops

(RANGEL et al. 2002, SUTTIE & REYNOLDS 2004). The choice for the use of black oats in soil cover is related to the speed (ROS & AITA 1996), facility of seed acquisition, implantation, high tillering capacity, resistance to pests and diseases, rusticity, prolonged persistence in the field after desiccation, efficient nutrient recycling, C:N ratio (>30) and the high allelopathic effect on weeds (GFELLERA et al. 2018, MOURA et al. 2021).

The species stands out for being an alternative to anticipate the period of use of pastures in the cold season, due to the availability of dry mass at the beginning of this period, if the sowing takes place in April (QUADROS & MARASCHIN 1987). Reports of three to six cuts and yields of over 20 Ton. MS/ha (NORO et al. 2003, PIN et al. 2011). Despite the numerous advantages of cultivating the species, the continuous use associated with the mismatch of desiccation practices at the time of plant maturation favors the formation of dormant seed banks in the soil (RIZZARDI & VARGAS 2005, AISENBERG et al. 2016), careful handling is essential to prevent this species from becoming a weed.

A problem observed in the *A. strigosa* genotypes is the presence of dormancy in the seeds and, like other grasses, black oat produces ontogenetically delayed tillers, with staggered dehiscence, characteristics that favor its dispersion over time and hinder control practices (AGOSTINETTO et al. 2001, LORO et al. 2021). The seeds that fall and remain dormant after dissemination form the so-called "soil seed banks", which are viable seed reserves that can be located both on the surface and at different depths (LACERDA, et al. 2005). According to VAN ACKER (2009), wild oat seeds (*A. fatua*) can remain viable in the soil for four to five years.

Studies carried out with *A. fatua* demonstrated a variation in seed viability between two and six years (THURSTON 1961, PETERS 1982, ZORNER et al. 1984) and *A. sterilis* from 27 to 43 months depending on the burial conditions (ARCO et al. 1995, VOLIS 2009). The possibility of predicting the time that dormancy persists in seeds is important to improve weed management, as it would be possible to estimate the germination capacity of weeds, enabling the adoption of appropriate management techniques (GRUNDY & MEAD 2000).

To improve weed management systems for specific species, it is essential to have information on dormancy, germination, decomposition (deterioration) of seeds, plant emergence and variations between populations (MENNAN & NGOUAJIO 2006). In this context, work aimed to verify if there is a temporal effect on the viability of black oat seeds under natural conditions after harvesting, under burial.

MATERIAL AND METHODS

The experiment took place in a field area, under natural conditions, at the Agricultural Research and Extension Center (Cepagro) of the College of Agronomy and Veterinary Medicine in the University of Passo Fundo in Passo Fundo - RS (28° 13' 01'' S, 52° 23' 37'' W, altitude 700 m) in the northern region of the state of Rio Grande do Sul. The relief of the region is composed of gently undulating hills and the soil of the experimental area is a humid dystrophic Red Latosol (EMBRAPA 2018). The variables related to black oat seed viability took place at the Seed Analysis Laboratory of the College of Agronomy and Veterinary Medicine of the University of Passo Fundo. The monthly rainfall, average air and soil temperatures that occurred in the region during the period of the experiment, shown in Figure 1.

The experimental design used was completely randomized, in a bifactorial scheme (5 x 8), with 5 black oat genotypes and 8 exhumation periods (90; 180; 270; 360; 450; 540; 630 and 720 days after burial), distributed in four replicates of one hundred seeds buried 10 cm deep (Figure 2). The chemical characteristics of the soil determined after soybean cultivation in this area they indicated a water pH of 6.2; SMP index of 6.4, 33.4 mg dm^{-3} of P extractable; 307 mg dm^{-3} of exchangeable K; 2.1% MO; 0.0 cmolc dm^{-3} of exchangeable Al; 5.4 cmolc dm^{-3} of exchangeable Ca and 2.3 cmolc dm^{-3} of exchangeable Mg.

Obtaining the seeds used for the experiment through the multiplication of genetic seeds in the 2018/2018 season, with all precautions related to the cleaning of the harvester taken to guarantee the genetic purity of the materials. The genotypes had the following germination percentages at the time of burial: Agro Zebu-91%; Agro Esteio-83%; Agro Quaraí-89%; Agro Coxilha-85% and Agro Planalto-90%, therefore all had the minimum percentage required by the standards of production and commercialization of temperate forage seeds (BRASIL 2013).

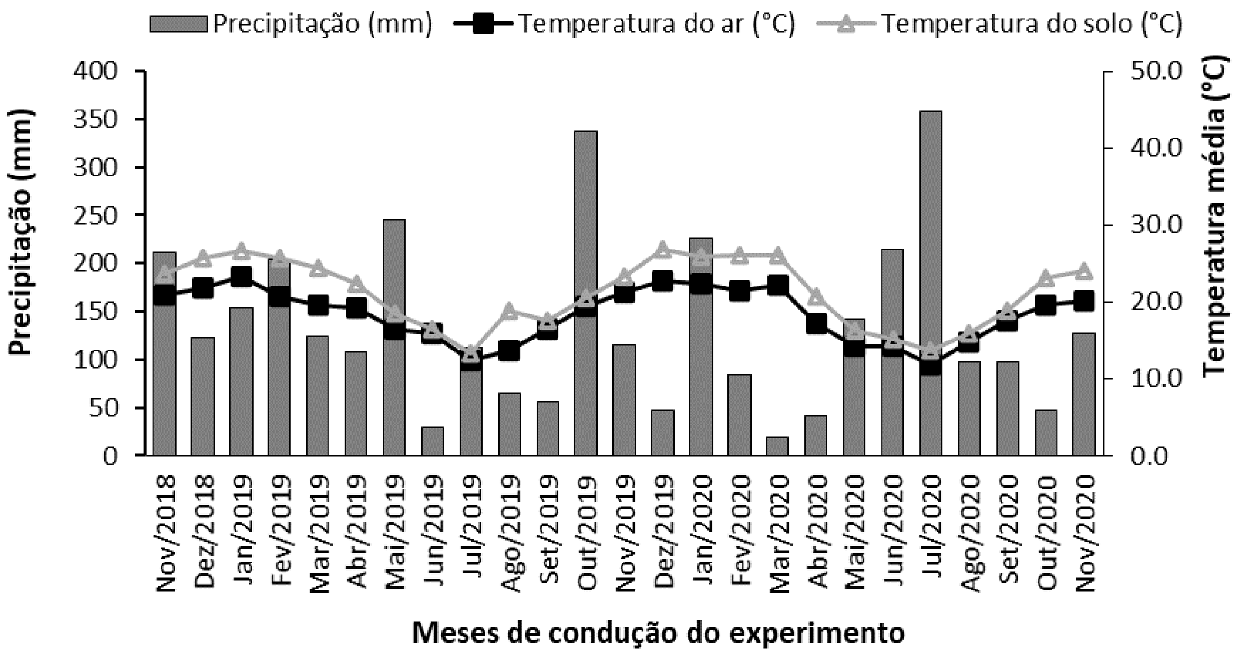

Figure1. Precipitation, mean air and soil temperature from November 2018 to November 2020. Passo Fundo, 2017 - 2019.

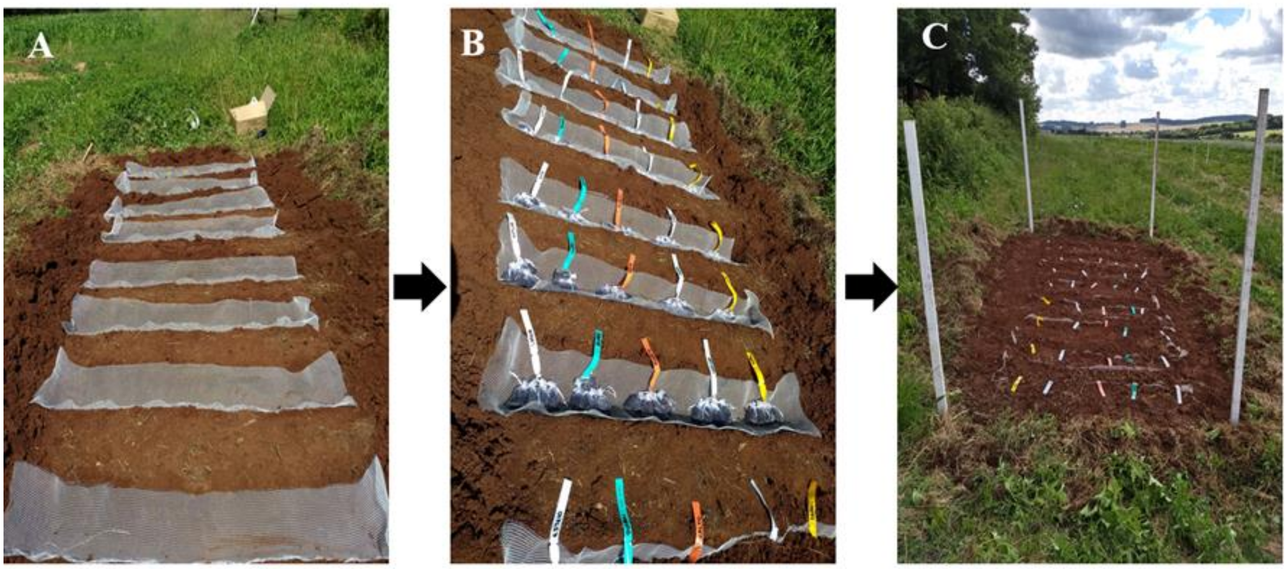

Figure 2. Experiment installation; A) Preparation of furrows; B) Distribution of treatments; C) Coverage with earth and delimitation of the test. Passo Fundo/RS, 2018.

After each exhumation, seeds separation and count, and those that did not germinate, did not rot or were predated were considered whole seeds, which underwent an asepsis and disinfection process through exposure for five minutes in 70% alcohol and for 20 minutes in 2% sodium hypochlorite, and then washed three times in running water (GALVAN 2013). The verification of the live seeds was carried out after the seeds considered whole were submitted to the germination test, without previously breaking dormancy, and to the vigor by the tetrazolium test (BRASIL 2009). For the germination test, the whole seeds were distributed on substrate-paper roll (Germitest) moistened with distilled water, which were transferred directly to the germinator at a constant temperature of 20 ºC for ten days. The evaluation was took place on the tenth day after the incubation of the rolls in the germinator, computing the percentages of normal seedlings, abnormal seedlings, dormant seeds and dead seeds (BRASIL 2009).

Next, the seeds from the germination analysis that were considered dormant (seeds that did not germinate, whole and/or hard) were submitted to the tetrazolium test. Longitudinal cuts were made in the seeds, removing the glumes, sectioning them in two parts through the embryo and 3/4 of the endosperm. For coloring, seeds immersion in a 0.75% tetrazolium salt solution for two hours at 30 ºC. In the evaluation, observing the cut surfaces using as a living seed criterion that with coloration of at least 2/3 of primary root (BRASIL 2009).

The normality of errors was verified using the Shapiro Wilk test and the homogeneity of residual variances using the Bartlett test at 5% significance. With the assumptions met, the results were submitted to analysis of variance by the F test at 5% probability, when the test was significant the data were analyzed by regression analysis for the quantitative factor (period of exhumation) and for the qualitative factor (genotype) Tukey test at 5% probability, using RStudio software version 3.6.1 (R CORE TEAM 2019).

RESULTS AND DISCUSSION

Analysis of variance revealed a significant effect for the interaction between genotypes x exhumation periods, for the variables whole seeds and live seeds. The percentage of whole seeds until the second exhumation period (180 days of burial) showed a significant difference between the black oat genotypes (Table 1). Agro Planalto had the lowest percentage of whole seeds at 360 days after burial, Agro Esteio at 450 days, Agro Coxilha, Agro Quaraí and Agro Zebu at 540 days.

Table 1. Whole seeds (%) of black oat genotypes from 90 to 720 days after burial. Passo Fundo/RS, 2020.

Genotypes	90	180	270	360	450	540	630	720
Agro Coxilha	35b	4d	6 ns	1 ns	1 ns	0 ns	0 ns	0 ns
Agro Esteio	44a	19b	1	1	0	0	0	0
Agro Planalto	31b	11bc	1	0	0	0	0	0
Agro Quaraí	46a	37a	1	3	1	0	0	0
Agro Zebu	28b	6cd	6	0	2	0	0	0
CV%				43,02				

Means followed by the same lowercase letter in the column do not differ statistically by Tukey's test at 5% probability of error. ns= not significant.

Therefore, at 540 days after burial (one year and six months) whole seeds were no longer found among the evaluated genotypes, similar results were found by GALVAN (2013) in a study carried out with biotypes of annual ryegrass (*Lollium multiflorum* Lam.), which did not identify whole seeds of the species after a period of 22 months (one year and ten months). MAHAJAN et al. (2021) found that 50% and 90% of oat seeds had deteriorated in six and 18 months, respectively.

The fact that the number of whole seeds decreases over time can be explained by the seeds having encountered environmental conditions that provided their germination or deterioration due to predators (HOSSAIN & BEGUM 2015, DUBAL et al. 2016). The dormancy release rate increases by complete and intermittent hydration (alternation of dry and wet) of the seeds (LUSH et al. 1981).

The percentage of live seeds (normal, abnormal and viable seedlings by the tetrazolium test) differed between the genotypes only in the third period of exhumation (270 days after burial) in which there was a significant drop in seed viability. With the exception of Agro Zebu 86% of live seeds, the other genotypes remained between 55 and 13% (Table 2). The lowest percentages of live seeds were identified in the genotypes Agro Esteio and Agro Planalto at 360 days after burial, in Agro Coxilha and Agro Quaraí at 450 days and Agro Zebu at 540 days. The percentage of live seeds remained at zero in the period of 540 days (one year and six months) after burial, an expected result since no more whole seeds were found during the collection in this same period. The longevity of seeds in the soil is the most determining factor for the success of future generations (SCHWARTZ-LAZARO & COPES 2019).

Seeds that fall and remain dormant after dissemination form the so-called "soil seed banks", which can be classified as transient and persistent (THOMPSON & GRIME 1979). Defining a transitional seed bank as one in which seeds do not live until the second germination season after maturation, whereas seeds in a persistent seed bank live until the second or subsequent germination seasons (BASKIN & BASKIN 2014, SCHWARTZ-LAZARO & COPES 2019). The results obtained in this study demonstrate that *Avena strigosa* has a persistent seed bank in the soil.

Table 2. Live seeds (%) of black oat genotypes in a period of 90 to 720 days after burial. Passo Fundo/RS, 2020.

Genotypes	90	180	270	360	450	540	630	720
Agro Coxilha	81^{ns}	67^{ns}	55ab	25^{ns}	0^{ns}	0^{ns}	0^{ns}	0^{ns}
Agro Esteio	78	68	13c	0	0	0	0	0
Agro Planalto	77	85	13c	0	0	0	0	0
Agro Quaraí	62	57	25bc	8	0	0	0	0
Agro Zebu	72	47	86a	0	5	0	0	0
CV%				48,84				

Means followed by the same lowercase letter in the column do not differ statistically by Tukey's test at 5% probability of error. ns= not significant.

Studies carried out with wild oat species have shown a variation in seed viability between two and six years in *A. fatua* (THURSTON 1961, PETERS 1982, ZORNER et al. 1984) and *A. sterilis* from 27 to 43 months depending on burial conditions (ARCO et al. 1995, VOLIS 2009). When evaluating the survival of red rice seeds in soil PESKE et al. (1997) observed that there are phenotypes that remained with a high percentage of viable seeds at a depth of 30 cm in the soil for more than one year. Likewise, *Brachiaria* species exhibit a long period of dormancy, characteristic for species perpetuation (FERRARI et al. 2016). However, in improved cultivars, this same study demonstrates that in a period of 1 year, seed viability decreases significantly.

Knowing that black oat seeds remain viable in the soil for up to 450 days (one year and three months after burial), the seed producer is able to establish a rotation plan between the areas destined for the production of winter cereal seeds so that the history of cultivation with black oats does not compromise the quality of the seeds produced in the field. The breeder, in turn, is able to guarantee a quality genetic seed, ensuring that “the breeder's seed” really has genetic purity. While the farmer can adopt management practices in order to reduce or deplete the seed bank in the soil, preventing the species from becoming a species that is difficult to control. Understanding the process of dormancy, germination and viability of seeds in the soil contributes to the choice of appropriate tools in view of the different aptitudes that black oats provide to the producer.

CONCLUSION

Black oat genotypes show similar behavior regarding seed survival and viability in the soil.

Black oat seeds remain viable in the soil for a period of 450 days after burial.

REFERENCES

AGOSTINETTO D et al. 2001. Arroz vermelho: Ecofisiologia e estratégias de controle. Ciência Rural 31: 341-349.

AISENBERG GR et al. 2016. Effect pf pre-emergent herbicides on the germination and initial growth of *Trifolium repens* L. International Journal of Current Research 8: 39600-39606.

ARCO MJS et al. 1995. Seed dynamics in populations of *Avena sterilis* ssp. *Ludoviciana*. Weed Research 35: 477-487.

BASKIN CC & BASKIN JM. 2014. Seeds: ecology, biogeography, and evolution of dormancy and germination 2.ed. San Diego: Elsevier.

BRASIL. 2013. Instrução Normativa nº 45, de 17 de setembro de 2013. Brasília: Diário Oficial da República Federativa do Brasil. 18 set. 2013. Seção 1. p.16.

BRASIL. 2009. Ministério da Agricultura Pecuária e Abastecimento. Regras para análise de sementes. Brasília: Mapa/ACS. 399p.

DUBAL ITP et al. 2016. Effect of temperature on bean seed germination: vigor and isozyme expression. American Journal of Agricultural Research 1: 1-9.

EMBRAPA. 2018. Empresa Brasileira de Pesquisa Agropecuária. Centro Nacional de Pesquisa de Solos. Sistema brasileiro de classificação de solos. 5.ed. Brasília: Embrapa - Centro Nacional de Pesquisa de Solos. 356p.

FERRARI M et al. 2016. Qualidade fisiológica de lotes de sementes de Brachuaria brizantha submetidas à superação de dormência. Revista Sodebras 10: 1-5.

FREY L.1991. Distribution of *Avena strigosa* (Poaceae) in Europe. Fragmenta Floristica et Geobotanica 1: 281-288.

GALVAN J. 2013. Banco de sementes e fluxo gênico de azevém sensível e resistente ao herbicida glifosato. 200f. Tese (Doutorado em Agronomia). Passo Fundo: UPF. 184p.

GFELLERA A et al. 2018. Explanations for *Amaranthus retroflexus* growth suppression by cover crops. Crop Protection 104: 11-20.

GRUNDY AC & MEAD A. 2000. Modeling weed emergence as a function of meteorological records. Weed Science 48: 594-603.

HOSSAIN MM & BEGUM M. 2015. Soil weed seed bank: Importance and management for sustainable crop production- A Review. Journal of the Bangladesh Agricultural University 13: 221–228.

LACERDA ALS et al. 2005. Levantamento do banco de sementes em dois sistemas de manejo de solo irrigados por pivô central. Planta Daninha 23: 1-7.

LUSH WM et al. 1981. Presowing hydration-dehydration treatments in relation to seed germination and early seedling growth of wheat and ryegrass. Functional Plant Biology 8: 409-425.

LORO MV et al. 2021. Relationships of primary and secondary wheat yield components. Brazilian Journal of Agriculture-Revista de Agricultura 96: 261-276.

MAHAJAN G et al. 2021. Seed longevity and seedling emergence behavior of wild oat (*Avena fatua*) and sterile oat (*Avena sterilis* ssp. ludoviciana) in response to burial depth in eastern Australia. Weed Science 69: 362-371.

MENNAN H & NGOUAJIO M. 2006. Seasonal cycles in germination and seedling emergence of summer and winter populations of catchweed bedstraw (*Galium aparine*) and wild mustard (*Brassica kaber*). Weed Science 54: 114-120.

MOURA NB et al. 2021. Akaike criteria and physiological indexes on black oak seeds. Communications in Plant Sciences 11: 22-29.

NORO G et al. 2003. Gramíneas anuais de inverno para produção de forragem: avaliação preliminar de genótipos. Agrociência 7: 35-40.

PESKE ST et al. 1997. Sobrevivência de sementes de arroz-vermelho depositadas no solo. Revista Brasileira de Agrociência 3: 17-22.

PETERS NCB. 1982. Production and dormancy of wild oat (*Avena fatua*) seed from plants grown under soil waterstress. Annals of Applied Biology 100: 189-196.

PIN EA et al. 2011. Forage production dynamics of winter annual grasses sown on different dates. Revista Brasileira de Zootecnia 40: 509-517.

QUADROS FLF & MARASCHIN GE. 1987. Desempenho animal em misturas de espécies forrageiras de estação fria. Pesquisa Agropecuária Brasileira 22: 535-541.

R CORE TEAM. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. 2019. Disponível em: < https://www.R-project.org/>.

RANGEL MAS et al. 2002. Manejo da aveia preta em sistema de produção Agropecuário integrado. Dourados: Embrapa Agropecuária Oeste (Boletim de Pesquisa e Desenvolvimento 13).

RIZZARDI MA & VARGAS L. 2005. Papel trocado. Revista Cultivar 75: 28-30.

ROS CO & AITA C. 1996. Efeito de espécies de inverno na cobertura de solo e fornecimento de nitrogênio ao milho em plantio direto, Revista Brasileira de Ciência do Solo 20: 135-140.

SCHWARTZ-LAZARO LM & COPES JT. 2019. A review of the soil seedbank from a weed scientists perspective. Agronomy 9: 1-13.

SUTTIE JM & REYNOLDS SG. 2004. Background to fodder oats worldwide In: SUTTIE JM & REYNOLDS SG. Plant Prodution and Protection Series. Roma: FAO.

THOMPSON K & GRIME JP. 1979. Seasonal variation in the seed banks of herbaceous species in ten contrasting habitats. Journal of Ecology 67: 893-921.

THURSTON JM. 1961. The effect of depth of burying and freqtsency of cultivation on survival and germination of wild oats (*Avena fatue* L. and *A. ludoviciana* Dur,). Weed Research 1: 19-31.

VAN ACKER RC. 2009. Weed biology serves practical weed management. Weed Research 49: 1-5.

VOLIS S. 2009. Seed-related traits and their adaptive role in population differentiation in *Avena sterilis* along an aridity gradient. Israel Journal of Plant Sciences 57: 79-90.

ZORNER PS et al. 1984. Sources of viable seed loss in buried dormant and non-dormant populations of wild oat (*Avena fatua* L.) seed in Colorado. Weed Research 24: 143-150.