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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

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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) species from the western Mediterranean, with its center of diversity located in the northwest Pyrenees, on the Iberian Peninsula (Spain and Portugal) (FREY 1991). Its suitability occurs in several ways: production of green forage, hay, and straw for direct sowing of summer crops (RANGEL et al. 2002, SUTTIE & REYNOLDS 2004). The choice of using black oats as soil cover is related to speed (ROS & AITA 1996), ease of seed acquisition, implementation, 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 as an alternative to anticipate the period of pasture use in the cold season due to the availability of dry mass at the beginning of this period, if sowing occurs in April (QUADROS & MARASCHIN 1987). Reports of three to six cuts and yields of over 20 tons. DM/ha (NORO et al. 2003, PIN et al. 2011). Despite the numerous advantages of cultivating the species, 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), and careful management is essential to prevent this species from becoming a weed.

A problem observed in *A. strigosa* is that black oats produce ontogenetically delayed tillers with staggered dehiscence, characteristics that favor their dispersion over time and make control practices difficult (AGOSTINETTO et al. 2001, LORO et al. 2021). Seeds that fall and remain dormant after dissemination form so-called "soil seed banks", which are reserves of viable seeds 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 soil for four to five years.

Studies conducted 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 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 because 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 obtain information on dormancy, germination, seed decomposition (decay), plant emergence, and variations among populations (MENNAN & NGOUAJIO 2006). In this context, this study aimed to verify whether there is a temporal effect on the viability of black oat seeds under natural conditions after harvest.

MATERIAL AND METHODS

The experiment was conducted in a field area under natural conditions at the Agricultural Research and Extension Center (Cepagro) of the Faculty of Agronomy and Veterinary Medicine of 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 region’s relief comprises gently undulating hills, and the soil in the experimental area is a humid dystrophic Red Latosol (EMBRAPA 2018). Variables related to the viability of black oat seeds were determined at the Seed Analysis Laboratory of the Faculty of Agronomy and Veterinary Medicine of Passo Fundo. Monthly rainfall, average air, and soil temperatures in the region during the experiment period are shown in Figure 1.

The experimental design used was completely randomized in a factorial 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 100 seeds buried at a depth of 10 cm (Figure 2). The chemical characteristics of the soil determined after soybean cultivation in this area indicated a water pH of 6.2; SMP index of 6.4, 33.4 mg dm^{-3} of extractable P; 307 mg dm^{-3} of exchangeable K; 2.1% of OM; 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.

Obtain the seeds used for the experiment through the multiplication of genetic seeds in the 2018/2018 harvest, with all care related to cleaning the harvester to guarantee the genetic purity of the materials. The genotypes showed 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 production and commercialization standards for temperate climate forage seeds (BRASIL 2013).

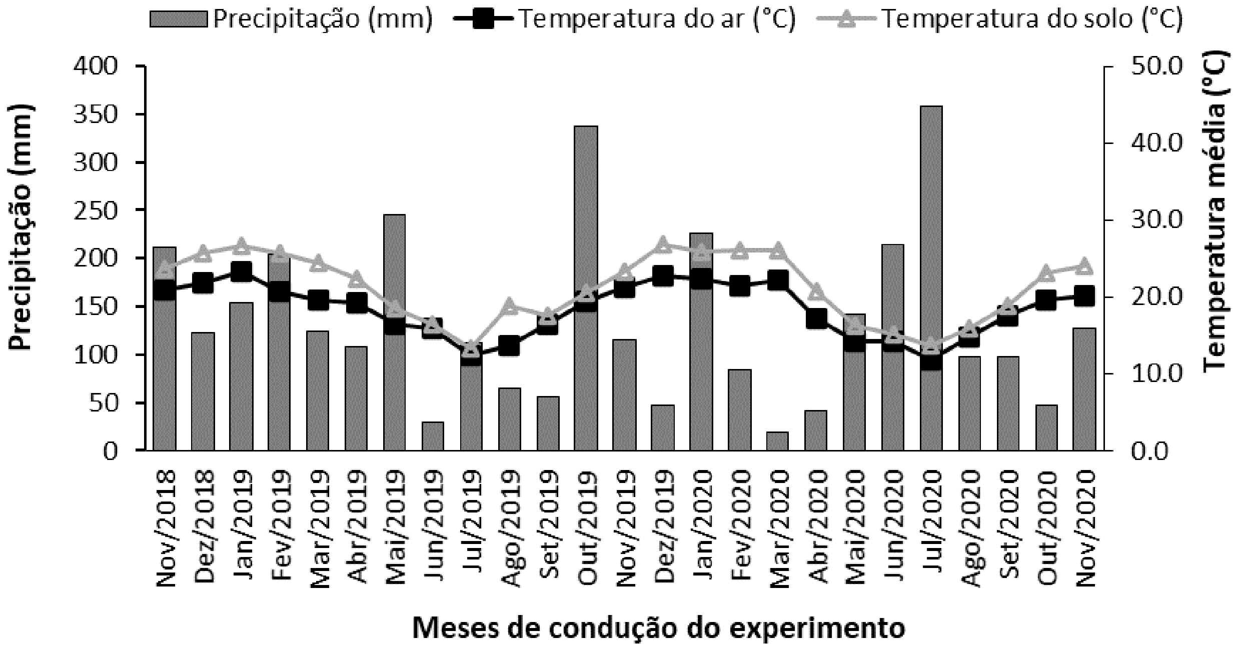

Figure 1. Precipitation, average air, and soil temperatures from November 2018 to November 2020. Passo Fundo, 2017-2019.

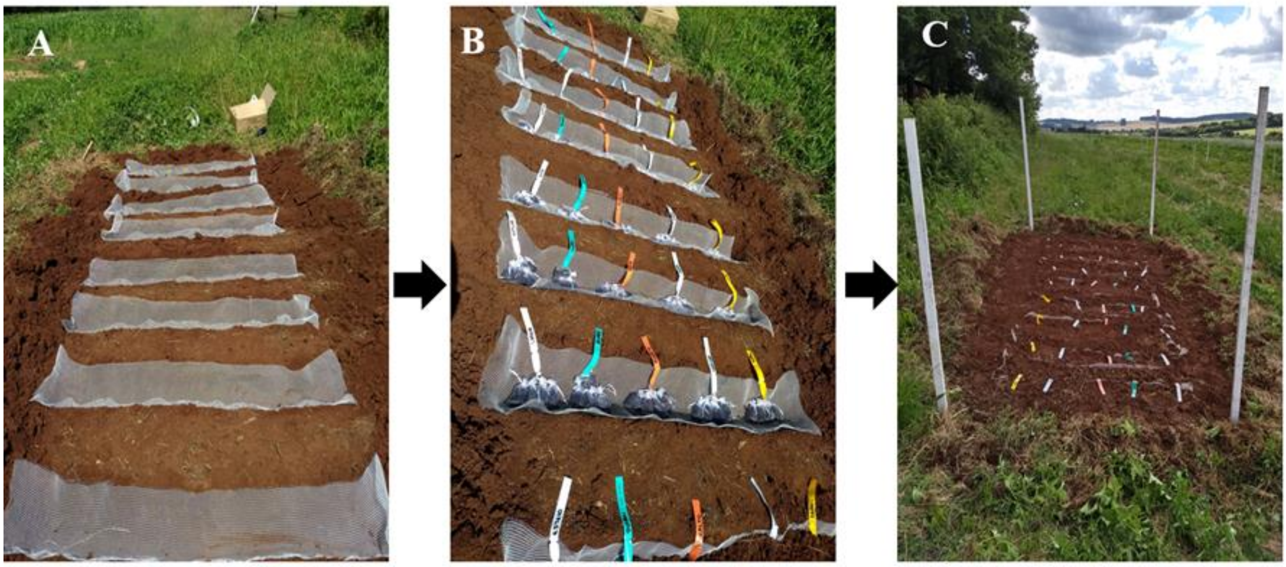

Figure 2. Experimental installation; A) Furrow preparation; B) Treatment distribution; C) Covering with soil and delimiting the test. Passo Fundo/RS, 2018.

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

Then, the seeds from the germination analysis that were considered dormant (seeds that did not germinate, whole and/or hard) were subjected to the tetrazolium test. Longitudinal cuts were made in the seeds, removing the glumes and sectioning them into two parts through the embryo and 3/4 of the endosperm. For staining, the seeds were immersed in 0.75% tetrazolium salt solution for 2 h at 30 ºC. In the evaluation, the cut surfaces were observed using live seed with coloration of at least 2/3 of the primary root (BRASIL 2009).

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

RESULTS AND DISCUSSION

The analysis of variance revealed a significant effect of genotype exhumation period on whole and live seeds. The percentage of whole seeds up to 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 were collected 90–720 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 Quarai	46a	37a	1	3	1	0	0	0
Agro Zebu	28b	6 cd	6	0	2	0	0	0
CV% 43.02								

The means followed by the same lowercase letter in the column do not differ statistically by the Tukey test with a 5% probability of error. ns = not significant.

Therefore, 540 days after burial (one year and six months), no more whole seeds were found among the genotypes evaluated. Similar results were found by GALVAN (2013) in a study of annual ryegrass biotypes (*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 deteriorated within six and 18 months, respectively.

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

The percentage of live seeds (normal, abnormal and viable seedlings according to the tetrazolium test) differed between genotypes only in the third exhumation period (270 days after burial) when 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 Agro Esteio and Agro Planalto genotypes at 360 days after burial, in the Agro Coxilha and Agro Quaraí varieties at 450 days, and in Agro Zebu at 540 days. The percentage of live seeds remained at zero for the period of 540 days (one year and six months) after burial, which was an expected result because no more whole seeds were found during collection in this same period. The longevity of seeds in the soil is the most important factor determining 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 or persistent (THOMPSON & GRIME 1979). A transitional seed bank is defined 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 season (BASKIN & BASKIN 2014, SCHWARTZ-LAZARO & COPES 2019). The results of this study demonstrate that *Avena strigosa* has a persistent seed bank in soil.

Table 2. Live 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	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 Quarai	62	57	25bc	8	0	0	0	0
Agro Zebu	72	47	86a	0	5	0	0	0
CV% 48.84								

The means followed by the same lowercase letter in the column do not differ statistically by the Tukey test with a 5% probability of error. ns = not significant.

Studies conducted with wild oat species showed 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 remain with a high percentage of viable seeds at a depth of 30 cm in the soil for more than a year. *Brachiaria* species also exhibit a long period of dormancy, which is characteristic of the persistence of the species (FERRARI et al. 2016). However, in improved cultivars, this study demonstrated that seed viability significantly decreased over a period of 1 year.

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 can establish a rotation plan between the areas intended 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, can guarantee quality genetic seeds, ensuring that "the breeder's seed" really has genetic purity. Meanwhile, the farmer can adopt management practices to reduce or deplete the seed bank in the soil, preventing the species from becoming a difficult-to-control species. Understanding the process of dormancy, germination, and viability of seeds in the soil contributes to the selection of appropriate tools, considering the different capabilities that black oats provide to producers.

CONCLUSION

Black oat genotypes exhibit similar behaviors related to seed survival and viability in soil.

Black oat seeds remain viable in the soil for 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.