DORMANCY RELEASING MECHANISMS IN SOIL SEED BANKS OF Desmanthus GENOTYPES[1]

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ABSTRACT - Desmanthus is a genus of forage legumes with potential to improve pastures and livestock production on clay soils of dry tropical and subtropical regions such as the existing in Brazil and Australia. Despite this patterns of natural or enforced after-ripening of Desmanthus seeds have not been well established. Four year old seed banks of nine Desmanthus genotypes at James Cook University were accessed for their patterns of seed softening in response to a range of temperatures. Persistent seed banks were found to exist under all of the studied genotypes. The largest seeds banks were found in the genotypes CPI 78373 and CPI 78382 and the smallest in the genotypes CPI's 37143, 67643, and 83563. An increase in the percentage of softened seeds was correlated with higher temperatures, in two patterns of response: in some accessions seeds were not significantly affected by temperatures below 80º C; and in others, seeds become soft when temperature rose to as little as 60 ºC. At 80 °C the heat started to depress germination. High seed production of Desmanthus associated with dependence of seeds on elevated temperatures to softening can be a very important strategy for plants to survive in dry tropical regions.

Keywords: Donkey bean. Bush fire. Strophiole. Seedcoat dormancy.

MECANISMOS DE SUPERAÇÃO DE DORMENCIA EM BANCOS DE SEMENTES DE GENÓTIPOS DE *Desmanthus*

RESUMO – *Desmanthus* é um gênero de leguminosas forrageiras com potencial para melhoria das pastagens e da produção animal em solos argilosos das regiões tropicais e subtropicais secas tais aqui as existentes no Brasil e Austrália. Por outro lado, mecanismos naturais ou forçados de superação de dormência em sementes deste gênero não foram ainda bem estudados. Os bancos de sementes do solo com quatro anos de idade, de nove genótipos de *Desmanthus* da Universidade James Cook, na Austrália foram estudados quanto à superação da dormência das suas sementes, em resposta a diferentes temperaturas. Bancos de sementes persistentes foram encontrados em todos os genótipos estudados. Nos genótipos CPI 78373 e CPI 78382 foram encontrados os bancos mais populosos e nos genótipos CPIs 37143, 67643 e 83563 os menos populosos. O aumento do número de sementes com tegumento permeável esteve correlacionado com temperaturas mais altas em duas vertentes de resposta: em alguns genótipos as sementes não foram muito afetadas por temperaturas inferiores a 80 °C, e em outros as sementes já estavam com seus tegumentos permeáveis quando a temperatura atingiu 60 °C. Aos 80 °C o calor começou a ter efeito negativo sobre a germinação. Uma alta produção de sementes associada a uma dependência de altas temperaturas para a superação da dormência em sementes de *Desmanthus* pode ser uma estratégia muito importante das plantas para sobreviver em regiões tropicais secas.

Palavras-chave: Feijão de burro. Fogo em pastagem. Estrofiolo. Dormência tegumentar.

INTRODUCTION

Species of the genus *Desmanthus* have shown potential to improve animal production (RANGEL: GARDINER, 2009) and to be a potentially valuable pasture legume for clay soils in the semiarid seasonally dry tropical and subtropical regions. In many such situations it is the only sown pasture legume genus so far tested that can persist and spread (RANGEL; GARDINER, 2009).

All tropical pasture legumes produce seed with prolonged impermeability to water caused by external structures known as seedcoat or testa (HOPKINSON, 1993a). The seedcoat is watertight over most of seed surface being the strophiole the only exception. Seed dormancy imposed by seed-coat impermeability is known as hardseededness. This is one of the most important features influencing seed survive in soil (SOUZA et al., 2011) and the establishment and regeneration of tropical legumes (VERNIER et al., 2012). The releasing of seed-coat dormancy in seeds from soil seed banks allowing new seedling recruitment, depends on the type of seed-coat dormancy of the species and on the occurrence of environmental factors, wherein soil heating is the most important (OOI et al., 2012; GRESTA et al., 2011). The strophiole is apt to split to produce a cleft that allows water to penetrate as the natural route of the entry of water. It may cleave over time or through sudden physical shock or temperature changes (HOPKINSON, 1993a). Considering being the strophiole the natural structure for water access in hard and intact legume seeds, the degree of permeability of this structure in ripe seeds would be a very useful parameter to determine the potential of a specific genotype to release soft seeds.

With the exception of the observations of Burrows and Porter (1993) on the formation of soil seed bank and seedling recruitment of *D. virgatus* CPI 78382 at Gayndah, Queensland, Australia, the patterns of natural or enforced after-ripening of *Desmanthus* seeds are not well established. Ripe seeds of different accessions of *Desmanthus* stored in soil seed-banks seem to have a relatively high fraction of dormant seeds (HOPKINSON; ENGLISH, 2004; RANGEL: GARDINER, 2009).

The strophiole of a *Desmanthus* seed submitted to a heat treatment was described by Hopkinson (1993b) as a "colourless but light reflective cap bulging out from the testa". Hopkinson and English (2004) obtained around 100% of soft and viable seeds of the *Desmanthus* cultivars Marc, Uman and Bayamo by submitting hard seeds of these cultivars to boiling water treatment for 10 seconds, with very few deaths. Very little increases of softening were obtained by longer periods of exposures. These results are important for seed companies and farmers that need to know how treat their *Desmanthus* seeds in order to assure field germination after sowing. However, softening of hard seeds deposited in soil seed banks depend of soil heating during summer or occasional bush fires in which nor temperatures or time of exposure can be controlled by man.

The present study aimed to evaluate the four year old seed banks of nine *Desmanthus* genotypes, examining their patterns of seed softening in response to a range of heat intensities, and how they can be grouped according to their accession and or origin.

MATERIALS AND METHODS

The study was conducted in an area of the School of Biomedical and Tropical Veterinary, James Cook University Douglas Campus, located 20 m above the sea level, at 19˚19'41'' South and 146˚45'38'' East, northwest of Townsville, in northern Queensland, Australia. Townville has a climate characterized by a hot mild summer from September to March and a dry and cool winter season from April to August, with an 1144 mm mean annual rainfall (CLIMATE DATA ONLINE, 2005). Fifty years averaged monthly rainfalls and 1992-1994 period at experimental site are presented in Figure 1.
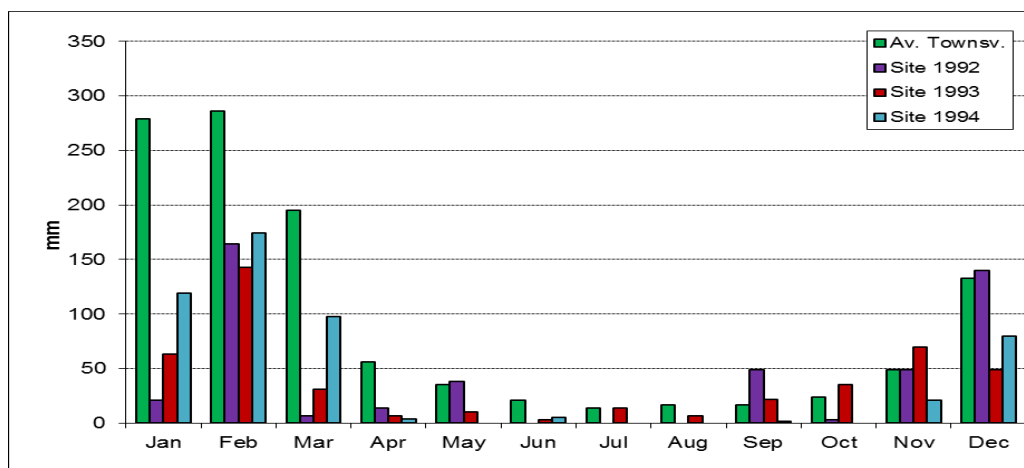

Figure 1. Fifty-four years (1941-1994) average Townsville monthly rainfall (mm) and experimental site monthly rainfall during the experimental period (1992-1994).

The soil of the area is part of the Healy soil association that is characterised by having a strongly bleached sandy loam A horizon, showing an abrupt change to a mottled brownish grey and yellowish brown heavy clay B horizon at 20-40 cm, presenting an alkaline reaction trend (ISBELL, 2002).

An experimental collection of 30 tropical herbaceous pasture legumes including *Desmanthus* accessions were originally established in a three block randomized design in March 1989 at the Douglas Campus of James Cook University, Townsville, Australia. Plots sized 8 m x 2.5 m, composing blocks of 75 m x 8 m.

Plots were contiguous with a row of plants in the middle, which were spaced 250 cm from each other in the rows. Each row was composed by 12 plants.

The genotypes of *Desmanthus* selected for the study were those which, in Blocks 1 and 2, had a minimum of 2 surviving original plants per accession. Nine of the 12 genotypes originally sown met this requirement. Plants in block three were preserved and used in a separated fire study. Plant survival and seedling recruitment of the selected *Desmanthus* genotypes recorded in the area prior to the seed bank survey are shown in Table 1.

Table 1. Number of plant survival and seedling recruitment of *Desmanthus* genotypes in three blocks at the experimental site.

Genotype	Former classification	Original plant survival				Seedling recruitment
		Bl. 1	Bl. 2	Bl. 3	Mean	Mean
D. virgatus AusTRCF 67643	CPI 67643	3.0	2.0	7.0	4.0	12
D. virgatus AusTRCF 78372	CPI 78372	7.0	14.0	17.0	12.7	18
D.virgatus AusTRCF78373	CPI 78373	2.0	2.0	4.0	2.7	6
D. virgatus AusTRCF 78382	CPI 78382	2.0	10.0	7.0	6.3	19
D. virgatus AusTRCF 83563	CPI 83563	2.0	8.0	19.0	9.7	24
D. leptophyllus AusTRCF 321107	TQ88	9.0	11.0	12.0	10.7	36
D. leptophyllus AusTRFC 37143	CPI 37143	27.0	10.0	19.0	18.7	8
D. leptophyllus AusTFCR 38351	CPI 38351	10.0	17.0	22.0	16.3	29
Desmanthus sp	Alligator Creek	17.0	22.0	23.0	20.7	68

A one by one meter iron quadrate was placed on the soil surface surrounding each one of the selected, *Desmanthus* plants. All of the surface litter and soil down to a depth of 5 cm inside the quadrate was collected and stored in labelled plastic bags for further separation. Separation was processed by washing through a set of sieves (VOLL et al, 2003). After separation viability of recovered seeds was tested by the tetrazolium procedure for each genotype (LEIST; KRÄMER, 2003).

Recovered seeds were bulked into one lot of seed for each accession, mixed with a dry sandy loam soil and distributed in eighteen Petri dishes (60 seeds/ Petri dish) per genotype. Three Petri dishes for each genotype were exposed to the following six temperature treatments, in a three shelved drying oven: control (room temperature = 30 °C); 40 °C; 60 °C; 80 °C; 100 °C and 120 °C. The control temperature of 30 °C was the temperature of the oven room during the test. Temperatures higher than 80 °C are not common in soil normally heated by sun exposure during summer sea-

son, but it can reach temperatures higher than 100 °C during bush fires. The oven was turned off when it reached the set treatment temperature and left to cool down, for 12 to 15 minutes. Seeds were then separated from sand by sieving through a 1 mm sieve.

Fifty seeds for each interaction genotype x temperature x block were placed in Petri dishes of 10 cm diameter half filled with vermiculite, with two filter paper sheets (Whatman filter paper, medium porosity, 11 µm grade) on the top of the vermiculite and placed in a 28 °C constant temperature and 24 h fluorescent lighting room, and wetted twice daily with distilled water. Petri dishes were arranged in a randomised block design of nine genotypes, six heat treatments, and three blocks.

Germination was recorded daily over a 21 day period. Germination occurred up to the 14th day. Not germinated seeds (water-imbided or remaining hard) were recorded at the end of germination trial. Water imbibed but not germinated seeds were considered as killed by temperature.

Some originally soft seeds that took up water and became imbibed, during the washing and sieving process were removed and tested separately for germination, without any previous heat treatment. Their germination percentages, calculated from the total number of recovered seeds in the sample, were then added to germination percentage of the control treatment.

The strophiolar structure of the *Desmanthus* seeds was observed in heat-treated seeds not used in the germination test, and in heat-treated but not germinated seeds remains from the germination test.

Data on the number of recovered seeds were statistically analysed in a completely randomised design with nine factors (genotypes) with a different number of replications (sampled plants), using the ANOVA analysis of variance in the *Statistic version 4* software computer program. Means were compared by LSD test with a 0.05 confidence interval. A randomised block design with two factors (genotypes and temperatures), and three replications (Petri dishes) was used for the data analysis for heat effect parameters.

Significant differences within main factors and interactions were also analysed using the ANOVA model with means compared by LSD ($p \leq 0.05$).

RESULTS AND DISCUSSION

Persistent seed banks were found to exist under all of the studied genotypes. They were significantly different ($p < 0.01$) in the number of seeds m^{-2} recovered from a layer of five cm depth under individual plant canopies (Table 2). As the parent plants had all been cultivated on the same soil and under the same climatic and management conditions, these differences must be attributed to different rates of seed production and/or seedling recruitment between the genotypes and not to different management conditions as was found by Jacquemyn et al (2011). Certain species of the genus *Desmanthus* are regarded as prolific seed producers (COOK et al., 2005). Nevertheless, the present study highlighted the variability between genotypes in the size of the seed bank that they produced in the soil.

Table 2. Number of seed m^{-2} in the 0 to 5 cm layer of soil seed bank of *Desmanthus* genotypes.

Genotype	Origin	Seed m^{-2}
CPI 78382	Sub-tropical Argentina	1303.10 a*
CPI 78373	Sub-tropical Argentina	1227.50 ab
CPI 78372	Sub-tropical Argentina	818.25 abc
TQ 88	Origin unknown	747.75 bcd
CPI 38351	Northern Venezuela	640.75 cd
Alligator Creek	Origin unknown	605.98 cd
CPI 83563	Tropical Central America	491.65 cd
CPI 67643	Tropical Central America	329.50 cd
CPI 37143	Tropical Central America	280.98 d
Mean		716.16

*Means followed by the same low case letter are not significantly different at LSD ($p < 0.05$).

The highest numbers of seeds were found in the genotypes of the group in which CPI reference number starting with 78 (Table 2). These genotypes originate in Argentina. Such a seed bank indicates that they have adapted well to their new environment in northern Australia. The highest individual seed banks were recorded for genotypes CPI's 78373 and 78382 (more than 1200 seeds m^{-2}). Alligator Creek, TQ 88 and CPI 38351 had seed banks of intermediate size (600 to 800 seed m^{-2}); while CPI's 37143, 67643, and 83563 had

relatively small seed banks (less than 500 seeds m^{-2}).

The sizes of the seed banks suggest that some seeds falling on the soil surface persist in the soil seed bank for several seasons. Although the introductions from Argentina (CPI numbers 78372, 78373, and 78382), had large seed banks, they presented a small stand of plants in plots. By contrast, some of the other accessions, such as, Alligator Creek, TQ 88 and CPI 38351, had small seed banks (Table 2), but high seedling recruitment (Table 1).

For the average of all genotypes more than 700 seeds m^{-2} were recovered from soil (Table 2) that was around five times higher than the 150 seeds m^{-2} for ungrazed paddocks reported for *D. virgatus* CPI 78382 by Burrows and Porter (1993). Specifically for CPI 78382, in an ungrazed area, 1303 seeds m^{-2} were recovered from soil (Table 2), which is nine times more than the 150 seeds m^{-2} observed by those authors also in ungrazed paddocks and three times the 450 seeds m^{-2} in grazed paddocks. Such differences may be expected, given the differences in the conditions of the environment and of the parent plants. This fact was stressed by Dehaan et al. (2003) that found differences

in seed production among accesses of Desmanthus *ilinoensis* and attributed such differences to latitude of origin of the accessions. The capacity of *D. virgatus* CPI 78373 to form large seed banks (1228 seed m^{-2}) shown in this study was also recognized by Gardiner et al. (2004), in plots 10 - 14 years old, after planting at Blackall and Isisford, in the semi-arid, black clay soil of Queensland's Mitchell Grass Bioregion in Australia. For CPI 78373 contrasting with the relatively low plant survival and seedling recruitment observed in the present study (Table 1), at Blackall it had the highest survival rate with a mean of nine plants m^{-2}, showing its better adaptation to the black clay soil conditions of Mitchell Grass Bioregion than to the duplex soil of the Coastal region (GARDINER et al., 2004).

Seeds recovered from the soil seed banks showed high viability in all genotypes as indicated by the tetrazolium test (Table 3). Seeds were clearly still viable after being buried in the soil for up to four years. This must be attributed to the effectiveness of the seed-coat and sealed strophioles in preventing water entry and invasion by soil insects and saprophytes (SOUZA; MARCOS-FILHO, 2001).

Table 3. Seed viability of nine genotypes of *Desmanthus* by the tetrazolium test.

Genotype	Viability (%)
CPI 83563	96
CPI 37143	94
CPI 38351	94
CPI 78372	92
CPI 78373	92
CPI 78382	90
Alligator Creek	86
TQ 88	82
CPI 67643	80
Mean	89.6

Table 4 has the comparisons of means of soften seeds for different genotypes under different temperature and interactions by LSD (p < 0.05). Higher temperatures were correlated with an increase in the percentage of soften or permeable seeds. There were, however, two patterns of response. In the first, as in genotypes CPIs 67643, 78373, and 78382, strophiolar structures were not significantly affected by temperatures below 80 °C, and genotype CPI 78372 was little affected by temperatures less than 100 °C. In contrast, significant changes in the strophiolar structure of the remaining genotypes occurred in temperatures as little as 60 °C.

In contrast to what was found for seed softening, there was only a weak relationship between temperature and seed germination (r^{2} = 0.24) (Table 5).

Such lack of significance was caused by a reduction in germination of seeds of many genotypes exposed to temperatures higher than 80 ºC (Table 5). Seed germination of individual genotypes in response to heat has to be interpreted firstly with reference to the lowest temperature necessary to promote germination; and secondly with regard to the highest temperature to which seeds can be exposed without reduction in viability.

Germination of all genotypes started to be promoted by temperatures of 60 ºC, had a maximum at 80 ºC, and was reduced again by higher temperatures (Figures 2, 3 and 4). In these figures, room temperature was taken as 30 ºC, for ease preparation of the graphics.

Table 4. Percentage of raised seed strophioles (soften seeds) of nine *Desmanthus* genotypes in response to heat treatments (control (30 °C), 40 °C, 60 °C, 80 °C, 100 °C, and 120 °C). Data represents the means of three replications.

Genotype No.(CPI)	Heat treatments (ºC)						
	Control (30)	40	60	80	100	120	Mean
	Soften seeds (%)						
CPI 37143	0	0	50	83	80	100	52
CPI 38351	9	4	33	93	93	96	55
CPI 67643	10	20	28	100	100	100	52
CPI 78372	0	3	3	58	70	100	39
CPI 78373	3	7	7	37	37	100	32
CPI 78382	4	4	10	65	60	100	41
CPI 83563	15	13	40	73	77	93	52
Alligator Creek	4	6	54	93	100	100	60
TQ 88	8	13	71	100	100	100	65
Mean	6	8	33	78	82	99	

ANAVA [1]   CV (%) 23,5   F value for interaction Genotype x Heat = 2,15 **
LSD between means inside columns = 7,4
LSD between means inside rows = 14,6

[1] Variance analysis of a randomized block design with 40 degrees of freedom in the interaction genotype x temperature and 106 degrees of freedom in the residue.

Table 5. Percentage of germination in seeds of nine *Desmanthus* genotypes in response to heat treatments (Control (30 °C), 40 °C, 60 °C, 80 °C, 100 °C, and 120 °C). Means of 3 replications.

Genotype(CPI)	Temperatures (ºC)						
	Control (30)	40	60	80	100	120	Mean
	Germination (%)						
CPI 37143	1	6	40	75	45	14	30
CPI 38351	8	4	41	61	62	1	30
CPI 67643	10	13	42	67	19	10	27
CPI 78372	7	4	15	50	51	9	23
CPI 78373	8	8	4	32	7	3	10
CPI 78382	4	5	5	68	19	33	22
CPI 83563	18	23	20	80	55	27	37
Alligator Creek	7	4	53	64	60	3	32
TQ 88	16	19	72	79	43	9	40
Mean	9	9	33	64	40	12	

ANAVA [1]   CV (%) 9,3 F value for interaction Genotype x Temperature = 1,54*
LSD between means in columns = 7,4
LSD between means in rows = 20,2

[1] Variance analysis of a randomized block design with 40 degrees of freedom in the interaction accession x temperature and 106 degrees of freedom in the residue.

The genotypes could be divided into three groups in their germination responses to heat: one group is "highly specific temperature" for germination (Figure 2), and consisted of CPI 78373 CPI 78382, and CPI 83563, where germination was promoted by a very narrow range of temperatures around 80 ºC. In this group CPI 78373 and CPI 78382 had percentages of germination greater than 10% only at a temperature of 80 ºC. Seeds of seven Mediterranean *Leguminoseae* species only started to have seedcoat dormancy significantly released at temperatures higher than 90 °C (HERRANZ et al., 1998).

Another group is "intermediate temperature specific" for germination (Figure 3) and comprises CPI 37143 and CPI 67643, where germination was promoted by an intermediate range of temperature of 60-80 ºC, or 80-100 ºC.

The last group, "indifferent to temperature" in its germination (Figure 4), is composed of the genotypes Alligator Creek, TQ 88, CPI 78372 and CPI 38351, where germination was not correlated with increasing temperatures over the temperature range of 60-100 ºC.

Two different groups of genotypes showed reductions of germination at temperatures higher than 80 °C. One group consisting of CPI 38351, CPI 78372,

and the genotype Alligator Creek, in which seeds were exposed to temperatures as high as 100 ºC, without reduction in germination.

The failure of a seed to germinate, either with or without heat treatment, can be attributed to one of three causes: the seed was dead before treatment; it was killed during the treatment; or it remained dormant despite the treatment (GRESTA et al., 2011). As the number of viable seeds used in the experiment was known (from the tetrazolium test), as was the number of germinated and hard seeds, it was possible to calculate the number of seeds killed by the heat treatment.
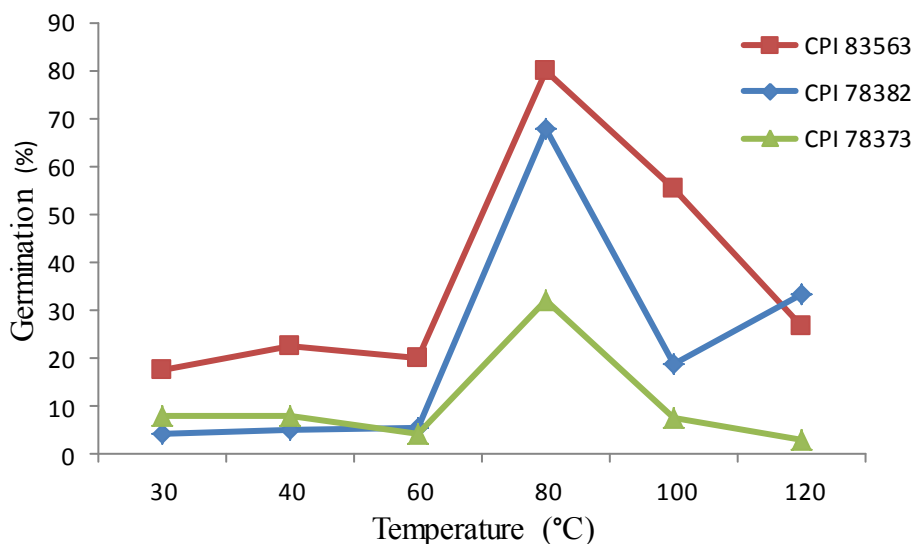

Figure 2. Effect of heat on the percentage of germination in seeds of *Desmanthus* genotypes, in the group with "highly temperature specific" for germination.
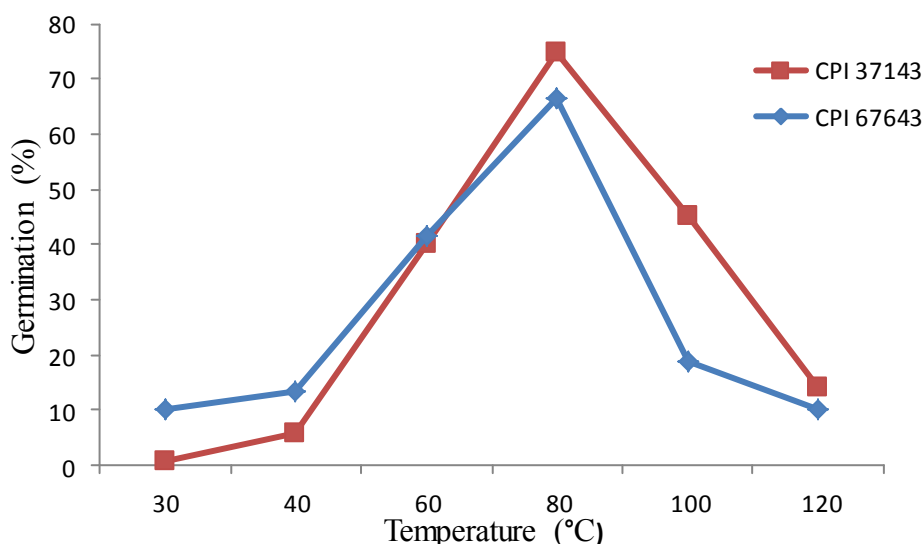

Figure 3. Effect of heat on the percentage of germination in seeds of *Desmanthus* genotypes, in the group with "intermediate temperature specific" for germination.

Seeds of CPI 78382 and CPI 83563, showed an outstanding resistance to temperature, recording respectively 33.3% and 26.7% of germination at 120 ºC. The other group consists of all the remaining genotypes that showed a significant reduction in germination percentage at all temperatures above 80 ºC.

Seed polymorphism in terms of the temperature required to break seed-coat dormancy has been reported in many legume genera (GRESTA et al., 2011); but there are only very few reported data for the genus *Desmanthus*. The results presented here on raised strophioles, germination rates, and remaining hard

seeds as a function of a range of applied temperatures show that *Desmanthus* genotypes vary widely in their responses to heat (Tables 4 and 5, and Figures 2, 3 and 4). Sune and Franke (2006) found that a temperature of 60 °C during five minutes was enough to breakdown seed dormancy of *D. depressus.*

In genotypes belonging to the "highly temperature specific" group, seed did not become soft and germination was not increased until temperatures reached 80 °C. On the basis of these results, seeds of such gen-

otypes might or might not have their seed-coat dormancy removed by normal summer heat as suggested by Moreira and Pausas (2012). Ooi et al. (2012) studying the effect of soil temperatures over the release of seed dormancy in four different populations of the tree legumes *Acacia suaveolens* and *Dillwynia floribunda* concluded that dormancy-breaking temperatures for each populations were positively related to parental environment temperature.
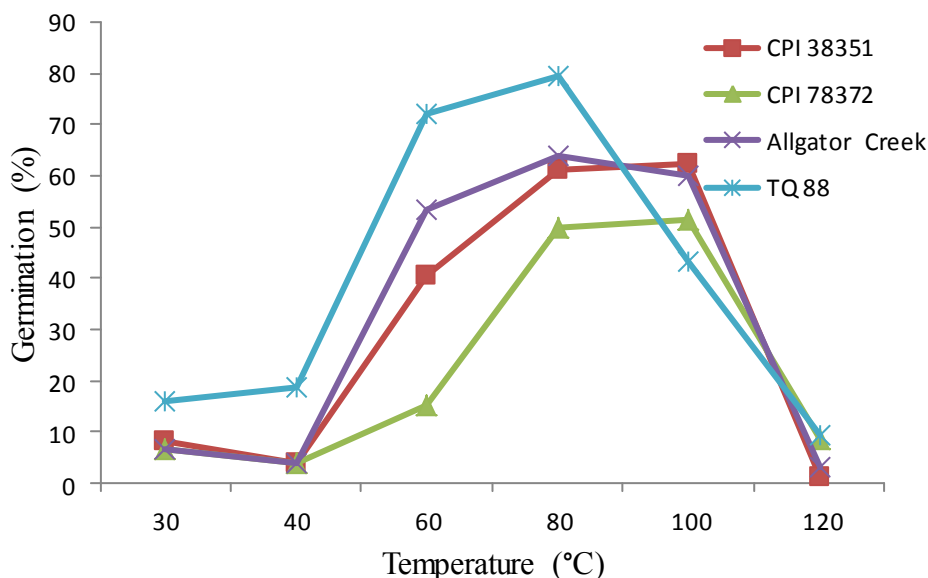

Figure 4. Effect of heat on the percentage of germination in seeds of *Desmanthus* genotypes, in the group "indifferent to temperature for germination".

Dormancy would not also be affected, during a grass fire, in seeds below 3 cm in the soil (GRESTA et al., 2011). It is also clear that temperatures higher than 80 ºC did not further stimulate germination in any of the genotypes and, indeed, were harmful for the majority of them. Seeds of genotypes in the "intermediate temperature specific" group and "indifferent to temperature" group were more likely to become soft and germinate in response to summer heat or grassfires if not buried in the soil below 3 cm. According with Moreira and Pausas (2012) in fire-prone regions, the post-fire environment is characterized by a flush of seedling emergence and consider and advantage for seedlings to emerge quickly after fire as there are increased levels of nutrients, decreased levels of competition, and consequently a greater chance of survival. Seeds of some genotypes needed temperatures higher than 100 ºC to have 100% softening. These temperatures however, promoted very high seed mortality (Figure 5). In general, softening and germination success in seeds of *Desmanthus* responded in a similar way within a range of temperatures from room temperature up to 60 ºC.

Above this temperature the heat started to depress germination (Figure 5).

High seed production associated with dependence of seeds on elevated temperatures to release their seed-coat dormancies can be a very important strategy used by plants such as *D. virgatus* CPI 78373, to survive in dry tropical regions subjected to periodical droughts. Such plants will form large seed banks in soil and intensive seedling recruitments will occur only after the occurrence of certain events such as a drought period. Seed-coat dormancy of seeds in the soil seed bank will be broken by the intense heat in the dry period and intensive seedling recruitment will certainly occur in the next wet season assuring the establishment of a new stand of plants (HERRANZ et al., 1998). Such as strategy can probably explain the greatest number of seeds in soil seed bank and the highest rate of plant survival found by Gardiner et al. (2004) in *Desmanthus virgatus* CPI 78373 when compared to 35 other accessions of *Desmanthus,* in plots 14 years after planting at Blackall, in the semi-arid, black clay soils of Queensland's Mitchell Grass Bioregion.
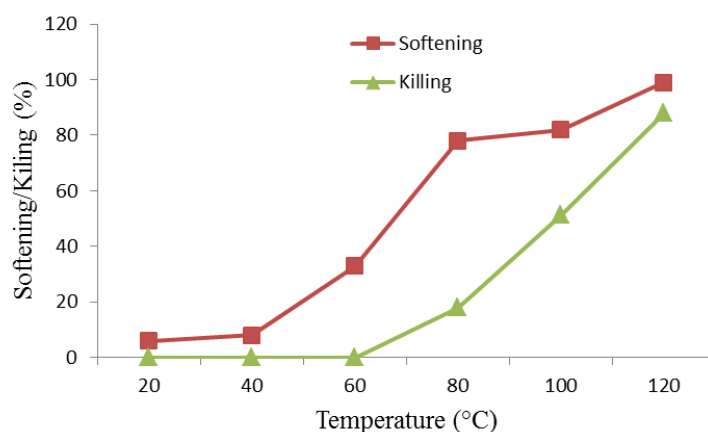
Figure 5. Softening or killing effect of heat on seeds of *Desmanthus* genotypes. The curves represent the means of the nine genotypes tested.

Genotypes with similar behaviour to CPI 78382 and CPI 83563 would appear to be particularly suitable for agronomic use in areas subjected to occasional burning in view the ability of their seeds to resist high temperatures without serious losses in viability. The success of such genotypes however will be dependent of the longevity of their seeds in soil seed bank and the length between fires interval (ORSCHEG; ENRIGHT, 2011). For regions not subject to occasional burning, and where soil temperatures are not expected to reach levels much higher than 60 ºC, genotypes having similar ecological behaviour to CPI 78382 and CPI 83563 are not recommended. Therefore the genotypes CPIs 37143, 38351, 67643, 78372, TQ 88 and Alligator Creek would probably be more suitable for such conditions. Reasonable number of seeds of these genotypes would be expected to become soft and germinable in the soil-seed bank after a normal summer wet season in tropical and sub-tropical regions. Similar germination trend was proposed by Funes and Vernier (2006) for seeds of *Acacia aroma*, *Acacia cavens* and *Acacia furcatispina* in semiarid region of central Argentina and by Michael et al. (2006) in seeds of *Malva paviflora* populations. The results presented here should assist graziers, ecologists and seed merchants with future management of *Desmanthus* seed and seed banks. However field confirmation of these conclusions would also be very beneficial.

CONCLUSIONS

Variations in seed bank sizes below studied *Desmanthus* spp. are closely associated with genotypes.

High temperatures may be used to overcome seed-coat dormancy in *Desmanthus* genotypes. Seeds of different genotypes, however, have different responses to the amount of heat necessary to promote seed germination.

ACKNOWLEDGMENTS

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