Effect of duration of flooding on germination and emergence of sown *Stylosanthes* seed

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Abstract

Seeds of *Stylosanthes hamata* cv. Verano
(Verano) and *S. Scabra* cv. Seca (Seca) were
sown in buckets and subjected to 0 (control), 1, 2
and 3 weeks of flooding to a depth of 3 cm. Stylo
seedlings were recorded for 46 days. Hard seeds
were recovered and counted from the soil after
the initial growing period.

Stylo emergence declined exponentially with
flood duration. There was no significant difference
between Verano and Seca. Flooding for 3 weeks
resulted in a reduction of 88% of the emergence
measured in control treatments.

Flooding resulted in higher hard seed levels
than in the control. Seed lost by rotting was higher
with Verano than with Seca and increased with
duration of flooding. Overall it varied from
15–58%.

Introduction

Legumes in the genus *Stylosanthes* have been
shown to improve pasture and animal production
in the semi-arid tropics of northern Australia and
in other tropical countries (Stace and Edye 1984).
Their ability to grow on low fertility soil and to
tolerate droughts and high grazing pressure fit
them well for the extensive grazing systems in
the tropics. Some species are tolerant of flooding
(Brohlmann 1977) including *S. hamata* and
S. scabra (Thomas 1984), though there appear to
be no studies of the effect of flooding on the fate
of seeds in the soil.

In a long-term grazing experiment at
Lansdown (Jones 2001), it was noticed that after

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a period of flooding (≈1 month) the number of
legume seedlings to emerge was greatly reduced.
Flooding could, therefore, have significant impli-
cations for establishing and young pastures.

This experiment was conducted at the CSIRO
Davies Laboratory in Townsville to investigate
the effect of flooding on the germination and
emergence of stylo seeds, and its effect on the
residual hard seed component in the soil

Materials and methods

Four (4) treatments were examined to measure
the effect of duration of flooding on the germi-
nation of seeds of 2 *Stylosanthes* species —
S. hamata cv. Verano (hereafter Verano) and
S. scabra cv. Seca (hereafter Seca). Both cultivars
are widely grown in northern Australia.

The treatments were: control (no flooding); and
flooding for 1, 2 or 3 weeks. Treatments were
replicated 4 times in a randomised block design set
up in a glasshouse at the CSIRO Davies
Laboratory. Batches of seed of the 2 legumes were
chosen to give about 50% of hard seed and 50%
of soft seed, so that the effect of flooding on both
types of seeds could be measured. These levels of
soft seed were established by germinating batches
of 100 seeds in petri dishes containing agar.

The soil used was the A horizon of a
'Woodridge loam to sandy loam' (Murtha and
Crack 1966) from the CSIRO Lansdown Research
Station. It contained 0.02% total soluble salts
(NaCl<0.01%), 0.069% N, 4 ppm available
P (bicarbonate extraction), 1.0% organic C and a
pH (1:5 water) of 5.8. The particle size distribution
of the soil was 34% coarse sand, 40% fine sand,
14% silt and 12% clay.

Experimental technique

The soil was sieved to remove large clods and
large clumps of roots, thoroughly mixed and
added to 9L plastic buckets fitted with drainage
taps. The bottoms of the buckets were filled with

small rocks of about 1 cm diameter, to a depth of 3.5 cm (a volume of 2 litres of rocks). Soil (4 litres) was then added to bring the level to within 6 cm of the rim of the bucket. A circular small screen mesh was then placed on the soil, and more soil to a depth of 5 mm was placed on the mesh (Figure 1). To each bucket, 100 legume seeds were added and mixed into the soil above the mesh. The mesh was used to prevent seeds from moving deeper into the soil, and to facilitate the subsequent recovery of ungerminated seeds.

On the day seeds were planted, waterlogged treatments were flooded to a depth of 3 cm above the soil surface. Water was added daily to maintain this depth to compensate for evaporation.
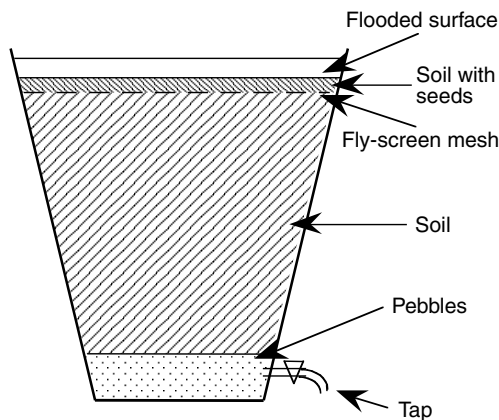

Figure 1. Bucket layout for the experimental treatments.

Control buckets were watered daily to about 80% of field capacity. After the duration of flooding had expired, the taps on the buckets were opened to allow water to drain off. Buckets were then watered as for controls. In all, there were 32 buckets in the experiment: 2 legume species × 4 water treatments × 4 replicates.

Measurements

Daily maximum and minimum temperatures were recorded in a Stephenson screen inside the glasshouse.

Stylo seedlings were counted for each bucket on 14 occasions over a 46-day period (see Figure 2).

Residual hard seeds

To assess the number and viability of residual seeds at the end of the experimental growing period, the stylo seeds were recovered and subjected to a germination test. The buckets were allowed to dry out and the soil layer above the mesh containing the seeds was removed. This was then passed through a series of sieves 1.7 mm, 1.4 mm and 0.85 mm. The soil, which retained the seeds, was collected from the 1.4 mm and 0.85 mm sieves. The sifted samples, with reduced soil volume, were then heated at 70°C for 24 h in a dehydrator and then rapidly cooled, in order to soften the hard seed content. The method was based on Gilbert and Shaw (1979) but with heating for 24 h. Each sample was weighed and a subsample of 40% of soil weight plus 25 ml of water was placed on 9 cm diameter paper germinating pads ('Wetex') in 6 cm high plastic containers. Each container was then sealed with plastic film to retain moisture. Seed containers were randomly allocated on a bench in the laboratory that was maintained at a temperature between 26°C maximum and 20°C minimum. Seeds that germinated were counted over 8 days. The soil and any ungerminated seed was then dried, reheated and then wetted using the same procedure as above, and seedlings counted. Remaining ungerminated seed in the containers was counted and classed as 'hard'.

Data analyses

ANOVA were conducted on stylo emergence, estimated hard seeds and rotted seeds using SAS (1989) with procedure General Linear model. Exponential regressions were also fitted to the stylo emergence data for the flooding treatments.

Results

Temperature

Overall mean daily maximum and minimum temperatures during the flooding phase were 37.9°C and 19.6°C, respectively.

Initial seed germination

Germination of the seed used on agar plates gave values of 37.4% ± 1.3 and 53.4% ± 1.8 for Seca and Verano, respectively. There were no rotten seeds, so the ungerminated seeds were regarded as 'hard'.

Stylo emergence

The emergence pattern of seedlings during flooding differed (P<0.05) between the 2 stylos (Figure 2). The seedling data for Seca fitted an
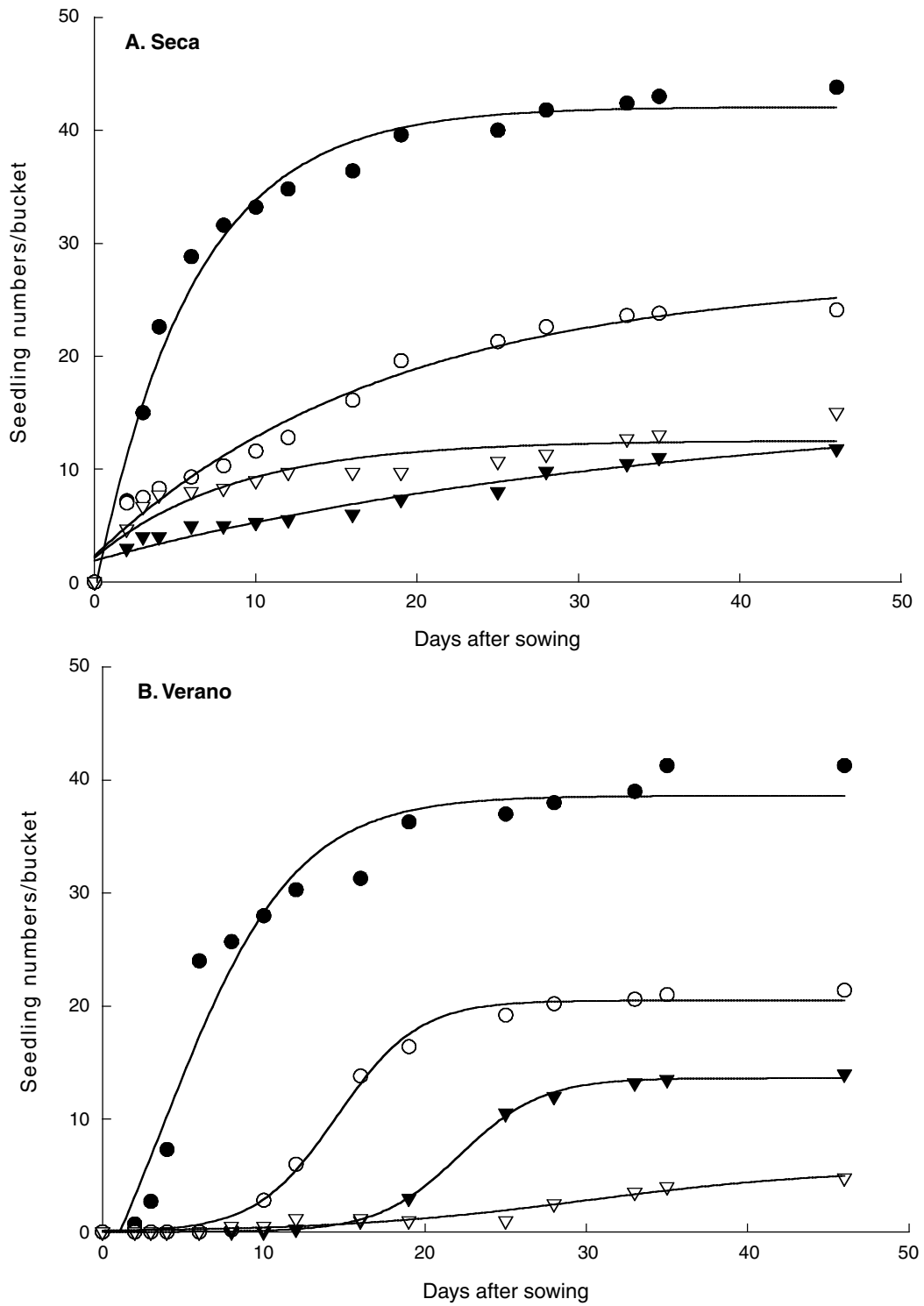
Figure 2. Seedling emergence over time for the 4 flooding treatments. A. Seca; B. Verano. For Seca, the data fitted an exponential rise to maximum model, and for Verano, a sigmoidal model. Control ●; 1-week ○; 2-week ▼; 3-week ▽ flooding.

exponential rise to maximum model (Figure 2A), whereas the data for Verano fitted a sigmoidal model (Figure 2B). Very few Verano seedlings emerged in the flooding treatments until the water was removed resulting in waves of germination following draining of the buckets. Most of the Verano seeds that germinated during flooding showed some sort of deformity or very stunted growth. The roots did not develop beyond 5 mm from the seed and no seedlings survived.

With Seca, seed that germinated under flooding conditions also had difficulty establishing. Seedlings tended to be stunted with little root penetration into the soil. Although 90% of the seeds that germinated after one week of flooding survived, very few survived in the 2 and 3-week flooding treatments.

Numbers of surviving seedlings 46 days after sowing declined exponentially with duration of flooding (P<0.001) (Figure 3). There was, however, no significant difference (P<0.05) between Seca and Verano. The exponential equation $y = 42.2\exp - 0.766$, $r^2 = 0.992$, described the decline in numbers of surviving seedlings (Figure 3).
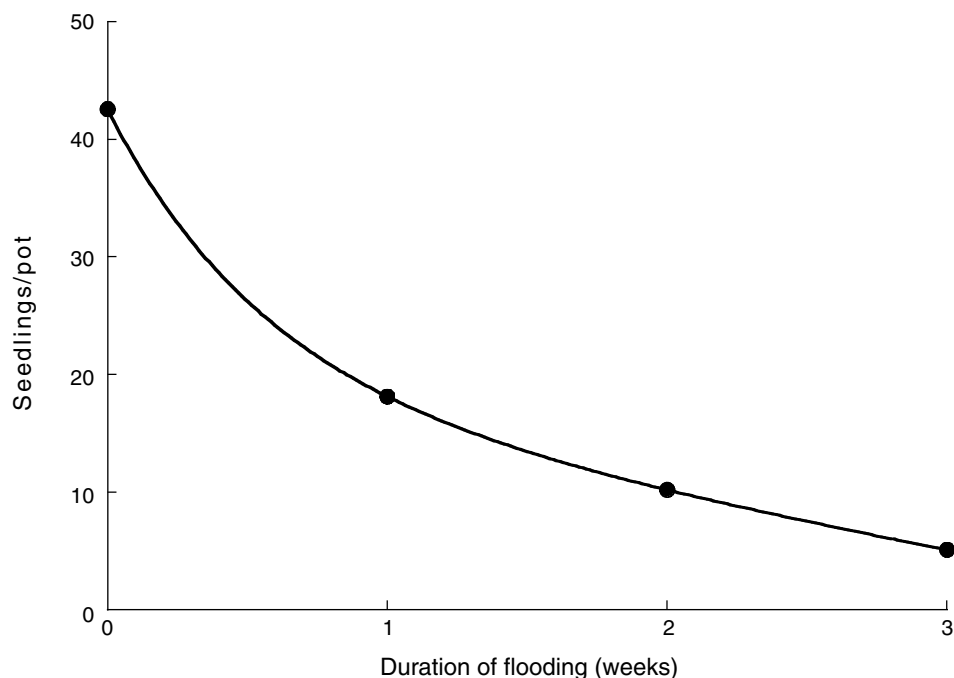
Hard seed and rotted seed

For all flooding treatments, Seca had higher hard seed levels than Verano (P<0.05), but the pattern was similar for both species. Hard seed numbers increased with flooding duration to 2 weeks (P<0.05) then declined at 3 weeks. A high level of rotted seeds was noticed in all treatments. Rotted seed, calculated as 100 – (germinated seed + hard seed), was higher in Verano than in Seca and overall varied from 15–58% depending on treatment (Table 1). For both stylos, rotted seed was lowest with no flooding and highest with 3-week flooding. The 1 and 2-week flooding had similar levels of rotted seeds with values intermediate between those for 0 and 3-weeks flooding (Table 1).

Discussion

The numbers of stylo seeds that germinated in the unflooded soil were expected to be similar to the numbers of soft seed measured on the agar plates. This proved to be the case for Seca, but the values for Verano were lower and unexplained (Table 1).

Figure 3. Relation between number of surviving stylo seedlings after 46 days and duration of flooding after sowing (means for the 2 stylo species). The exponential equation: $y = 42.2\exp - 0.766$, $r^2 = 0.992$, described the relationship.

Table 1. Effect of flooding treatments on the fate of seeds of *Stylosanthes scabra* (Seca) and *Stylosanthes hamata* (Verano) 46 days after sowing.

Fate of seeds	Duration of flooding (weeks)				LSD (P<0.05)
	0	1	2	3	
			Seca		
Surviving seedlings (%)	43.8	14.8	6.3	5.3	5.3
Died after flooding (%)	0	9.2	5.0	8.0	3.4
Hard seed (%)	37.5	50.6	67.5	50.0	9.7
Rotted seed (%)	18.7	25.4	21.2	36.7	10.0
			Verano		
Surviving seedlings (%)	41.3	21.4	14.0	4.8	5.3
Died after flooding (%)	0	0	0	0	NS
Hard seed (%)	31.7	39.5	45.0	37.5	9.7
Rotted seed (%)	27.0	39.1	41.0	57.7	10.0

The results show a very significant reduction in germination and emergence of Verano and Seca due to flooding, even after only 1 week. Soft seed would have been most susceptible to the adverse effects of flooding causing many to rot. Although some of the soft seed near the soil surface germinated under flooded conditions, the seedlings had low viability once the floodwater was removed. Inability of the seedling roots to penetrate the soil appeared to be the main reason for their demise.

The higher numbers of hard seeds in the flooded treatments compared with the control, and especially with Seca, is not easy to explain. It seems unlikely that soft seeds became hard in flooded conditions, but it may be that some soft seeds were prevented from germinating. Another possibility is that, at lower soil temperature and lower oxygen status of the flooded soil, none of the original hard seeds softened whereas in the control a proportion of the hard seeds present initially softened and then germinated or rotted. It is also possible that seed classed as hard contained some dead seed that had not yet rotted. A combination of these factors could also have occurred.

The absence of any detrimental effect of flooding on the residual hard seed shows that there would be no depletion of the soil seed bank of hard seed.

The major effect of periodic flooding would therefore be a reduction of the soft seed that would have germinated in the year of flooding. The effect of flooding would be greater where the stylo seed bank was small, such as under a young improved pasture than where the seed bank was high, such as under a well managed older stylo pasture. For example, at "Lansdown" mean germinable stylo seed density in the surface soil of 12 pastures containing *S. hamata* was 1830/m^2 (McIvor and Gardener 1991). Furthermore, sowing scarified seed with 40–50% of soft seed would be less risky than sowing all soft seed if flooding after sowing was anticipated.

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