Persistence of *Arachis pintoi* cv. Amarillo on three soil types at Samford, south-eastern Queensland

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Abstract

A small area of *Arachis pintoi* cv. Amarillo was established in 1984 in each of 3 farm pastures at Samford, south-eastern Queensland. On one soil, the original plants of Amarillo persisted poorly (with a half-life of only 4 months), there was little seed set, and the stand died out. This is attributed to poor soil physical, and possibly chemical, conditions. On the other 2 sites the original plants had a half-life of just over 2 years and there was a build up in soil seed reserves over 8 years to 250–450 seeds/m^2. In another 10-year-old sowing at Samford, seed reserves had increased to 1000/m^2. Good stands of Amarillo had 15–40 m of stolon per m^2 with 60–400 roots > 1 mm diameter per m^2. Most of these roots were primary taproots that resulted from seedling recruitment.

Amarillo has good attributes for persistence in grazed pastures as it has a prostrate growth habit, perennial crowns, sets seed under grazing and is able to root from stolons.

Resumen

Una pequeña área de Arachis pintoi *cv. Amarillo fue establecida en 1984 en las pasturas de cada una de las 3 granjas de Samford, al sur-este de Queensland. En una de las granjas, las plantas originales de Amarillo tuvieron una baja persistencia, con una vida media de únicamente 4 meses, produjeron una baja cantidad de semilla y el cultivo murió. Esto es atribuido a las pobres condiciones físicas, y posiblemente químicas del suelo. En las otras 2 granjas, las plantas originales tuvieron una vida media ligeramente superior a los 2 años y las reservas de semillas en el suelo se incrementaron de 250 a 450 semillas/m^2 a los 7 años. En otra siembra vieja de 10 años en Samford la reservas de semillas se incrementaron a 1000 semillas/m^2. Los cultivos buenos de Amarillo tuvieron un largo de estolón de 15–40 m por m^2 con 60–400 raíces > 1 mm de diámetro por m. La mayoría de estas raíces fueron primeramente raíces pivotantes de plátulas reclutadas.*

Amarillo tiene atributos buenos tales como hábito de crecimiento postrado, coronas perennes, producción semilla aún bajo pastoreo y capacidad de producir raíces a partir de los estolones, los cuales le permiten persistir en pasturas en pastoreo.

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Introduction

Arachis pintoi cv. Amarillo has recently been released in Queensland as a legume for ground cover in horticulture (Dwyer *et al.* 1989) and for use in pastures (Cook *et al.* 1990). Experiences in subtropical Australia (Cameron *et al.* 1989; Cook *et al.* 1990) and in the eastern plains of Colombia (Grof 1985) indicate that it can persist under heavy grazing. There is little understanding of how this persistence is achieved as there are only 2 isolated measurements of soil seed reserves, in Colombia (Grof 1985) and at Samford, Queensland (Cameron *et al.* 1979), and 1 measurement of the half-life of plants in Costa Rica (Ibrahim *et al.* 1993). Consequently this preliminary study on the demography of Amarillo under grazing was initiated in 1984.

Materials and methods

Areas of 10 × 10 m were cultivated in 3 farm pastures on Samford Research Station (27°22'S, 152°53'E, 1100 mm annual rainfall). One soil was a well drained yellow podzolic on a hillslope (Dy 5.22, Northcote 1977), another was a poorly structured gleyed podzolic on alluvium (Gn 3.65) and the third, a well structured gleyed podzolic on colluvium (Gn 2.84). The poorly structured alluvial soil had a silty loam topsoil, probably with poor infiltration rates, and a massive silty clay loam to silty clay at 20 cm overlying a silty clay layer containing Mn nodules. These relatively impermeable layers would prevent appreciable subsoil storage of moisture, but also result in a perched water table, saturated topsoil and possible Mn toxicity following sustained wet periods. The well structured colluvial soil had a sandy loam topsoil gradually changing after 40 cm to a sandy medium clay at 1 m depth. Thus infiltration was good and yet moisture was maintained longer into dry periods due to a perched water table at depth. The yellow podzolic soil had a sandy loam texture to 20 cm, then increasing clay content to a blocky medium heavy clay at 50–70 cm, with increasing amounts of parent schist at 70–85 cm. The soils will be referred to as alluvial, colluvial and podzolic.

Paspalum notatum was the dominant grass on the alluvial site and *Setaria sphacelata* on the colluvial site. The podzolic site was initially dominated by *Setaria sphacelata*, but by 1990 was dominated by *P. notatum*. All sites had received regular applications of superphosphate over the last 30 years. Each area was sown with 1 kg of Amarillo seed (including pods), inoculated with rhizobial strain CB3036 (CIAT 3144) in November 1984. Plots were later top inoculated with CIAT 2138. Ten fixed quadrat positions of 1 × 0.5 m were pegged out at random in each site 1 month after sowing, and all Amarillo seedlings in the quadrat were marked. The areas were fenced from grazing during the year of sowing, but after that they were rotationally grazed as farm pastures. Typically, the pastures were regularly grazed down to 3–5 cm height.

The survival of the original plants was monitored every 12 months, up to June 1990, as was the survival of seedlings which emerged in 2 major emergence events in May 1986 and October 1986. The half-life of these plants was determined from the linear relationship of log density against time.

Soil seed reserves were measured in August 1985, August 1987, June 1990 and August 1992, by taking 30 cores of 7 cm diameter to 20 cm (1985) or 10 cm depth per site. In 1985 and 1987 the cores were split into 5 cm intervals. Seed was recovered by the technique of Jones and Bunch (1988a) and only full pods were counted. In 1990 the seed was shelled and tested for viability using 10 day pre-treatment at 40 °C, followed by 35/20 °C day/night temperatures in a germination cabinet.

In the 1985 and 1990 samplings, all stolons on or within 2 cm of the soil surface were included in the soil cores and were recovered and washed. The lengths of stolons and the numbers and sizes of roots were measured. The number of roots > 1 mm diameter was also recorded in 1992. In both 1990 and 1992, an assessment of whether roots were primary taproots or secondary adventitious roots formed from stolons was made, based on the way that stolons originated from, or were attached to, the root. Primary taproots also have a "carrot-like" form.

In 1986, 1990 and 1992, similar measurements of soil seed, stolons and roots were made on 3 rows of Amarillo which had been sown in a 5 cm wide band in a red-yellow podzolic soil at Samford in 1982, as described by Cameron *et al.* (1989). Ten cores were sampled to 10 cm depth along each row, and 10 cores were taken 50 cm away from this.

Results

During the 8 growing seasons (October–March inclusive) from 1984/85 to 1991/92, rainfall was above the long-term average (760 mm) in 3 years, with individual years ranging from 369 mm (1985/86) to 1134 mm (1991/92).

Establishment from sowing ranged from 10–20 plants/m^2. Survival was much poorer on the alluvial soil, where the half-life of plants was 4 months, as contrasted with 25 and 26 months on the podzolic and alluvial soils respectively (Table 1). The regression equations of log plant density (y) and time (x), used to calculate half-life, account for 93, 94 and 99% of the variation on the alluvial, colluvial and podzolic soils respectively. In the seedling strikes that were monitored, seedling density and survival were worst on the alluvial soil.

With time, soil seed reserves increased on the podzolic and colluvial, but decreased on the alluvial (Table 2). In the 1985 sampling, 95% of seed was in the 0–5 cm depth, 5% in 5–10 cm and

Table 1. Density of Amarillo seedlings in January 1985 after sowing into full cultivation and of two seedling cohorts, with their subsequent half-life, on 3 soil types.

	Original plants		Seedlings (May 86 cohort)		Seedlings (Oct 86 cohort)	
Soil type	Initial density	Half-life	Initial density	Half-life	Initial density	Half-life
	($/m^2$)	(months)	($/m^2$)	(months)	($/m^2$)	(months)
Podzolic	13.6	25	6.4	10	26.6	10
Colluvial	10.2	26	0	—	4.0	35
Alluvial	20.4	4	0	—	1.4	3

Table 2. Changes over time in soil seed reserves, stolon length and rooting characteristics in 3 sowings of Amarillo.

	1985 sites			1982 site	
	Podzolic	Colluvial	Alluvial	In sown row	50 cm away
Soil seed reserves (no./m^2)					
August 1985	107	46	46	—	—
December 1986	—[1]	—	—	560	—
August 1987	363	127	35	—	—
June 1990	343	398	33	1270	219
August 1992	470	231	0	988	374
Stolon length (m/m^2)					
August 1985	8	2	3	—	—
June 1990	17	26	0.1	47	13
Roots (1990)					
Rooted points (no./m of stolon)[2]	29	45	0	35	30
1-4 mm diam. roots (no./m^2)	54	107	0	305	33
4-10 mm diam. roots (no./m^2)	39	27	0	80	0
> 10 mm diam. roots (no./m^2)	<1	0	0	13	0
Total > 1 mm diam. (no./m^2)	93	134	0	398	33
Total > 1 mm diam. (no./m of stolon)	6	5	0	8	3
Roots (1992)					
1-4 mm diam. (no./m^2)	24	64	0	312	64
4-10 mm diam. (no./m^2)	56	0	0	56	16
Total > 1 mm diam. (no./m^2)	80	64	0	367	80

[1] Indicates not measured or not applicable.
[2] A rooted point is where one or more roots originate from a stolon, regardless of root size.

none in the 10–20 cm depth. In the 1987 sampling all the seed was in the 0–5 cm depth. Seed reserves on the old experimental site of Cameron *et al.* (1989) also increased during 1985–1990. Seed reserves were similar in 1990 and 1992. In 1990 the germination percentage of the recovered seed, which was apparently sound, averaged 54%.

Stolon length per m^2 was much higher in 1990 than in 1985 on the podzolic and colluvial soil, but was lower on the alluvial (Table 2). On average, 93% of the stolons recovered in 1990 were 1–4 mm diameter and 7% were 4–10 mm diameter.

As stolon length was very low in 1985, there were very few roots, and the root data are not presented. In 1990 there were some 30–45 rooted points per metre of stolon on the podzolic and colluvial soils, but most of these roots were very small and there were only some 5 roots of >1 mm diameter per metre of stolon (Table 2). Most of these latter roots were in the 1–4 mm size class. It was estimated that more than half of the roots of >1 mm diameter were primary taproots that developed from a seedling. In the 1982 experiment, there was a build up of stolons 50 cm away from the original row by 1990, but there were no roots larger than 4 mm until 1992.

In the 1992 sampling, almost all roots >1 mm appeared to be primary taproots that developed from seedlings rather than from adventitious rooting. There was a strong linear relationship between soil seed reserves and root density in the bulked 10 core samples in both 1990 ($r = 0.92$) and 1992 ($r = 0.93$).

The crowns recovered in 1990 from seedlings which were tagged in 1985 were 10–15 mm diameter. There was only negligible damage to roots by insect larvae.

Discussion

Amarillo has many of the attributes of a persistent legume. Although well eaten by livestock (Carulla *et al.* 1991), some of the stolons escape because of their prostrate growth habit. The 25-month half-life of the original plants is similar to the half-life of *Macroptilium atropurpureum* (siratro) at Samford (Jones and Bunch 1988b), *Desmodium intortum* and *D. uncinatum* at Beerwah, south-eastern Queensland (Jones 1989) and *A. pintoi* in Costa Rica (Ibrahim *et al.* 1993).

The reserves of soil seed were higher than those of siratro at Samford (Jones and Bunch 1988c), and spanned the 620/m^2 of Amarillo seed measured under *Brachiaria* pastures in Colombia by Grof (1985). However these levels are much lower than the $\geq$ 3000 seeds/m^2 of white clover (*Trifolium repens*) and *Cassia rotundifolia* cv. Wynn measured at Samford. Both these legumes rely heavily on seedling recruitment for long-term persistence (R.M. Jones, unpublished data). As evidenced by the crown densities in 1990 and 1992, the seed reserves of Amarillo can effectively contribute to plant recruitment.

Most of the roots counted in 1990 were small hair-like roots. Their density would probably be transient and depend on previous soil moisture level, temperature, grazing pressure and the surface soil structure. In 1990 and 1992, there were some 60–400 roots > 1 mm diameter/m^2. Over half (in 1990) or almost all (in 1992) of these roots were seemingly primary taproots resulting from seedling recruitment. The difference in results between 1990 and 1992 may reflect differences in soil moisture and grazing pressure prior to sampling. This suggests that, in the Samford environment, seedling recruitment is a more important means of maintaining plant density than is adventitious rooting. The final density of 60–400 roots > 1 mm/m^2 is appreciably higher than the initial densities of 10–20 seedlings/m^2 in the 1985 sowing.

Although persistence through adventitious rooting was not the major pathway for persistence at Samford, it may be of more importance in other environments. The ability of *A. pintoi* to develop adventitious roots in other environments is illustrated by the fact that it is propagated from stolon cuttings under field conditions in Colombia (Asakawa and Ramirez 1989).

Consequently, when compared with some other tropical legumes grown in the same region, Amarillo has good characteristics for persistence in terms of its prostrate growth habit, survival of plants, recruitment from seed banks and ability to root from stolons. It is unusual for all these attributes to be present in 1 genotype. *Vigna parkeri*, for example, sets seed and roots down under grazing and has a prostrate growth habit, but has poor survival of individual plants (Jones and Clements 1987).

Persistence of Amarillo was good on all soils except the alluvial site. Good persistence has also been recorded in several other sites in south-east Queensland (B.G. Cook and K.F. Lowe, personal communication; author's unpublished data) with surface soil textures ranging from sand to heavy clay, and annual rainfalls from 650–1600 mm. Poor persistence on the alluvial soil is primarily attributed to the poor physical structure of this soil and low soil moisture storage. There is also the possibility of Mn toxicity, although Amarillo has reasonable tolerance of Mn (G.E. Rayment, personal communication). However, there are areas of similar soils along most river valleys in Queensland (C.H. Thompson, personal communication), even though the areas may be small. The problem on this particular soil could have been exacerbated by the competitive associated grass, *Paspalum notatum*. However, Amarillo has persisted very well with *P. notatum* on the podzolic soil and also in an old seed production stand of Amarillo at Samford, sown in 1974–75, where it is spreading into *P. notatum* under infrequent grazing. Like the colluvial site, this soil is well drained on the surface but maintains subsoil moisture into dry conditions.

Amarillo has also persisted well with competitive *Brachiaria* species in an area receiving 2000 mm rainfall per year in Colombia (Grof 1985) and also in Costa Rica (Ibrahim *et al.* 1993), but the soils are well structured and soil moisture stress is low by Australian standards. However, the results from this study suggest that even in areas of coastal Queensland where Amarillo is climatically adapted, persistence may occasionally be restricted by soil type.

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