Yellotas: A unique yellow serradella cultivar with potential for permanent pasture environments

Martin, G[*]; Smith, R.W[*]; Hall, E.J; Newell, M.T[†]; Haling, R[#]; Hayes, R.C[†]
* Tasmanian Institute of Agriculture, University of Tasmanian, Launceston, TAS, Australia.;
† NSW Department of Primary Industries, Cowra and Wagga Wagga, NSW, Australia.;
[#] CSIRO, Canberra, ACT, Australia

Key words: *Ornithopus*, hardseed, breakdown, regeneration, development

Abstract
Yellow serradella (*Ornithopus compressus* L.) has been identified as a priority self-regenerating annual legume species for permanent pasture environments in south-eastern Australia. However, most yellow serradella genotypes exhibit high levels of hard seed and slow rates of hard seed breakdown, which reduces regeneration density in the years following the year of sowing . One cultivar, Yellotas, exhibits a much faster rate of hard seed breakdown and has been identified as one of only a handful of cultivars of that species with promising persistence in permanent pasture environments. In addition, this cultivar is substantially easier to de-hull than other cultivars of that species, potentially reducing seed costs. In a field evaluation under severe drought conditions, this cultivar was shown to exhibit a high level of tolerance to close grazing. Yet, doubt still exists as to whether cv. Yellotas produces sufficient residual hard seed to withstand periodic drought suggesting further improvement may be required. This paper details the origins of cultivar and observations of its performance under a range of conditions in south-eastern Australia.

Introduction
Yellow serradella has long been a species of interest for crop and livestock production systems across southern Australia. It is a self-regenerating annual pasture legume adapted to acidic, low-fertility soils, and has a demonstrated ability to tolerate periodic droughts. The species has been used extensively in mixed crop-livestock systems across south-western Australia (WA) and parts of northern New South Wales (NSW), but to date has achieved relatively low levels of utilisation in the higher-rainfall permanent pasture environments of south-eastern Australia. The low penetration into such environments is in-part attributable to a lack of adapted cultivars with proven ability to self-regenerate over the long term. A second contributing factor was the historically high cost of yellow serradella seed compared to other pasture legume options (Nichols *et al.* 2012). The curled and segmenting characteristics of early cultivars of yellow serradella meant that suction harvesting was required and dehulling was difficult; leading to high seed costs (Nichols *et al.* 2007). This was later addressed in cultivars such as Yelbini and Santorini, which were selected for non-segmenting straight pods and pod retention meaning they could be direct headed (Nichols *et al.* 2007).

This paper describes the attributes of a cultivar, cv. Yellotas, developed specifically for use in permanent pasture environments in south-eastern Australia. Although developed two decades ago, the unique traits of the cultivar have scarcely been documented as cv. Yellotas was never registered for Plant Breeder's Rights (IP Australia 2022). Recent investment in legume research for south-eastern Australia by the red meat industry body, Meat and Livestock Australia (MLA), has sparked renewed interest in this unique cultivar.

Yellotas (sometimes misspelt Yellowtas) was developed from an accession introduced to Australia in 1972; CPI 50484. It was maintained by Agriculture Victoria (previously Vic DPI) under the derivation Ham 1038 and later received by Natural Resources and Environment Tasmania (previously the Department of Primary Industries, Parks, Water and Environment Tasmania) and maintained as Tas 349. Yellotas was bred by Eric Hall and Andrea Hurst at the Tasmanian Institute of Agriculture during the early 2000s through a process of 4 cycles of recurrent phenotypic selection. The breeders selected for traits including plant vigour, late flowering and high seed production. Seed attributes are described as having 'a high proportion of soft seed, which develop in straight to slightly curved pods'; differing from other yellow serradella cultivars. This paper reports on field observations comparing the relative performance of cv. Yellotas with other yellow serradella cultivars.

Methods and results
Initial evaluation in Tasmania
Yellotas was evaluated with a number of breeding lines and established cultivars in two experiments in the early 2000's at Cressy in Northern Tasmania. In May 2003, yellow serradella (11 lines), French serradella (*O. sativus* Brot.; 12) and hybrid serradella (*O. compressus* x *sativus*; 1) were dehulled, scarified and inoculated

(a subset reported here) and hand sown into 2 x 2 m plots with 3 replicates at a sowing rate of 20 kg/ha. Fertiliser (0-6-17-7 – NPKS) was applied at sowing at 300 kg/ha. Yellotas was one of the best performed yellow serradella lines under dy seasonal conditions in 2003 and 2004, and was superior to cv. Avila in the second year (2004) with higher regeneration densities and herbage yield (Table 1, Experiment 1). Following promising results in 2003, a further smaller evaluation was sown in 2004 with 3 breeding lines (one being Yellotas) and three commercial cultivars. These lines were sown into 2 x 1 m plots with 4 replicates, with seed inoculated and fertiliser applied as per 2003. Similarly, Yellotas performed better than cv. Avila with higher estalishment densities and spring yield (Table 1, Experiment 2).

Table 1 Performance of selected yellow serradella (*Ornithopus* compressus L.) cultivars in; Experiment 1 - year of sowing (2003) and first year of regeneration (2004); Experiment 2 - year of sowing (2004) at Cressy, Northern Tasmania, Australia.

	Experiment 1				Experiment 2	
Cultivar	**Plant count/m^2 May 2003**	**Yield kg DM/ha Nov 2003**	**Regeneration plant count/m^2 May 2004**	**Yield kg DM/ha Dec 2004**	**Plant count/m^2 May 2004**	**Spring yield kg DM/ha Nov 2004**
Yellotas	284	2028	428	896	348	1023
Avila	331	601	19	69	58	76
Tauro	161	1144	766	115		

These evaluations formed the basis of the selection of the Yellotas cultivar and subsequent seed bulking. It was not registered under Plant Breeder's Rights (IP Australia. 2022) at the time but was later marketed and sold by Tasglobal Seeds and their affiliates and has remained of interest in evaluations and experiments.

Year 2 regeneration

An evaluation of pasture legume persistence was recently undertaken in NSW (Hayes *et al.* 2022). Five cultivars of yellow serradella were included in experiments sown in 2017 at sites near Bigga and Middle Arm, on the NSW Southern Tablelands, and Bombala in the Monaro region, including cvv. Avila, Charano, King, Santorini and Yellotas. Here, we report year 1 seed production and year 2 seedling regeneration of those cultivars. Seed production was assessed at the end of spring in year 1 at each site after legumes had senesced and most of the serradella pod was detached and on the soil surface. A strip of soil 1.0 m long × 0.1 m wide × 0.02 m deep was excavated from each plot, perpendicular to the direction of sowing. Samples were transported back to the laboratory and pod and seed removed by threshing and running over a series of sieves of varying apertures. An assessment of seedling density was taken in autumn of Year 2 using a 1.0 × 1.0 m quadrat, divided into 100 equal cells, placed randomly in the plot and the number of serradella seedlings visible in a diagonal transect of this quadrat recorded. This was repeated at three locations within each plot and the average of those counts converted to plants/m^2.

There was no significant site x cultivar interaction (P>0.05) effects detected with either seed production or seedling regeneration. There was less yellow serradella seed produced at the Bigga site (295 kg/ha) compared to either Middle Arm (943 kg/ha) or Bombala (1201 kg/ha; l.s.d at P=0.05 was 302 kg/ha). Averaged across sites, there was little difference between cultivars in the quantity of seed produced in year 1 (P=0.057), with yields ranging from 574-1065 kg/ha. Seedling regeneration in year 2 was lower at Bigga (271 plants/m^2) compared to either Middle Arm (1072) or Bombala (1577). Averaged across sites, seedling density was greater in cvv. King (1848 plants/m^2) and Yellotas (1832) compared to cvv. Santorini (280) or and Charano (373), and intermediate in cv. Avila (777; l.s.d. at P=0.05 of 1140).

Tolerance of grazing under drought

The experiment at the Middle Arm site described above was continuously grazed by sheep in 2018, which also happened to be a drought year, with total rainfall recorded for that year almost 30% lower than the long term annual rainfall at that site. These circumstances provided an opportunity to assess the response of the yellow serradella cultivars under heavy grazing during dry seasonal conditions. Three assessments of relative pasture density were taken at that site during 2018 (year 2), including seedling regeneration on 13 March as described above, followed by two assessments of legume frequency on 15 June and 12 November (Table 2). Legume frequency was assessed using a 0.5 × 0.5 m quadrat divided into 100 cells of equal size and counting the number of cells in each quadrat containing the base of a serradella plant. Quadrats were placed in three random locations in each plot with values expressed as a percentage (%).

Pattern of hard seed breakdown

Hard seed (impermeable seed coat) content of cv. Yellotas was initially determined in Tasmania from seed grown on weedmats at Mt. Pleasant, Launceston in 2003 concurrently with other experiments. Seed was collected by hand and a known number of pod segments of each line were placed in germination trays where the seed was kept continually moist, replicated twice. The number of seeds that produced a radicle was assessed at 14, 21 and 28 days, with the remainder presumed to be hard seed. After 28 days, cv. Yellotas had a hard seed content of 65%, slightly lower than the original parent material of Tas 349, which was 69%, with both much softer than cv. Avila, which was 98%.

Patterns of seed softening were evaluated in seed grown in 2018 at Cowra in central NSW. Pod segments, totalling 100, of yellow serradella cvv. Avila, King, Pitman, Santorini and Yellotas were placed in separate pouches constructed from plastic coated fibreglass mesh. Pouches were laid flat on the surface of a cleared patch of soil in January 2019, as described in Newell *et al*. (2022). Initial proportions of hard seed were assessed at the start of the experiment (Day 0) by incubating 100 segments on moist filter paper for 14 days. Pod segments which were firm to touch were considered hard and used to calculate the percentage of hard seed. Progress of seed softening was followed in subsequent incubation tests by retrieving pouches at 30-day intervals for the first five assessments. The sixth and seventh harvest were at 509 and 745 days respectively.

There were two distinct patterns of seed softening among the cultivars tested (Figure 1). Yellow serradella cvv. Avila, King and Santorini had high proportions of initial hard seed (100%) with very slow seed softening during the first year (~Day 320). However, from mid-summer (Day 340) through the end of autumn 2020 (~Day 500) there was a significant increase in the rate of seed softening ($P< 0.001$). In contrast, cvv. Yellotas and Pitman were characterised by rapid seed softening during late summer-autumn 2019 (Day 28-138), and again in late-summer-autumn 2020. This resulted in loss of 80-90% of the hard seeds over the two-year experimental period (Day 500).

Table 2 Three assessments of relative pasture density of 2018 sown experiment at Middle Arm, New South Wales.

Cultivar	Seedling density Mar 2018	Frequency Jun 2018	Frequency Nov 2018
Avila	1080	77	43
Charano	373	50	5
King	2060	83	21
Santorini	280	27	5
Yellotas	1567	91	79
l.s.d.	*669*	*18.7*	*17.1*

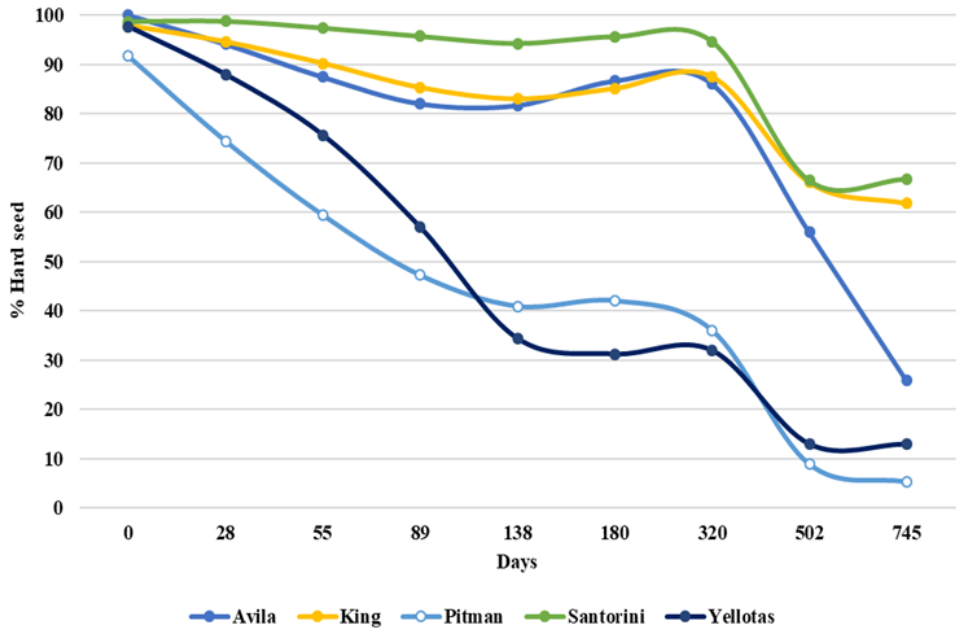

Figure 1: Mean of residual hard seed expressed as a percentage over time for yellow serradella cvv.

Discussion

The combination of characteristics found in Yellotas are unique. It has a hard seed breakdown pattern most similar to cv. Pitman, an old cultivar long recognised for low levels of winter production (Clark and Hamilton 1985). It is late-maturing similar to cv. Avila, yet has better 2nd year regeneration and tolerance to grazing. The rapid breakdown of hard seed suits environments in the higher rainfall zone where autumn breaks can occur very early (e.g February or March) yet conditions can be cool and moist enough for seedlings to survive. In this respect, cv. Yellotas is most similar to well-adapted subterranean clover cultivars that presently dominate much of the permanent pasture zone of south-eastern Australia (Newell et al. 2022). The ability to tolerate hard grazing under dry spring conditions is an obvious advantage in permanent pastures.

The observations and descriptions of the characteristics of cv. Yellotas in this paper indicate a context and farming systems fit for a cultivar such as Yellotas in the med-high rainfall permanent pasture zone and warrants further evaluation. More recent research identifying serradellas as having a lower phosphorus requirement (Sandral *et al.* 2019) has reinvigorated interest in this species.

Conclusions and/or Implications

Cultivar Yellotas is a late maturing yellow serradella cultivar with rapid seed softening, grazing tolerance and regenerative abilities suitable for the high rainfall permanent pasture zone. This cultivar, or cultivars with similar traits, have the potential to extend the reach of serradella into permanent pasture environments of south-eastern Australia.

Acknowledgements

The authors would like to acknowledge the breeders Eric Hall and Andrea Hurst in identifying and developing cv. Yellotas and conducting the evaluation of the cultivar with the assistance of Gary Martin. This development work was funded by the DPIPWE Cultivar Trust Fund.

References

Clark, SG, Hamilton, LJ 1985. Evaluation of yellow serradella accessions in southern Victoria. Proceedings of the Australian Agronomy Conference, Australian Society of Agronomy.

Hayes, RC, Newell, MT, Li, GD, Haling, RE, Harris, CA, Culvenor, RA, Badgery, WB, Munday, N, Price, A, Stutz, RS, Simpson, RJ 2022 Legume persistence for grasslands in tableland environments of south-eastern Australia. *Crop & Pasture Science* **In Press**,

IP Australia., 2022. Plant Breeders Rights Database Online. https://www.ipaustralia.gov.au/plant-breeders-rights.

Newell, MT, Haling, RE, Hayes, RC, Stefanski, A, Li, GD, Simpson, RJ 2022 Hard seed breakdown patterns of serradella (*Ornithopus* spp.) in two contrasting environments of south-eastern Australia. *Crop and Pasture Science* -.

Nichols, PGH, Loi, A, Nutt, BJ, Evans, PM, Craig, AD, Pengelly, BC, Dear, BS, Lloyd, DL, Revell, CK, Nair, RM, Ewing, MA, Howieson, JG, Auricht, GA, Howie, JH, Sandral, GA, Carr, SJ, de Koning, CT, Hackney, BF, Crocker, GJ, Snowball, R, Hughes, SJ, Hall, EJ, Foster, KJ, Skinner, PW, Barbetti, MJ, You, MP 2007 New annual and short-lived perennial pasture legumes for Australian agriculture—15 years of revolution. *Field Crops Research* **104**, 10-23.

Nichols, PGH, Revell, CK, Humphries, AW, Howie, JH, Hall, EJ, Sandral, GA, Ghamkhar, K, Harris, CA 2012 Temperate pasture legumes in Australia—their history, current use, and future prospects. *Crop and Pasture Science* **63**, 691-725.

Sandral, GA, Price, A, Hildebrand, SM, Fuller, CG, Haling, RE, Stefanski, A, Yang, Z, Culvenor, RA, Ryan, MH, Kidd, DR, Diffey, S, Lambers, H, Simpson, RJ 2019 Field benchmarking of the critical external phosphorus requirements of pasture legumes for southern Australia. *Crop and Pasture Science* **70**, 1080-1096.