Flowering time responses of serradella cultivars

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Abstract
Serradellas (*Ornithopus* spp.) are alternative temperate annual pasture legumes, until recently grown mainly on deep sandy soils where their deep rooting habit and tolerance of low soil fertility/acidity confer an advantage over subterranean clover (*Trifolium subterraneum*). Expansion of serradella use requires cultivars with appropriate maturity type and hardseededness to underpin persistence in a wider range of growing seasons and climates. In 2018, a national experiment was conducted to determine the maturity types of a range of serradella cultivars that are potentially available in Australia. Thirteen cultivars of serradella (six *O. compressus*, six *O. sativus*, one *O. pinnatus*) and five cultivars of subterranean clover were sown in Perth, Canberra, Cowra and Tamworth to examine flowering times and duration in these environments. The results indicated a wide range in maturity types among serradella cultivars, but with significant gaps in the maturity types available for hardseeded *O. sativus* cultivars. A number of the serradellas had unstable flowering times indicating inadequate germination-date flexibility and will flower too early (during severe frost periods) after germinating on an early break to the growing season in eastern Australia.

Key Words
Days to flower, flowering time

Introduction
Serradellas (*Ornithopus* spp.) are temperate, annual legumes commonly grown on sandy, low pH soils in WA and northern NSW where their deep rooting habit and adaptation make them a preferred option to subterranean clover (*Trifolium subterraneum* L.) (Freebairn 1996; Nichols et al. 2007, 2012). The recent development of improved yellow serradella (*O. compressus* L.) and French (pink) serradella (*O. sativus* Brot.) cultivars, particularly new hardseeded cultivars, has seen a rapid expansion of serradella use in phase farming systems in WA and the NSW Riverina (Nichols et al. 2012).

There is interest among producers to use serradella in the permanent pasture zone of south eastern Australia which has traditionally been regarded as outside their region of adaptation. A number of experiments have demonstrated that some serradella cultivars can yield as well as subterranean clover in these areas and on duplex soils (Dear et al. 2002; Hackney et al. 2013). Indeed, French serradella cv. Margurita yielded as well as subterranean clover with a significantly lower critical soil phosphorus requirement in experiments in the Riverina and the Southern Tablelands of NSW (Sandral et al. 2019). However, there are some indications of poor persistence of serradella cultivars in areas where they are not already used (e.g. Hayes et al. 2015).

Long-term persistence of pasture legumes is critical for permanent pastures. Acceptable legume persistence has been achieved using yellow serradella on light soils where it can perform better than subterranean clover. However, because serradellas are aerial seeding, it is recommended that grazing be managed to ensure seed production every few years (Freebairn et al. 1996; Hackney et al. 2013). Other known issues for seed production and regeneration by serradellas in permanent pastures are susceptibility to native budworm (*Helicoverpa punctigera* Wallengren) during pod maturation and, until the recent development of cvs Margurita and Erica, a lack of French serradella cultivars with any level of hardseededness. Low levels of hardseed can lead to complete failure after a false break (Dear et al. 2002). Serradellas differ from subterranean clover in that they have indeterminate flowering. We anticipate that the suitability of hardseeded cultivars for new areas will primarily be determined by their ability to: (i) commence flowering when the risk of frost damage to seed production has declined to an acceptable level, (ii) flower early enough for seed production to be completed before there is a high risk of terminal drought, and (iii) flower reliably year-on-year within this 'optimum' window for seed production, as has been described for subterranean clover (Donald 1970).

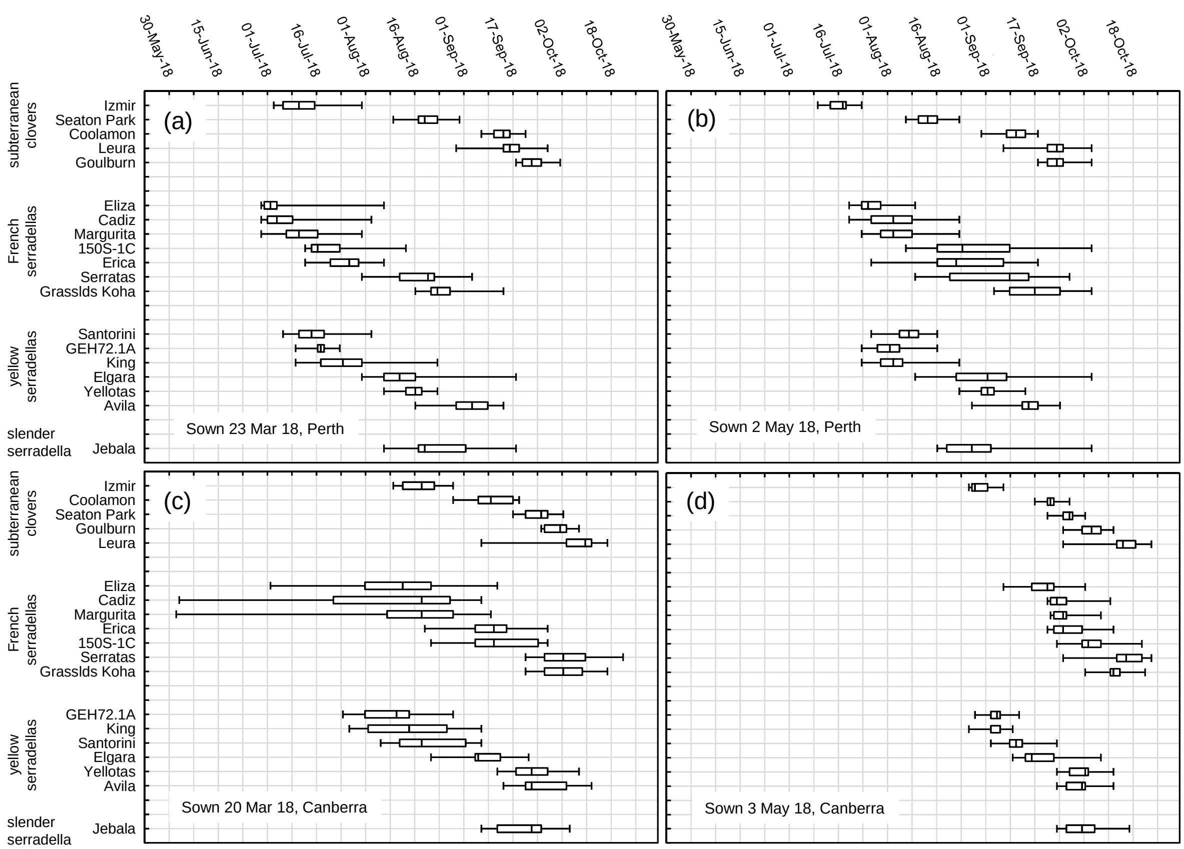
A coordinated study was conducted at four locations in southern Australia with two sowing dates to compare flowering times of serradella cultivars with subterranean clover cultivars (controls) selected to represent a typical range in the maturity types required for use across southern Australia.

Methods

Experiments were established at Perth (31.948022°S 115.795501°E, 20 m above sea level [ASL]), Canberra 35.201853°S 149.084478°E, 590 m ASL), Cowra (33.803282°S 148.701820°E, 385 m ASL) and Tamworth (31.145314°S 150.966542°E, 405 m ASL) in autumn 2018. Eighteen pasture legume treatments (six yellow serradella cultivars, six French serradella cultivars, slender serradella (*O. pinnatus* (Miller) Druce) and five subterranean clover cultivars; Figure 1) were sown at two times (weeks commencing 19 March and 1 May, except Cowra which was sown 4 April and 7 May) in a randomised block design (n=3) that was common to all sites. Each site was prepared similarly with weed mat (black, 0.91 m width) laid in parallel lengths about 1.1 m apart. Each plot was established by burning 20 holes (0.05 cm diam.) into the weed mat in two parallel rows (0.1 m apart), with holes offset and spaced at 0.2 m along each row. Plots were spaced 1.0 m apart along the length of the weed mat. At the appropriate sowing time, about four germinable seeds were sown in each hole with the objective of establishing 20 small groups of each cultivar in each plot. All sites were irrigated after sowing (for germination and emergence) and throughout the experiment as required to ensure low soil moisture did not affect plant growth rates and subsequent flowering times.

The plants were typically assessed about every 2-4 days to monitor the commencement of flowering. Individual plants were not distinguished, and once a flower was observed within a planting group (in each

Figure 1. Box plots of the dates on which flowering commenced within populations (max. n=60) of the serradella



and subterranean clover cultivars sown early and late at (a, b) Perth and (c, d) Canberra. The boxes show the interquartile range (i.e. when 25% to 75% of plants began flowering); middle bar is the median flowering date and the whiskers show the dates of first and last plants to commence flowering. NB: Grasslands Koha was included at these sites in addition to the core cultivars used at all sites in the national experiment.

weed mat hole), the plant group was recorded as having flowered. Assessments continued until all planting positions contained at least one plant with a flower.

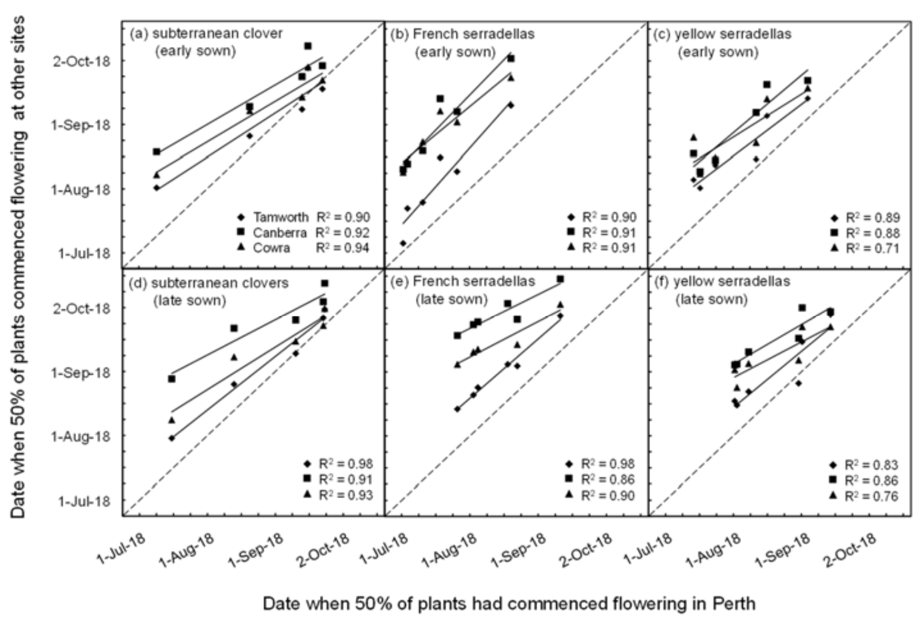
Box plots of flowering time were formed using all data (max. n=60) for each cultivar within a site. For other statistical analyses, average median flowering dates (i.e. when 50% of plant groups had produced at least one flower) were determined using the replicate structure of the experiment.

Results

At all sites, median flowering dates of all subterranean clover cultivars were relatively stable even when sown 6 weeks apart (Figures 1 and 2). Median flowering dates varied by only 1-2 days (average for all five cultivars) when the clovers were sown at the earlier date in Perth, Tamworth and Cowra. In Canberra, the most elevated (coolest) site, the median flowering date of the five clover cultivars occurred 7 days earlier when sown at the earlier date. In contrast, median flowering dates of the serradellas were often not stable. For example in Perth, early sowing brought forward the median flowering dates of the yellow serradella cultivars by 10-25 days and that of the French serradellas by 22-31 days, depending on the cultivar (Figure 1). In Canberra, similar shifts in median flowering date were observed for the yellow serradellas, but the median flowering dates of French serradella cultivars occurred 13-42 days earlier depending on the cultivar (Figure 1). Flowering of cvs Eliza, Cadiz and Margurita was particularly variable following early sowing (Figure 1c). The late season cultivars of French serradella (cvs Serratas and Grassland Koha) and yellow serradella (cvs Yellotas and Avila) expressed the most stable flowering times of the serradella cultivars.

Median flowering dates of the cultivars of each species were highly correlated when compared between the sites (R=0.84-0.99; Figure 2) indicating that maturity-type rankings of the cultivars were generally expressed consistently at all locations. However, the time from sowing to median flowering often differed among the sites and was usually longer at the three eastern sites than in Perth (e.g. commercial cultivars of French serradella flowered an average of 42 days later at Canberra than at Perth). The only exceptions were mid-late maturing subterranean clovers. Time from sowing to flowering in Perth was most similar to that in Tamworth, and least similar to that in Canberra.

Figure 2. Relationships between the median flowering dates of (a, d) subterranean clover, (b, e) French serradella and (c, f) yellow serradella cultivars recorded in Perth and those recorded in Canberra (squares),



Cowra (triangles) and Tamworth (diamonds).

Discussion

This study demonstrated that a wide range in maturity types (similar in range to early- through late-maturing subterranean clovers) are available among the yellow and French serradella cultivars. However, among the French serradellas, only cvs Margurita, Erica and breeders line 150S-1C have any level of hardseededness (data not shown), and significant gaps remain in the French serradella maturity types suitable for use in permanent pastures. Rankings based on median flowering dates were similar at all sites indicating that maturity type rankings for serradella developed at most sites (including in Perth, as has been common practice) will be indicative of maturity type across southern Australia. However, specification of maturity types using days-to-flowering, as is occasionally the practice, is misleading.

Persistence by annual legumes in permanent pastures also depends on cultivars having stable flowering times that ensure seed production will avoid high risk frost and terminal drought periods. In southern Australia, rainfall is highly variable during autumn with opening rains occurring at any time from February to June depending on location and season. Pasture cultivars must be capable of stable flowering times irrespective of the date on which they germinate, as exhibited in this study by the subterranean clover cultivars. Many of the serradella cultivars began to flower too early (during frost periods) when sown at the earlier sowing date which may have negative consequences for seed production, forage yield and feeding value.

Studies in southern NSW indicate that hardseededness is important for persistence of French serradella. Dear et al. (2002) reported poor persistence when the soft-seeded cv. Cadiz germinated following false breaks to the season. Our data suggest that early regeneration of Cadiz (and also cv. Margurita) on reliable rainfall will also result in suboptimal flowering times leaving flowers and pods exposed to frost. Consequently, it is possible that early rain leading to exceptional years for pasture production may result in relatively poor years for seed production by these cultivars.

Conclusion

Subterranean clover, yellow and French serradella cultivar maturity rankings based on flower dates recorded in Perth were similar to their rankings in eastern Australia but median flowering dates differed significantly. This study showed that many serradella cultivars have limited germination-date flexibility leading to unstable flowering dates. This is unlikely to be ideal for their use in permanent pastures in southern Australia.

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