

Cadiz and Casbah pastures in Western Australia: breeders' expectation, farmers' evaluation and achieved adoption

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Abstract. Traditional annual pastures have many shortfalls against the Western Australian soil and climatic constraints. To overcome those constraints, improved annual pasture legumes have been introduced into Western Australian farming systems. Since 1991, more than twenty annual pasture legumes have been released in WA, of which French serradella Cadiz and *Biserrula* Casbah are significant in terms of prospects for adoption. Our study shows a significant gap between maximum attainable adoption potential (MAAP) and current level of adoption with both of these species. Two questions were: Is this the level of adoption breeders had been expecting? Do the farmers support the breeders view? In this study we have applied a model to predict the adoption of Cadiz and Casbah using inputs from breeders and farmers. The model inputs are four pasture characteristics: superiority in establishment and growth, strength in controlling weeds, ability to supply feed and its quality, and competition between the existing pasture cultivars. The scores for the inputs were collected separately from breeders, who developed the legume species, and farmers who were growing them. Our results indicate that breeders were expecting Cadiz and Casbah would be adopted in about 32% and 22% of their potential areas (MAAP) compared to the achieved adoption of 23% for Cadiz and 20% for Casbah. On the other hand, model output using farmers' evaluation scores shows that adoption of both the pastures was within 3% of what has been achieved. Three key learnings from this paper are:

- The achievable adoption potential of an annual pasture legume can be predicted from farmers' and breeders' perceptions of its attributes.
- Farmers' perceptions of the inherent characteristics of an annual pasture legume were not always consistent with breeders' perceptions and this has implications for development and extension.
- The model used in the study can be used to help improve the breeding, development and extension of future annual pasture legumes.

Keywords: Annual pasture legume, breeding, predicting adoption

Introduction

Pasture is an integral part of Western Australian (WA) farming systems. In the broad-scale agricultural regions of WA, pasture-crop ratios vary between 0 to 50% (Salam et al. 2009a). In these areas, pasture has historically been annual regenerating legumes, practiced as ley-farming (1-2 years cropping, followed by self-regenerated pasture) (Underwood and Gladstones 1979). Two pasture species, i.e. subterranean clover and annual medics, had been dominant in the traditional ley-farming. The constraints of subterranean clover and annual medics in WA farming systems have been widely documented. For example, subterranean clover is suitable for acidic soils and areas with annual rainfall over 400 mm (Cocks and Philip 1979); it does not persist well when the rainfall is below this threshold (Loi et al. 2005a). On the other hand, annual medics are suitable for neutral and alkaline soils and low rainfall regions (Puckridge & French 1983); by contrast, acidic soils, unfavourable for annual medics, are common in low rainfall regions of WA (Howieson and Ewing 1989). Lately, Western Australian traditional ley farming has shifted to phase farming (i.e. three to six years cropping then a legume pasture) (Reeves and Ewing 1993; Ewing 1996; Howieson et al. 2000). In these systems, with a long-delayed cycle, subterranean clover is unable to regenerate reliably (Loi et al. 2005a).

To overcome these constraints, a second generation of annual pasture legumes (APLs) have been introduced in WA farming systems (Loi et al. 2005a), and since 1991 more than twenty APLs have been released (Nichols et al. 2007). For example, *Biserrula pelecinus* cultivar Casbah (Casbah) was introduced in WA in 1997 as an exceptionally promising pasture (Howieson et al. 1995; Carr et al. 1999). It was considered a potential pasture for its ability to grow under low rainfall in most of the acidic sandy soils where annual medics failed to establish (Howieson et al. 1995; Loi et al. 2005b). Another APL, soft-seeded French serradella (*Ornithopus sativus*) cultivar Cadiz (Cadiz) was introduced in 1996, which would grow in poor acid soils where subterranean clover doesn't grow (Nutt and Paterson 1997).

However, there is a lack of information about the adoption of the newly released APLs (Salam et al. 2008). This is mainly because there is no formal record of the area of these pastures sown annually in WA. Seed sales information can not be used as it has restricted public access and is

not reliable. Moreover, there is no system to measure the potential adoption of the pasture cultivars released. Salam et al. (2009a) propose that agro-ecological suitability is an essential criterion for fitting a plant species/cultivar into an agricultural system. For an APL, soil and climate requirements usually designate the agro-ecological suitability. This suitability can designate the maximum attainable adoption potential (MAAP) of any APL into an agricultural system. Recently, the MAAP of two APLs, Cadiz and Casbah, has been determined (Salam et al. 2009a). The MAAP was based on suitable soil and rainfall requirements, moderated by percent cropping land and percent pasture within cropping land, and then adjusted by seasonal certainty. When MAAP was compared with achieved adoption (AA), measured from a field survey (Nichols et al. 2007), the results indicated that a significant gap existed between the AA and MAAP.

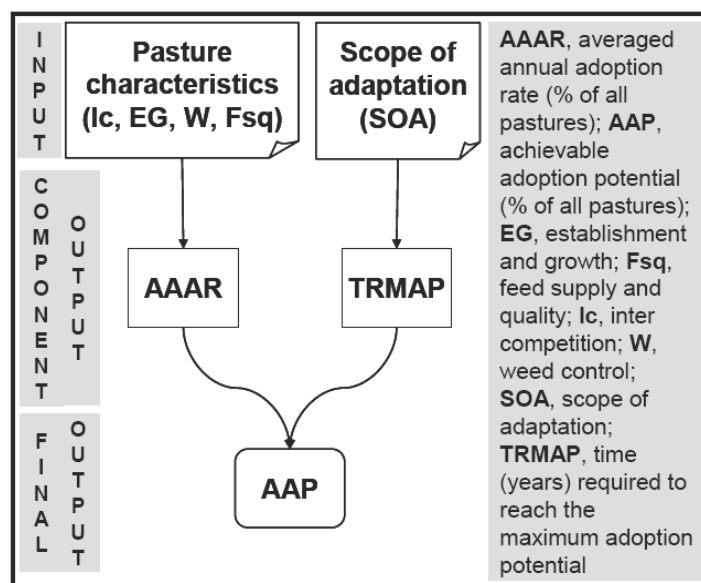
With this background, this paper addresses some key questions in relation to improving the fit of annual pasture legumes in Western Australian farming system: (i) Is the level of adoption what the breeders had been expecting for Cadiz and Casbah?; (ii) Do the farmers support the breeders' view?; (iii) Why the difference, if any, between the views of breeders and farmers; and (iv) How to improve, if there is any scope, the fit of annual pasture legumes in WA farming systems with interventions through research and development (R & D).

Methodology

Breeders' expectation and farmers' evaluation scores on adoption of Cadiz and Casbah were based on data from a previous study conducted by Salam et al. (2009b). Breeders' expectation was based on their perception of those two pastures, whereas, farmers' evaluation was based on their different levels of experience in growing them. In that study, an empirical model, achievable adoption potential (AAR) of APL, was outlined (see details in Salam et al. 2009c). The model consisted of two components, calculating the averaged annual adoption rate (AAAR) and quantifying the time required to reach the maximum adoption potential (TRMAP) of an annual pasture legume (Figure 1). The former part of the model was developed using multiple linear regression analysis and the latter with simple linear regression analysis. The former had an adjusted R^2 of 0.978 and was significant at 0.001. This indicates that more than 98% of AAAR was explained in the model by the combined linear function of four independent variables (in this case, Ic, EG, W & Fsq). The later part of the model had an adjusted R^2 of 0.997 and was significant at 0.001. The model explained 99.5% of the total variation in TRMAP (dependent variable) by the linear function of SOA (scope of adaptation). A model was developed from the data gathered from two separate surveys undertaken from 2007 to 2008. Multiple approaches, i.e. Triangulation approach (Denzin, 1978); qualitative enquiry (Patton, 1990), were applied to gather data by means of face-to-face interview, personal mail-out and general distribution of questionnaires tagged with agricultural information booklet. Data was analysed using a systems (Spedding, 1975) and grounded theory (Glaser and Strauss 1999) approaches. Details of this data collection and pasture characteristics framework can be found in Salam et al. (2009b). The model was used to determine the adoption of an APL, expressed as achievable adoption potential (AAP). The AAP is the calculated adoption potential of an APL based on scores on four pasture characteristics, which were the inputs of the model (Table 1). The scores are superiority of an APL in establishment and growth, its strength in controlling weeds, its ability to supply feed and quality of feed, and the competition it can face from other available pasture species.

Questionnaires were developed on the basis of scores of pasture characteristics (see Salam et al. 2009c) and distributed to the farmers of WA through mail and faxes, addresses obtained from the Department of Agriculture and Food telephone lists. The same questionnaires were given to the two pasture breeders who were involved in the WA pasture industry. As they were also engaged in developing these two APLs, they developed expectations that these pastures would perform in certain way against the pasture characteristics. Therefore, they were asked to score Cadiz and Casbah on those pasture characteristics. Their scores were analysed and incorporated in the model of achievable adoption potential of an APL, to quantify the breeders' expected adoption. On the other hand, 18 farmers who grow Cadiz and 18 farmers who grow Casbah voluntarily provided scores for similar pasture characteristics through the questionnaires. Other farmers who had not sown Cadiz and Casbah before did not respond to the questionnaires. Since, these two APLs were released more than 10 years ago, the farmers who responded to the questionnaires had either adopted the APLs and continued to grow, or had discontinued after several years of adoption. Both groups were considered as they had developed enough knowledge about the performance of these APLs in relation to the pasture characteristics. Scores were analysed and averaged and incorporated in the model to quantify farmers' evaluation of adoption for Cadiz and Casbah. The measured adoption, breeders' expectations and farmers' evaluation were expressed as percentage of the maximum attainable adoption potential (MAAP).

Figure 1. The schematic diagram, showing input and output sections, of the model that predicts the achievable adoption potential of any annual pasture legumes under Western Australian farming systems



Source: Data from Salam et al. 2009c

Adoption of Cadiz and Casbah in WA farming systems

Breeders’ expectations and farmers’ evaluations

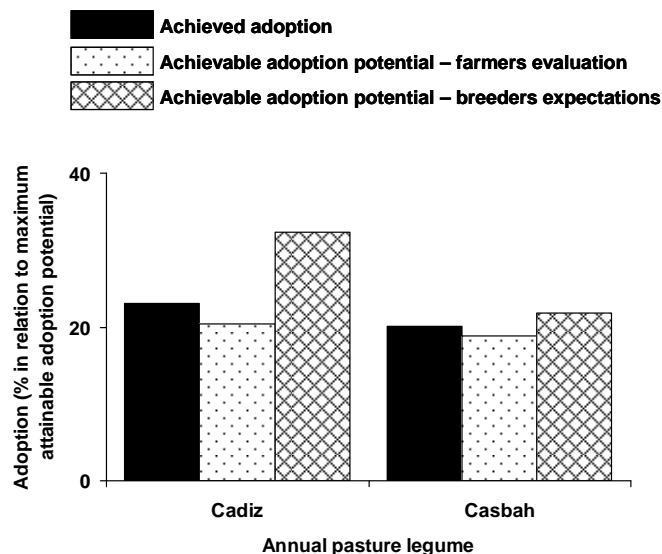
The Measured Achieved Adoption was derived from a survey 2005 of Nichols et al. (2007) and used in this study to compare with breeders’ expectations and farmers’ evaluations. Figure 2 shows that breeders expected about 9% higher adoption (32% of MAAP) in Cadiz compared to its measured adoption (23% of MAAP). In the case of Casbah, breeders’ expectation (22% of MAAP) was only 2% higher than measured adoption (20% of MAAP). Farmers’ expected the adoption of Cadiz would have been 20% of MAAP and Casbah would have been 19% of MAAP (Figure 3). This indicates farmers’ evaluation was within 3% and 1% of measured adoption for Cadiz and Casbah, respectively. Thus, breeders’ expectation for the adoption of Cadiz in the Western Australian farming systems was much higher than farmers’ expectation. In the case of adoption of Casbah, the expectation of breeders’ also differed from the farmers’ evaluation, but the difference was much smaller than for the adoption of Cadiz.

Why the difference between breeders’ expectation and farmers’ evaluation?

The difference between breeders’ expectation and farmers’ evaluation on adoption potential of Cadiz and Casbah is discussed here on the basis of evaluation scores provided by the two groups on different aspects of pasture characteristics: establishment and growth (that includes regeneration ability when seeds stay on surface soil [RSS] and are buried [RSB], seed setting [SS] and persistence [P]); ability to control weeds (tolerance to herbicide [HT]) and grazing ability to control weeds [GA]); ability to supply feed [FS]; and feed quality [FQ].

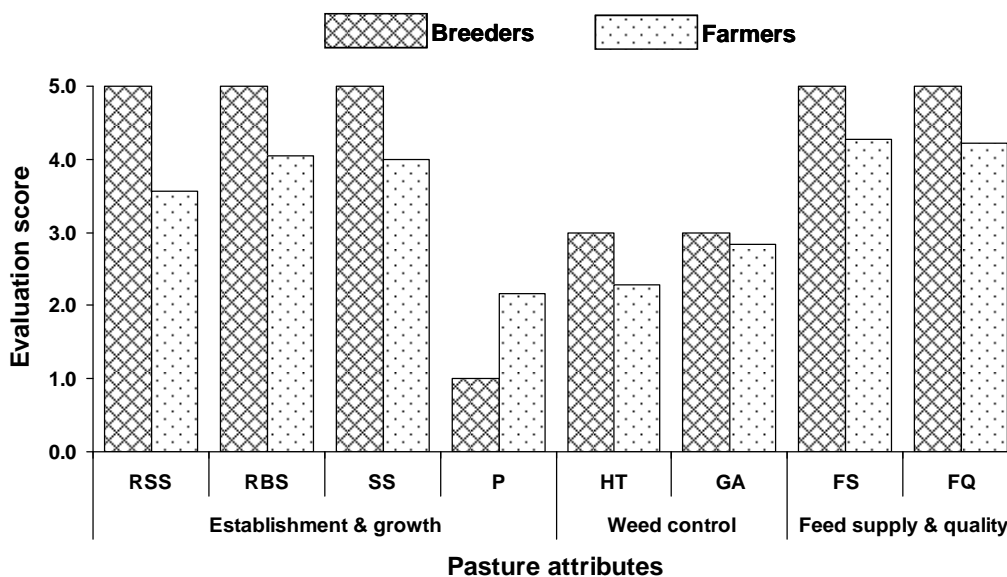
Figure 3 shows breeders expected Cadiz would provide better establishment and growth through perfect regeneration and seed setting attributes. Farmers, on the other hand, evaluated those characteristics with lower scales, but found persistence better (double the breeders’ value). Both had almost similar views about weed control through grazing (GA), but breeders rated Cadiz higher on tolerance of herbicides (HT). On feed supply and feed quality attributes of Cadiz, breeders’ view was excellent (perfect score), while farmers rated it slightly lower.

Figure 2. The achieved adoption and predicted achievable adoption potential (based on farmers’ and breeders’ inputs) of two annual pasture legumes in Western Australian farming systems



Source: Data from Salam et al. 2009c.

Figure 3. Evaluation scores of pasture characteristics from breeders and farmers for Cadiz in Western Australian farming systems

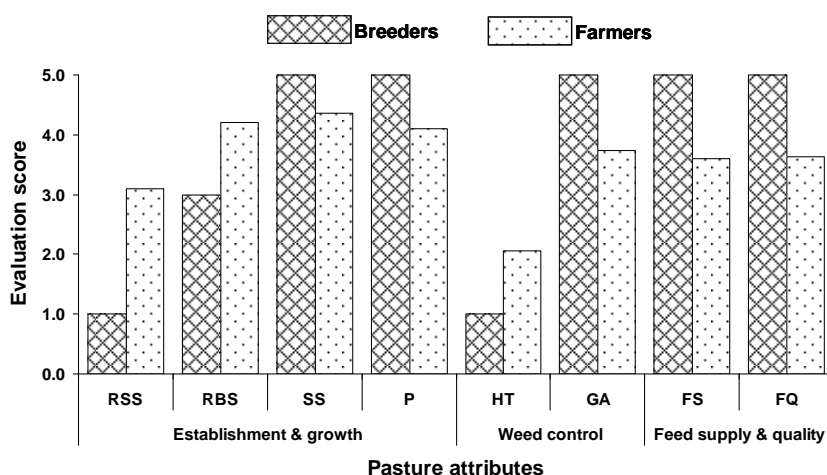


Source: Data from Salam et al. 2009c.

Pasture attributes: RSS-Regeneration ability when seeds remain on surface soil; RBS- Regeneration ability when seeds remain buried; SS-Seedsetting; P-Persistence; HT- Tolerance to herbicides; GA- Grazing ability to control weeds; FS- Potential to supply feed; and FQ-Feed quality.

In the case of Casbah (Figure 4), there was a mixed view on the establishment and growth attributes, and weed control abilities. Breeders expected higher seed setting and persistence, whereas farmers evaluated it better for regeneration ability. Farmers rated it higher for herbicide tolerance, while breeders expected superior weed control with grazing. Both feed supply and feed quality attributes of Casbah were evaluated lower by farmers.

Figure 4. Evaluation scores of pasture characteristics from breeders and farmers for Casbah in Western Australian farming systems



Source: Data from Salam et al. 2009c.

Pasture attributes: RSS-Regeneration ability when seeds remain on surface soil; RBS- Regeneration ability when seeds remain buried; SS-Seedsetting; P-Persistence; HT- Tolerance to herbicides; GA- Grazing ability to control weed; FS- Potential to supply feed; and FQ-Feed quality

Towards improving adoption of Cadiz and Casbah in Western Australian farming systems

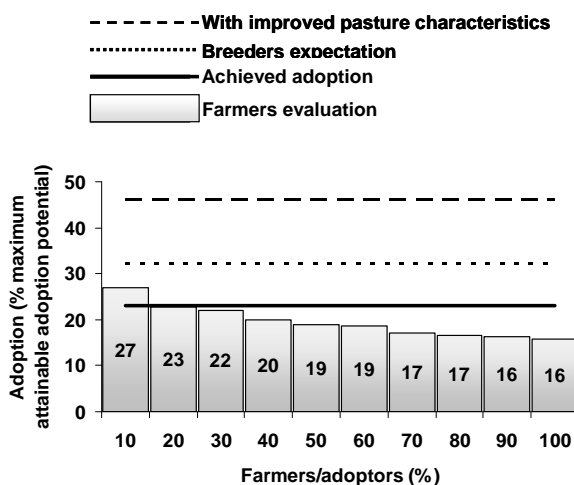
Our results raise two issues for further consideration if the adoption levels of Cadiz and Casbah were to be increased in WA farming systems: Decreasing the knowledge gap, and breeding for improved pasture characteristics.

Decreasing the 'knowledge-gap'

There was a wide range in individual farmers' scores for achievable adoption of both Cadiz and Casbah. This range was bigger for Casbah than Cadiz, with scores ranging from 16% to 27% for Cadiz (Figure 5) and 3% to 32% for Casbah (Figure 6).

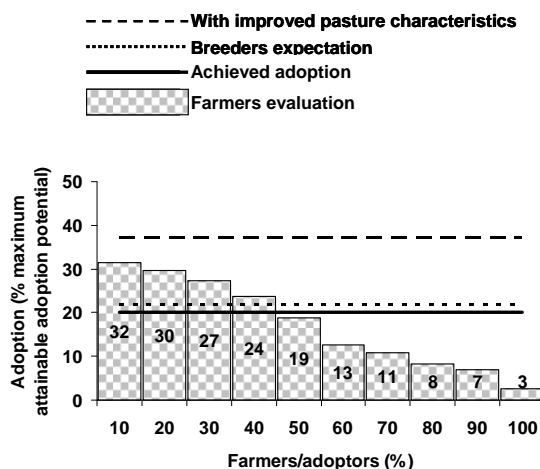
Figure 5 shows a comparison between the calculated adoption potential and the achieved adoption of Cadiz. Only 20% of farmers had scores exceeding the level of achieved adoption; however most were not far below the achieved level. Conversely the distribution of adoption potential in Casbah, as shown in Figure 6, indicates that 50% of the farmers' evaluated adoption of Casbah as very close or above the achieved adoption (20%). The remaining 50% of farmers rated it much lower.

Figure 5. Distribution of farmers' scores for adoption potential of Cadiz compared with achieved adoption, breeders' expectation and likely adoption with improved pasture characteristics



Source: Data from Salam et al. 2009c.

Figure 6. Distribution of farmers' scores for adoption potential of Casbah compared with achieved adoption, breeders' expectation and likely adoption with improved pasture characteristics



Source: Data from Salam et al. 2009b.

Pasture attributes: RSS-Regeneration ability when seeds remain on surface soil; RBS- Regeneration ability when seeds remain buried; SS-Seedsetting; P-Persistence; HT- Tolerance to herbicides; GA- Grazing ability to control weed; FS- Potential to supply feed; and FQ-Feed quality

The differences in farmer ratings of the species raises two questions. What are the reasons for the differences in ratings of a species? Why the much smaller range for Cadiz in comparison with Casbah?

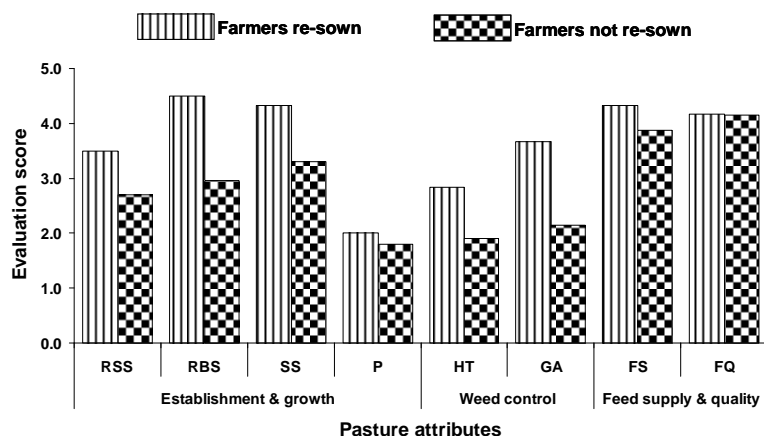
One possible explanation might be the cost of the technology, although it was probably not a major factor since there is no substantial difference in seed price between Cadiz, Casbah and other APLs. Most of the Western Australian farmers were not concerned about seed price but they were enthusiastic to grow APLs which can impact on their systems by increasing crop yield through nitrogen fixation. Our previous study, from a survey conducted in 2008, indicated that 85% of the WA farmers who grow pastures do not perceive 'cost' as a barrier provided its performance in establishment, growth and weed control is good (Salam et al. 2008). During the face-to-face interview, some of the farmers opined that they would not mind spending a few extra dollars provided they had APLs with superior performance in germination and establishment. They also claim that if APLs do not germinate or are difficult to establish, then all other costs, such as soil preparation, fertiliser cost, weed clearing cost, would be a more important consideration. A similar study by Davis and Hogg (2008) also found that 50% of 14 farmers discontinued APLs cultivation because of unreliable establishment and poor persistence. Those farmers, who scores exceeded the level of achieved adoption (Figure 5 and 6), may have had more appropriate knowledge about growing Cadiz and Casbah than the other farmers. This knowledge may be in relation to weed control or better ways of establishing these APLs. There could also be variation between the farmers in using better practices that can affect the adoption of an innovation - this notion is supported by Ghadim and Pannel (1999). Taeymans (1999) argues agricultural production is becoming increasingly knowledge-based and science intensive. Therefore a 'knowledge-gap' can exist between 'how-to-use' the technology and 'what-is-applied' in the field.

The existence of a 'knowledge-gap' has been recognised for pasture (GRDC 2006). This 'knowledge-gap' can be filled in two ways. First, provide information that is specific to growing environments during the pre-release phase of a pasture cultivar. Such information could be made available in a similar way to how the national crop variety information is made available to farmers (GRDC 2006). Pasture breeders and associated personnel would have a major role in this respect. Secondly, in the post-release phase, extension specialists have a major role. As a discipline, agricultural extension is central in formulating and disseminating knowledge and in teaching farmers to be competent decision makers (SDC 1995, pp. 2-3).

Agricultural extension can be a leading part of a system of actors; others include researchers and farmers' groups who influence farmers' decisions. In relation to this study, extension can play an important role by analysing the overall situation of current adoption of Cadiz in WA, identifying the characteristics of the farmers and applying appropriate techniques to help farmers who experience problems with pasture varieties, thereby influencing adoption (Harper

et al. 1990). Hackney et al. (2008) mention that lack of information about establishment and sowing techniques for new annual pasture legumes is inhibiting their adoption. Davis and Hogg (2008) recommend that proper extension tools need to be developed to increase the adoption of APLs in Western Australia. They suggest extension should address current associated problems in APLs adoption, such as seed preparation, sowing and break of season management issues, insect damage and broadleaf weed control. This situation can be improved by providing simple and clear information on better establishment and sowing techniques to the farmers (Keys and Orchard 2000). An example may be cited here on how an appropriate practice can lead to better success in pasture adoption. Cadiz is a soft-seeded pasture (Nutt and Paterson 1997); therefore, it is recommended that farmers re-sow this pasture for desired establishment (Nutt and Paterson 1997). Based on interviews in our study, some respondent farmers understood or accepted this recommended technique and re-sowed Cadiz after a cropping phase. Some farmers (67%) did not follow or were not aware of this technique and used the traditional practice of relying on regeneration of Cadiz from previous years. A comparison of these two groups (see Figure 7), shows farmers who re-sowed had higher scores for establishment and growth, weed control and feed supply than those who used traditional practice (regeneration). If we calculate the adoption using the evaluated-score of those two groups, the adoption (AAP) would have been about 23% according to the farmers who re-sowed compared to 19% for those who used traditional practice.

Figure 7: A comparison of scores for characteristics of Cadiz between farmers who established pasture through re-sowing and through regenerating



Source: data from Salam et al. 2009c.

There is an additional reason for the wider range in farmer ratings for Casbah in comparison to Cadiz that is thought to have had a negative impact on the adoption of Casbah. A few years after its release, several cases of photosensitivity were reported in spring grazing ewes and lambs in Western Australia. Photosensitisation is like sunburn and usually affects animals' ears, muzzle, tail and backline. Affected areas start to swell and animals will rub affected areas abundantly (Loi et al. 2005c). Several media statements released by the Department of Agriculture and Food Western Australia (DAFWA) warned against photosensitisation and its consequent issues including wool loss (Revell and Revell 2006). In spite of that, overall, this study indicates farmers' evaluation of Casbah was positive.

Breeding for improved pasture characteristics

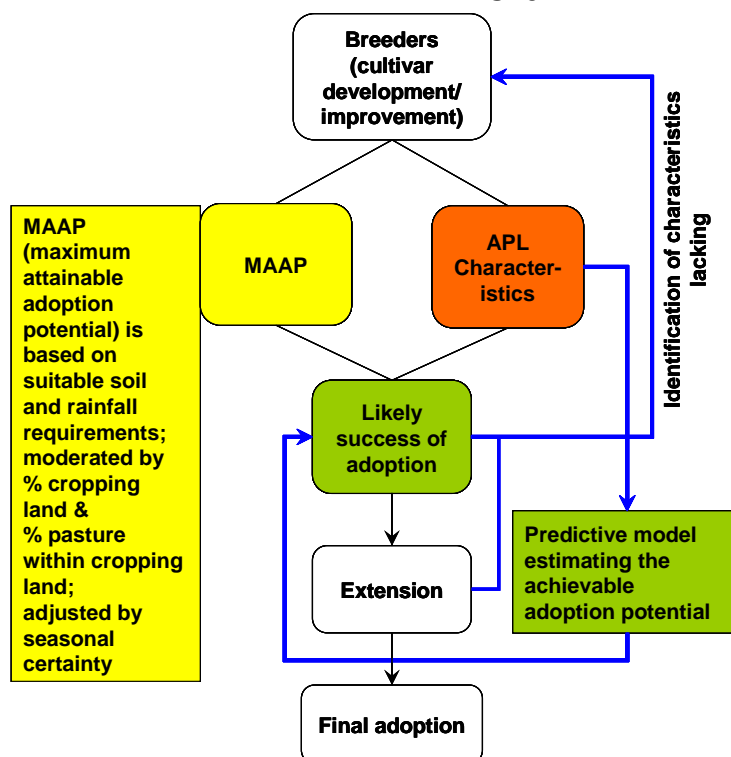
While adoption of APLs such as Cadiz and Casbah can be increased through extension efforts, their levels of adoption can only be pushed to a certain limit. If, for an example, all the pasture farmers of Western Australia possessed the same experience of Cadiz and Casbah cultivation as do the top 10% of respondent farmers, who acquired best management skill in soil preparation, sowing and establishment techniques, pest control, grazing management, weed control, our models suggest the adoption of Cadiz and Casbah would be 27% and 32% of MAAP, respectively (Figures 5 and 6). In that case, the adoption of Casbah would have greatly exceeded breeders' expectations (22% of MAAP). By comparison, the adoption of Cadiz would remain considerably below the breeders' expectation (32% of MAAP). It appears farmers may prefer the inherent characteristics of Casbah, therefore strengthening extension would probably enhance its adoption. On the other hand, adoption of Cadiz may not reach breeders' expectation with its inherent characteristics. In that case, it would require improvement of pasture characteristics through breeding. By improving the attributes related to establishment and

growth (20% in Cadiz and 30% in Casbah), and weed control (40% in both Cadiz and Casbah), the adoption in existing Cadiz and Casbah could be increased to 46% and 37% (of MAAP), respectively.

A system for improving the fit of annual pasture legumes in WA farming systems

The overall study, however, provides a system for improving the fit of annual pasture legumes in WA farming systems. The system, shown in Figure 8, consists of three major components: the maximum attainable adoption potential (MAAP), the annual pasture legume characteristics framework (APL-characteristics for WA) and achievable adoption potential (AAP). The MAAP of a new released pasture cultivar can be calculated based on its rainfall and soil type constraints (defined by the breeders during its release), moderated by the percentage of cropping land, and the percentage of pasture within this cropping and finally, adjusted by the seasonal certainty. The geographical distribution of MAAP can also be worked out. The likely adoption of a cultivar (AAP) can be worked out (by using a predictive model) through its inherent characteristics as defined by the breeders. The AAP and the MAAP can provide guidance for the extension effort on the adoption of the pasture cultivar. Extension personnel can also receive feedback on farmers’ experience with the pasture characteristics of the cultivar and pass it on to the breeders. This framework will assist in the development of future cultivars of APL, and help in extension work for better adoption. This system is a common platform where breeders, farmers, extension specialists and policy makers can work as a team and improve the fit of an APL.

Figure 8. Layout of a system for improving the fit of annual pasture legumes in Western Australian farming systems



Source: Salam et al. 2009d.

Conclusions and implications

Our results suggest the maximum attainable adoption potential of an annual pasture legume can be estimated based on soil and climate requirements. Furthermore, the achievable adoption of a pasture legume can be predicted based on key APL attributes as perceived by farmers and breeders. Using our models, the achieved adoption of Cadiz in Western Australia (WA) is shown to be about 9% lower than what breeders expected; in the case of Casbah, breeders’ expectation was 2% higher than what has been achieved. Model predictions based on farmers’ evaluation scores largely supported the measured adoption of these two species.

In WA, farmers consider adopting a APLS in their farming systems based on some perceived attributes of the APL. The strength of these attributes, as perceived by breeders, was not completely reflected in most of the farming environments. This was partly because of farmers’ poor knowledge about some practices in relation to growing the APLs and partly because some

inherent characteristics of the APLs were not wholly desirable to farmers. This study also shows how far current adoption can be increased in these two pastures through extension and breeding programs.

The approach outlined can also help improve the breeding, development and extension of future cultivars of APL.

Acknowledgements

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