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Technical dossier for SerraMax Yellow Serradella (Ornithopus compressus L)

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Summary

SerraMax (Breeder's code 87GEH72.1a) is an early flowering genotype of yellow serradella (*Ornithopus compressus* L.) and has been submitted for PBR registration through IP Australia. When seed/pod of SerraMax is buried, it has a greater rate of hard-seed breakdown and rapid germination compared to the commercially available cultivars Yelbini(b), Charano and Santorini.

The seed ecology of SerraMax is suited to the summer and twin sowing techniques that establish serradella pastures at lower cost than traditional techniques. Its closest competitors for this use are Margurita(b) and Fran2o French serradella.

The areas of use (of both genotype and technique) will be acidic soils in 275mm to 600mm annual rainfall areas where it will be either sown into rotational pastures or as a legume companion in subtropical perennial grass-based pastures.

SerraMax can be harvested with conventional harvesters in most seasons with >300mm growing season rainfall (GSR) with about 40% harvest efficiency. This combination has yielded between 500kg to 1000 kg/ha of harvested pod. Harvesting with vacuum harvesters is also an option with a greater harvesting efficiency but greater risk of post-harvest soil erosion.

SerraMax has a medium level of dehulling efficiency. Approximately 45% of available seed is extracted through the Trangie disc Dehuller compared with 70% with Santorini. The remaining un-dehulled seed has an enhanced germination and is a useable by-product. Better extraction of seed with reduced seed damage has been achieved with hammer milling.

The predominant use of SerraMax is expected to be in pod form with a small percentage of dehulled seed traded in the market for the specific purpose of pod production.

Summer sowing plot – SerraMax, Mingenew 2011. Photograph – A. Loi.

Summer sowing plot – SerraMax, Coorow 2011. Photograph – A. Loi.

Rationale

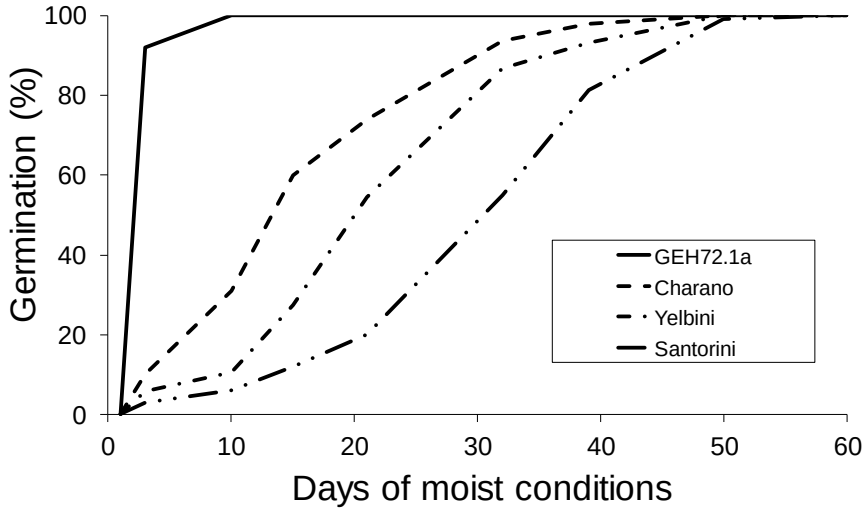
Sown pastures (containing legumes) and weedy fallow (typically with little or no legume) remain common phases within crop sequences in the low to medium rainfall cereal growing regions of southern Australia. They occupy between 20% to 60% of arable land use, depending on region and farm enterprise mix, and account for 80% of the 'break' or non-cereal crop area in Western Australia (Lawes *et al.* 2009). In any one year up to 5 million hectares fall into this land use category in Western Australia.

SerraMax yellow serradella has the potential to increase livestock carrying capacity and residual value of a pasture phase to subsequent crop sequences. It has seed germination traits that will complement rather than replace currently available cultivars of yellow serradella. It will also expand the use of yellow serradella as the more rapid breakdown of hard-seed dormancy is more suited to longer pasture phases, particularly as a companion legume with sub-tropical grasses.

The cultivars Santorini, Charano, and Yelbini(b) have protracted germination patterns when the seed undergoes natural hard-seed breakdown in the field. In contrast, SerraMax has a rapid hard-seed breakdown when in the soil and once the dormancy is broken, a rapid germination pattern (Figure 1, Taylor and Revell, 2002). This produces higher regeneration densities and a greater ability to compete with early germinating weeds.

SerraMax has a high tendency for pod segmentation that, although reducing harvest and dehulling efficiency, improves the handling of bulk quantities of pod.

Figure 1 - Germination patterns in serradella cultivars and SerraMax.



The greatest application of SerraMax is expected to be through the sowing of un-processed pod in the twin and summer sowing techniques. Twin sowing refers to drilling the untreated serradella pod with a cereal or oilseed crop in autumn/winter. The serradella will have little or no germination under the crop due to a high level of seed dormancy.

This principle can also be applied when sowing sub-tropical perennial grasses in spring. The dormancy of the seed (in the pod) remains intact until exposed to high temperature (summer) and specific diurnal temperature fluctuations that occur in the soil surface over the following summer and early autumn. Summer sowing uses a similar concept except that the pod is not sown until late summer/early autumn either into crop stubbles or established perennial grasses.

There is insufficient breakdown (around 50%) in the seed dormancy of the current yellow serradella cultivars to suit the twin and summer sowing techniques - unless impractical amounts of pod are sown (Table 1). In comparison almost all the hard-seed of SerraMax will break down by June (99% hard-seed at sowing to 15% in mid-winter) when the seed is drilled into the soil at 0.5 to 1cm.

Table 1. Initial (February) and final (June) hard-seed proportions and the resulting plant establishment when dormant serradella seed (in pod segments) is sown into the soil at 1cm in February.

	Medina 2009			Muresk 2010		
Cultivar	Feb hard-seed (%)	June hard-seed (%)	Plant est. (% of all seed)	Feb hard-seed (%)	June hard-seed (%)	Plant est. (% of all seed)
SerraMax	91	10	75	99	15	53
Santorini	88	58	14	98	42	10
Margurita(b)	81	8	84	84	36	41

The pod of SerraMax can be harvested on-farm with conventional combine harvesters but at lower efficiency compared to other cultivars of yellow serradella.

The pod breaks into single or double seed segments that do not present a problem with bulk handling. The harvested pod seed can have less than 10% germination unless the surrounding pod is removed and the seed coat scarified. The twin and summer sowing techniques avoid these extra processing steps.

Background

Origin and selection

87GEH72.1a was collected in May 1987, on the island of Santorini in the Aegean Sea by J. Howieson and M. Ewing of the Western Australian Department of Agriculture. The site of collection, on the north-east coast of the island, was characterised as a deep grey sand, pH 7.5 (water), 150m altitude, subject to light grazing and in a 350mm rainfall area. SerraMax was derived from one of nine distinct single plants grown from the collected seed by the Australian Trifolium Genetic Resource Centre.

The ecotype of SerraMax has been selected for its relatively rapid breakdown of hard-seed, early maturity, rapid germination and pod characteristics that suit bulk handling with conventional machinery.

Morphological Description

SerraMax is similar in appearance to other cultivars of yellow serradella. It has a semi-erect growth habit when un-grazed, with the first flowers appearing on the fifth/sixth to the ninth node of the main runners depending on location and time of sowing. Each leaf has up to 15 leaflet pairs with 5-7 leaflets on the floral leaf. The inflorescence is composed of 2 to 3 flowers on a 5cm peduncle.

The most distinctive feature are pods that are light brown in colour, relatively straight with a small beak, flat in cross section and readily break into individual segments consistently at the pod segment wall without exposing the seed (Table 1, Figure 1 & 2).

There are usually 7 to 10 seeds or segments per pod and approximately 152,000 seeds per kilogram of pod or 344,000 seeds/kg when dehulled.

Table 2. Pod characteristics of SerraMax compared to other common yellow serradella cultivars.

Character	SerraMax	Charano	Paros	Yelbini[b]
Days to flower*	95	96	100	82
Full pod length (mm)	48.5	56.4	59.3	55.0
Pod thickness (mm)	1.56	1.50	1.38	1.54
Beak length (mm)	3.88	9.30	9.32	7.86
Max diameter (mm)	41.4	33.2	25.4	37.7
No. Segments per pod	9.50	7.95	9.95	8.73
Curvature**	1.22	1.70	2.36	1.48
Segmentation***	4.00	1.66	0.93	1.41
Pod colour	Light brown	Red brown	Light orange brown	Red brown

Note: * Days from germination to first open flower from a mid-May sowing in Perth, WA.

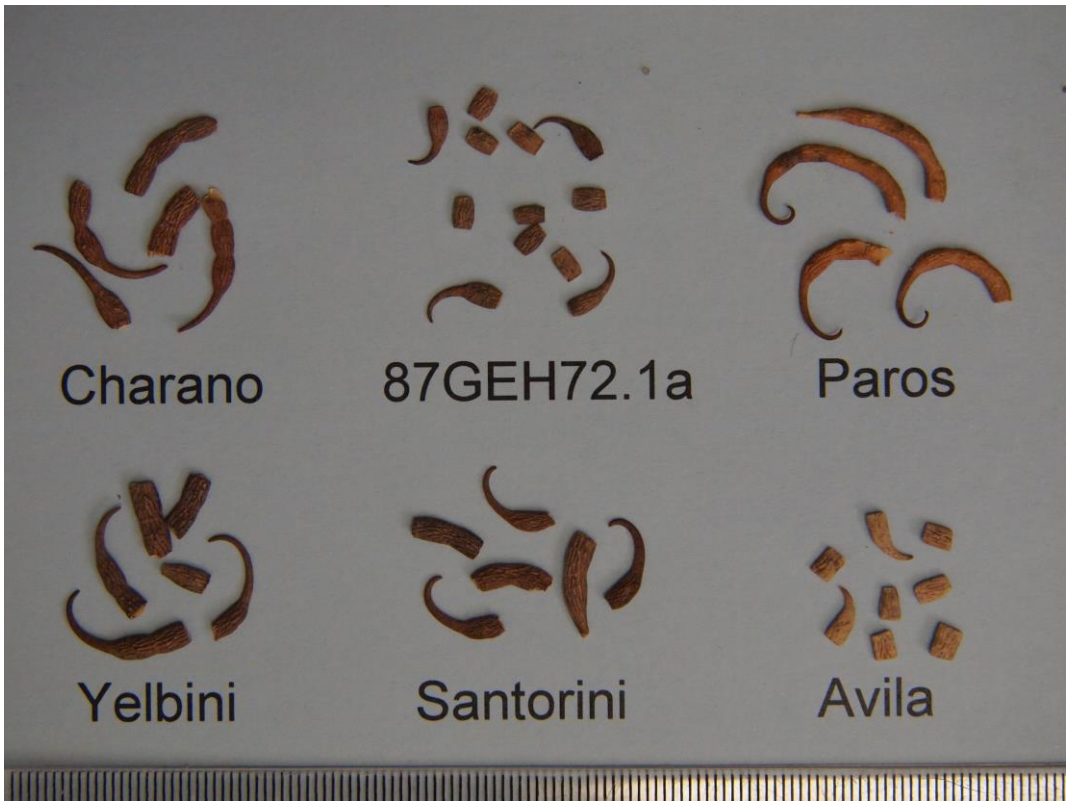
** Curvature is calculated from full pod length (non-linear) divided by longest diameter (longest linear length, usually from stalk to the bottom curve of the pod).

*** Segmentation rated as 4 = readily and always breaks between segments with no seed visible. 0 = does not readily break into segments and break will occur past the pod joint, exposing the seed.

Figure 2 - Whole pods of SerraMax

Photograph – P. Nicholls

Figure 3 - Pod segments of SerraMax compared to other common cultivars of yellow serradella.



Photograph – P. Nicholls

Agronomic characters

SerraMax is similar in maturity and insect tolerances to Charano yellow serradella and is 7-10 days earlier flowering than Santorini. Flowering time will vary according to seasonal conditions and can range from 80-95 days from sowing. It is not as tolerant of high active soil aluminium as Charano or Santorini (Table 3).

Table 3. Some agronomic characteristics of 87GEH 72.1a

Cultivar	Aphid Presence (1 to 10)*	% Dehull (Trangie)	RLEM Damage score (1 to 10)*	Al Root damage Index**	Seed size (mg)
SerraMax	**1**	**44**	**3**	**0.19**	**2.9**
Charano	1	74	2.3	0.04	3.5
Santorini	2	74	3.7	0.06	3.2

* Score 1 = low, 10 = high; ** Rating for aluminium toxicity at low soil pH

Seasonal dry matter yield and seed yield

Field experimentation in Western Australia has shown herbage production in spring of un-grazed plots of SerraMax of up to 8 t/ha and compares well with currently available cultivars of yellow serradella, French serradella, biserrula and subterranean clover.

SerraMax is a prolific seed producer consistently producing pod yields of over 1 t/ha with good growing conditions. The actual seed content of pod is usually 35% to 40%.

Table 4. Seed yield in establishment year, plant density after cropping, and dry matter yield in un-grazed swards on deep yellow sandplain at East Chapman Valley (Geraldton WA).

Cultivar	Seed Yield 1992	Plants/m^2 1994	DM 15/9/94 (kg/ha)	Seed Bank July 1994 (kg/ha)
SerraMax	**762**	**1762**	**2654**	**208**
Charano	657	682	2661	382
Santorini	281	1224	2389	48

Table 5. Dry matter and seed yield in the establishment year and plant density in the second year (prior to cropping) of SerraMax and other pasture legumes on acid duplex loamy sand soil at Pingelly (WA) in 1999.

Cultivar	DM (kg/ha)		Pod/seed yield (kg/ha)	Plants/m^2
	5/10/99	**3/11/99**	**10/12/99**	**28/6/00**
SerraMax	**2778**	**6820**	**1587**	**1242**
Margurita(b)	2931	5452	374	1328
Santorini	2141	4975	1313	111
Dalkeith	2878	5977	181*	506

*Seed

Table 6. Seedling regeneration, dry matter and pod yields in the third year from establishment and after cropping the second year at Pingelly.

Cultivar	Plants/m^2	DM kg/ha		Pod yield kg/ha
	20/06/01	**20/9/01**	**1/10/01**	**15/12/01**
SerraMax	**3700**	**4543**	**7913**	**1393**
Margurita(b)	4289	4002	7370	70
Santorini	1333	3585	6307	581
Dalkeith	2778	2800	4970	

Hard-seededness

SerraMax has a highly reactive hard-seed behaviour whereby seed on the surface remains dormant for several seasons but hard-seed breakdown is accelerated with shallow burial (Taylor and Revell, 2002).

This hard-seed behaviour suits a 1:1 pasture/crop ratio but two consecutive crop years should be avoided (Tables 3, 4 and 5). It is also ideally suited to twin or summer sowing as dormant seed drilled into the soil undergoes almost complete breakdown within the one summer/autumn period.

Summer sowing and Twin sowing

Normally forage legumes are sown after the main cropping program is completed and requires the application of a pre-sowing knockdown herbicide to control established weeds. This treatment seriously reduces early winter pasture production which is then compounded by the slow growth rate of legumes under the cold winter conditions (Tables 7, 8, 9, 10 and 11).

Summer sowing and twin sowing techniques could be applied to a number of scenarios and be more effective than the traditional winter sowing. In particular, they will offer early winter grazing in a mixed enterprise farm and will lift the legume component in a pasture with a low legume base due to drought and/or intensive cropping.

The high level of hard-seed breakdown by the end of summer (up to 60%) of French serradella Margurita(ⓑ) and SerraMax yellow serradella make them ideal cultivars to be used with summer sowing and twin sowing.

Table 7. The seedling establishment, dry matter (DM)/herbage yield in winter and spring, and seed yield for *Ornithopus sativus* (cv. Margurita) and *O. compressus* (acc. 87GEH72.1a) when sown as pod in summer (SS) or conventionally sown (CS) in late autumn using scarified seed, compared to *Trifolium subterraneum* (cv. Dalkeith) sown as scarified seed in late autumn at four sites in Western Australia in 2011. LSD values are P<0.05.

Species/ location	***Seedling establishment Plants/m²***		***DM winter (t/ha)***	***DM spring (t/ha)***		***Seed yield (kg/ha)***	
	SS	**CS**	**SS**	**SS**	**CS**	**SS**	**CS**
Mingenew			**14/7/11**	**5/9/11**	**5/9/11**		
Ornithopus sativus	511	329	1.2	6.1	3.7	400	461
O. compressus ***SerraMax***	412	343	1.1	5.9	3.1	1165	1216
Trifolium subterraneum	n/a	209	n/a		3.0	n/a	767
LSD spp	58.1		0.64 (ns)	1.11		357	
LSD sowing time	42.2			0.90		285 (ns)	
LSD spp x sowing time	58.1			1.22 (ns)		392 (ns)	
Coorow			**13/7/11**	**5/9/11**	**5/9/11**		
O. sativus	1015	217	1.5	4.1	1.2	232	327
O. compressus ***SerraMax***	776	295	1.1	4.7	2.3	440	417
T. subterraneum	n/a	175	n/a	n/a	1.3	n/a	173
LSD spp	215		0.24	1.21		224 (ns)	
LSD sowing time	161			0.97		178 (ns)	
LSD spp x sowing time	224			1.33 (ns)		246 (ns)	
Bullaring				**24/8/11**	**24/8/11**		
O. sativus	936	224	-	1.7	0.9	401	443
O. compressus SerraMax	408	302	-	1.6	1.2	1295	676
T. subterraneum	n/a	168	-	n/a	0.7	n/a	120
LSD spp	86.6			0.34		333	
LSD sowing time	69.1			0.28		266 (ns)	
LSD spp x sowing time	95.2			0.38 (ns)		365 (ns)	
Ravensthorpe				**15/8/11**	**15/8/11**		
O. sativus	120	317	-	2.7	0.6	-	-
O. compressus SerraMax	130	343	-	3.0	0.6	-	-
T. subterraneum	n/a	208	-	n/a	0.9	-	-
LSD spp	36.7 (ns)			0.61			
LSD sowing time	29.3			0.49			
LSD spp x sowing time	40.3(ns)			0.67 (ns)			

Table 8. Seedling establishment and herbage production of three annual pasture legumes when sown at two different times: Summer Sowing (SS) or Conventionally Sown (CS) at the break of the season, at Brookton, WA, in 2015.

		Seedling establishment (plants/m^2) (19th June)		*Herbage mass (t DM/ha) (2nd July)*		*Herbage mass (t DM/ha) (4th Aug)*		*Herbage mass (t DM/ha) (7th Sept)*		*Herbage mass (t DM/ha) (8th Oct)*		*Seed yield (kg/ha)*	
Species	**Cultivar/ accession**	**SS**	**CS**	**SS**	**CS**	**SS**	**CS**	**SS**	**CS**	**SS**	**CS**	**SS**	**CS**
Ornithopus sativus	Margurita	377	417	0.76	0.04	1.30	0.14	2.85	0.55	4.66	2.85	355	220
O. compressus	SerraMax	255	405	0.51	0.03	1.12	0.12	2.38	0.60	5.64	2.09	780	410
Trifolium spumosum	Bartolo	127	305	0.59	0.02	1.25	0.14	3.04	0.72	5.09	2.70	1115	767
	LSD spp	76.0 (ns)		0.20 (ns)		0.25 (ns)		0.44 (ns)		0.96 (ns)		184	
	LSD sowing time	87.8		0.23		0.28		0.51		1.11		213	
	LSD spp x sowing time	152		0.41 (ns)		0.50 (ns)		0.89 (ns)		1.92		370 (ns)	

Table 9: Seedling establishment, the subsequent above ground herbage sampled on three occasions, and seed yield for seven annual legumes when sown as hard-seed or pod in the final week of February (Summer Sowing- SS) or scarified seed sown in the final week of May (Conventional Sowing - CS) at Greenethorpe, NSW in 2014.

		Seedling establishment (plants/m^2)		*Herbage (t DM/ha) (19/5/14)*	*Herbage (t DM/ha) (5/8/14)*	*Herbage (t DM/ha) (2/10/14)*		*Seed yield (kg/ha)*	
Species	**Cultivar/ accession**	**SS (28/4/14)**	**CS (15/7/14)**	**SS**	**SS**	**SS**	**CS**	**SS**	**CS**
Ornithopus sativus	Margurita	213	232	0.2	1.8	6.3	2.3	450	206
O. compressus	Avila	203	113	0.3	0.7	5.2	1.8	203	88
O. compressus	SerraMax	232	115	0.2	0.4	4.5	0.7	345	57
Biserrula pelecinus	Casbah	312	251	1.2	6.7	8.1	3.9	751	461
Trifolium spumosum	Bartolo	341	214	0.7	3.0	7.8	0.5	1138	161
T. glanduliferum	Prima	328	328	0.9	4.5	7.3	4.2	713	344
T. subterraneum	Seaton Park	-	160	-	-	-	0.9	-	63
	LSD spp	41.9		0.1	1.1	0.63		50.9	
	LSD sowing time	23.8				0.36		28.9	
	LSD spp x sowing time	58.4				0.90		71.2	

Table 10. Seedling establishment, the subsequent above ground herbage sampled on three occasions, and seed yield for seven annual legumes when sown as hard seed or pod in the final week of February (Summer Sowing- SS) or scarified seed sown in the final week of May (Conventional Sowing - CS) at Uranquinty, NSW in 2014.

		Seedling establishment (plants/m^2)		*Herbage mass (t DM/ha) (9/6/14)*	*Herbage mass (t DM/ha) (20/09/14)*		*Herbage mass (t DM/ha) (30/10/14)*		*Seed yield (kg/ha)*	
Species	**Cultivar/ accession**	**SS (30/4/14)**	**CS (14/7/14)**	**SS**	**SS**	**CS**	**SS**	**CS**	**SS**	**CS**
Ornithopus sativus	Margurita	211	150	1.5	2.0	nm*	2.9	0.9	383	152
O. compressus	Avila	133	137	0.6	0.9	nm*	2.0	0.7	136	88
O. compressus	SerraMax	140	132	0.8	1.3	nm*	1.9	0.3	262	16
Biserrula pelecinus	Casbah	138	228	0.7	1.8	0.3	2.9	1.9	512	180
Trifolium spumosum	Bartolo	274	269	1.6	3.3	0.1	4.7	0.9	757	91
T. glanduliferum	Prima	240	255	1.2	3.0	0.5	4.8	1.9	560	179
T. subterraneum	Seaton Park	-	203	-	-	nm*	-	0.6	-	57
	LSD spp	31.8		334	0.26		0.46		52.8	
	LSD sowing time	15.7			0.23		0.22		26.0	
	LSD spp x sowing time	44.9			0.60		0.59		66.6	

Table 11. Seedling establishment (plants/m2) assessed in winter of annual legumes species summer sown in February at 18 sites in Western Australia in 2012 (SE in parenthesis), and three sites in NSW in 2015 (LSD P<0.05 in parenthesis).

Location	*Latitude*	*SerraMax* [a]	*Margurita* [b]	*Bartolo* [c]	*Cefalu* [d]	*Prima* [e]	*Casbah* [f]
Corrigin 1	32° 23.5'	137 (10)	252 (30)				
Corrigin 2	32° 23.4'	164 (17)	219 (23)	90 (16)			
Babakin 1	32° 5.3'	301 (28)	343 (32)	349 (38)			
Babakin 2	32° 5.6'	192 (32)	350 (37)				
Newdegate	33° 6.9'	389 (31)	316 (38)	305 (29)			
Lake King	33° 8.7'	443 (28)	343 (24)				
Ravensthorpe	33° 40.6'	139 (18)	217 (28)	138 (41)			
Cascade 1	33° 38.7'	190 (24)	320 (6)	280 (35)			
Cascade 2	33° 25.3'	455 (49)	390 (42)				
Neridup	33° 36.2'	108 (12)	216 (20)				
Condingup	33° 48.6'	263 (28)	251 (18)				
Brookton	32° 16.2'	687 (48)	795 (42)	645 (27)			
Kalannie	30° 30.7'	151 (26)	176 (12)	256 (19)			
Dalwallinu	30° 17.3'	350 (12)	602 (27)	380 (18)			
Dandaragan 1	30° 47.6'	241 (17)	290 (46)				
Dandaragan 2	30° 49.2'	170 (16)	314 (40)	268 (31)			
Badgingarra	30° 28.6'	160 (19)	233 (22)	116 (30)			
Carnamah	29° 37.0'	129 (7)	319 (27)	325 (2)			
*Beckom**	34°14.9'	188 (50)	214 (50)	300 (50)	264 (50)	396 (50)	310 (50)
*Condobolin**	33° 3.6'	200 (50)	179 (50)	369 (50)	269 (50)	266 (50)	160 (50)
*Peak Hill**	32° 47.4'	235 (25)	218 (25)	307 (25)	295 (25)	385 (25)	280 (25)

[a]Ornithopus compressus, [b]O. sativus, [c]Trifolium spumosum, [d]T. vesiculosum, [e]T. glanduliferum, [f]Biserrula pelecinus,

** NSW sites*

Harvesting and dehulling

SerraMax in most situations will develop enough height for direct harvesting, but in some poor years will require suction harvesting either directly or after a combine harvester pass to maximise pod yield. The pods of SerraMax are relatively straight with a high level of segmentation and should not be problematic in modern machinery. The dehulling of this variety is less efficient compared to other commercial cultivars (Table 3) and pod removal to enhance germination will be a necessary product for commercial success of initial seed production. Hammer milling has proven to be effective for extracting seed from the pod with less seed damage than with disc dehulling machines.

Areas of use

SerraMax is suitable for use on acidic sands and sandy loams in low to medium rainfall areas (275 to 600mm). Large areas of these soils occur in the south-west agricultural areas of Western Australia and in central New South Wales. In Western Australia this variety would complement cv Charano in mixtures for low to medium rainfall areas and where regular spray topping is used for control of weed seed set.

Trial results have shown that SerraMax may be a successful legume companion for the sub-tropical perennial grass-based pastures of Panic and Rhodes grass in the West Midlands and kikuyu on the south coast.

Disease reaction

The only serious diseases currently recognised in yellow serradella are collar and root rots at establishment due to rhizoctonia and pleiocheita. Screening for relative susceptibility to these diseases is not currently undertaken in the development of new pasture cultivars. Based on observation in field trials, SerraMax is no more susceptible than Santorini or Charano and is more tolerant than annual clovers.

Insect reaction

SerraMax is considered tolerant to bluegreen and cowpea aphids based on field observations and control should not be required in most situations.

It is considered moderately tolerant to red-legged earth mite (Table 3) based on glasshouse seedling screening and field observation. However early control is recommended in seed production crops.

SerraMax is susceptible to native budworm however the risk is low compared to other cultivars of yellow serradella due to early maturity. Regular monitoring is recommended in seed crops from the beginning of pod fill to senescence and should be controlled with an appropriate insecticide if present. SerraMax is moderately susceptible to lucerne flea and appropriate control is recommended with serious infestations.

Herbicide tolerance

Based of field observation and limited experimental data, SerraMax has a similar reaction to common herbicides as used on other cultivars of yellow serradella. It is

highly susceptible to sulfonyl urea, phenoxy (MCPA, 2,4-D), glyphosate, triazine and paraquat/diquat based herbicides.

Duty of care issues

Yellow serradella is not considered to have high risk potential for animal feeding or disease build-up for following crops. There have been no reported cases of anti-nutritional effects of yellow and French serradella on grazing animals in Australia despite widespread use.

Nomenclature

The name for 87GEH72.1a is SerraMax. This name has been chosen to assist with branding and marketing for this unique serradella cultivar which connects the species ‘serradella’ with ‘maximum’ regeneration and productivity.

References

Robertson M.J., Lawes R.A., Bathgate A et al (2009). Determinants of the proportion of break crops on Western Australian broadacre farms. *Crop and Pasture Science*, 61: 203 – 213.

Taylor G.B., Revell C.K. (2002). Seed softening, imbibition time and seedling establishment in yellow serradella. *Australian Journal of Agricultural Research*, 53: 1011 – 18.