Journal of the Department of Agriculture, Western Australia, Series 4

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

Volume 17
Number 1 *1976*

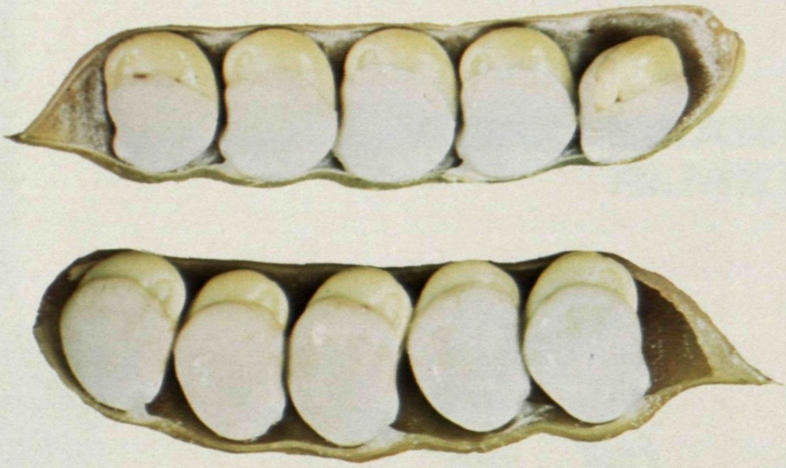
Article 7

1-1-1976

Lupin split seed : a disorder of seed production in sweet, narrow-leafed lupins

M W. Perry

J. W. Gartrell



Lupin "split seed"

A disorder of seed production in sweet, narrow-leafed lupins

by M. W. Perry and J. W. Gartrell
Research Officers,
Plant Research Division

Top: Immature seeds with the seed coat split to expose the cotyledons.

Above: Severe seed damage resulting from the embryo being ejected from the seed coat.

Commercial seed production from narrow-leafed lupins (*Lupinus angustifolius* L.) began in Western Australia in 1967, based on the newly-bred low alkaloid cultivar Uniwhite. The release of improved cultivars has led to the crop's wide acceptance and more than 100 000 ha were sown to sweet lupins in 1975.

With the greater area and wider range of soil types devoted to lupins, a developmental abnormality of the seeds, which became known as "split seed", was observed in some situations. In the most severe form of split seed, seed development was halted and even where the disorder was less severe, seed yield and germinability were decreased.

Research by the Department of Agriculture[8] and CSIRO[1] has shown that the abnormality is related to the gene "iucundus" which lowers the alkaloid content of lupin plants. Addition of manganese sulphate can control the disorder but at the high rates required it remains a serious cost to the grower.

Historical background

The first indications of abnormal seed development were seen in samples of 1971 crops examined by Dr J. S. Gladstones. The samples, from both the West Midlands and the south coast, showed similar symptoms: the plants had remained green as the crop matured and the flattened pods contained rotten seed. No reference to a similar disorder could be found in the literature.

Dr Gladstones considered the symptoms of degenerating seed sufficiently distinctive to rule out bean yellow mosaic virus as the cause and suggested instead a possible nutritional basis for the disorder. His earlier work[4,5] had shown that copper contents were generally lower in *L. angustifolius* than in other lupin species and as the samples were believed to be from potentially copper deficient soils, copper was suggested as a possible cause.

Calcium, zinc and boron, which are all involved in seed development, were also suggested, together with manganese, although manganese deficiency appeared unlikely because lupins had previously been shown to accumulate considerable manganese contents on gravelly soils where other species sometimes exhibit manganese deficiency.[4]

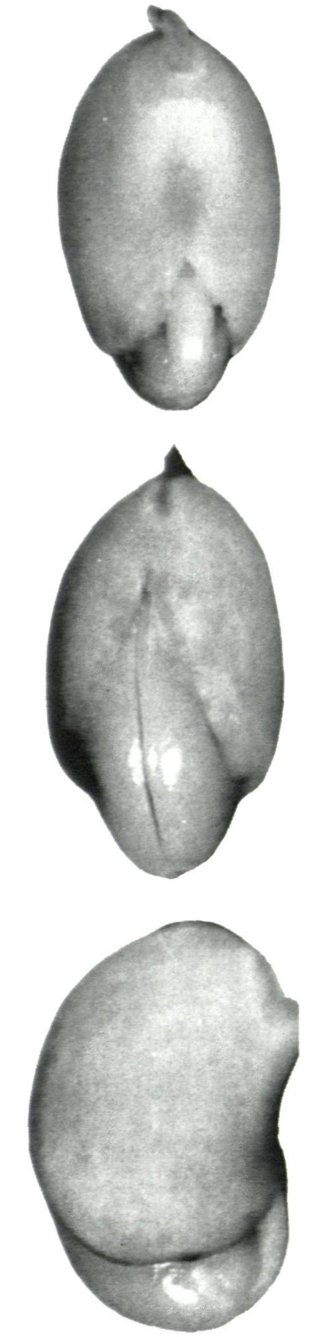
Also, split seed had not been observed in *Lupinus luteus,* which is considerably more susceptible than *L. angustifolius* to manganese deficiency in the vegetative stage.

The disorder was seen on a larger scale in 1972. Observations quickly confirmed the association with the deep sand and gravelly sand over clay soils of the West Midlands sandplain and south coast, although mild splitting was also observed on heavier soils.

Nutritional trials conducted by J. W. Gartrell during 1972 gave no indication that copper and a range of other elements, including calcium and boron, were involved. Other trials with varying rates of superphosphate showed that high rates which promoted vigorous growth increased the disorder, but they also eliminated phosphorus, calcium and sulphur deficiencies as likely causes of the problem.

In the spring of 1972, Mr G. H. Walton observed a small proportion of split seed in *L. luteus* at Badgingarra. The plants exhibited leaf chlorosis which Mr Walton believed to be manganese deficiency. Seed taken from affected plants contained 10.6 ppm manganese, which he considered to be critically low.

Observation on crops and field trials in 1972 also indicated that split seed was confined to the sweet white flowered, non-shattering cultivars. In particular it was related to the gene for alkaloid suppression "iucundus" rather than to genes for white flowers or reduced pod shattering.



Split seeds, fully grown but still green, enlarged to show detail of splitting of seed coat.

Thus, 1972 outbreaks established a relationship with soil type and geographic location and also implicated a genetic factor in the newly bred cultivars. To further search for a nutritional basis for the relationship between soil types and split seed more trials were planned for 1973. Manganese sulphate was included in these.

Severe split seed appeared in West Midlands crops in late October, 1973. In that year Mr S. Richardson, whose crops at West Dandaragan were badly damaged by split seed in 1971 and 1972, tried several elements suggested by Dr Gladstones. In mid-November he reported that manganese sprayed onto a strip in mid-August had greatly reduced split seed but it had no effect where sprayed five days later, with selenium, on a 20 ha block. This was followed closely by a report from Messrs W. Wood and B. Gorddard that a manganese spray had eliminated split seed in a small trial at Esperance.

Where manganese sulphate was drilled with the seed in mid-May in a trial at Lancelin, a dramatic reduction in split seed was detected at the end of November and grain yield was increased from 158 to 720 kg/ha.[2,3]

These results were supported by a survey of nutrient levels in diseased and healthy crops. This showed manganese was the only element consistently low in unhealthy plants.

Simultaneous work on the genetic side of the disorder[8,1] clearly confirmed the association of split seed with "iucundus", the sweetness gene incorporated into the sweet white-flowered cultivars Uniwhite, Unicrop and Uniharvest. Trials in subsequent years have confirmed that manganese sulphate can alleviate the disorder and have established a firm basis for its control.

What is split seed?

The name "split seed" originated from the presence, in mature seed samples, of seeds with a split seed coat. The cotyledons of these plump seeds protrude through the broken testa and are often slightly parted at the tip. Such seeds were first seen in harvester samples from the West Midlands, but subsequently a much wider range of seed and plant symptoms was identified as part of the same disorder.

In the field the disorder appears in late spring when most lupin crops have finished flowering and are beginning to mature. Its onset is sudden and vegetative symptoms are seldom seen before the onset of seed damage.

Seed symptoms

Two types of seed damage are commonly observed. In mild cases, the lupin seeds are fully formed but the seed coat is split and drawn back to expose the cotyledons, giving the classic "split seed". Such seed, although nutritionally sound, spoils the appearance of samples and germinates poorly.

In the more severe form of the disorder, the embryo of younger seeds is pushed from the seed coat by the growth of a callus which fills the testa. On drying, both the embryo and seed coat shrivel and discolour and virtually no seed remains for harvesting.

Both types of seed damage may occur on the same plant. Generally seed is least affected on the primary inflorescence and worst affected on the later formed pods on the topmost branches of the plant.

Plant symptoms

Vegetative symptoms of split seed are not usually seen until late in the season, when seed damage is already severe. Crops affected have usually grown vigorously and shown promise of good yields. Distribution of the disorder is characteristically patchy within a crop.

Affected plants fail to mature, their stems remain green and a bunchy regrowth of dwarfed leaves appears at the tips of the branches. These leaves are usually chlorotic and small inflorescences and pods may be formed.

Distribution of split seed

Split seed has affected lupin crops throughout the agricultural areas. It has been most severe on the sandplain soils of the West Midlands, where a large proportion of the crop has been seriously affected

each year. Through the south coastal and Esperance districts, split seed has been extensive but usually mild, while in northern agricultural districts and inland areas of the South-West, cases have been rare and always mild.

The soils affected (Table 1) are either deep sands with uniform texture profiles or the duplex sand over yellow clay soils, often with lateritic gravel. The map shows the areas where these soils predominate. Similar soils occur elsewhere but usually only as a minor component of the landscape.

The deep leached grey sands have proven particularly prone to the disorder and are a feature of all susceptible districts. In the West Midlands the strips of pale yellow and brown silicious sands adjacent to the coastal dunes have been as severely affected as the grey leached sands which lie along their inland margin. Large areas of sandy surfaced acidic soils with yellow mottled subsoils that occur in the West Midlands, south coast and Esperance districts, usually in association and merging with deep leached sands, have produced varying degrees of split seed, those with the deeper A horizons tending to be worst affected.

Yellow earthy sands dominate the eastern margin of the West Midlands and much of the northern agricultural region. The split seed disorder has been observed on these yellow earthy sands, but has rarely been severe.

In the West Midlands small areas of red earthy sands have been free from the disorder. Where the red and yellow sands merge, split seed has been seen on the yellow sands but not on the red sands even though separated by distances of less than 100 m.

In the Great Southern, split seed has been absent or only mild on the loamy soils on pallid zone material below laterite breakaways, where cereals are often prone to manganese deficiency.[5]

Table 1—Soil groups believed to be associated with lupin " split seed " and the soil associations within which these soils predominate

Soil group*		Soil association*	
		Observed	Suspected
Sands			
Uc 1.2	Deep yellow or white silicious sands	B 24	
Uc 2.12–2.3	Leached sand soils either with or without a compacted pan below the bleached A_2 horizon	Ca 27 Cb 39	Ca 19–28 Cb 38–44 Cd 22
KS Uc 2.2	Leached sands with ironstone gravel	Cz 1	
Uc 4.2	Brown sands with an unbleached subsurface horizon	JK 9	
Uc 5.2	Yellow earthy sands with weak pedological development	AC 2–7	
Sandy soils with yellow clayey subsoils			
Dy 5.41–Dy 5.81	Sandy surfaced acidic or neutral soils with mottled yellow clayey subsoils either with or without structure in the subsoil. Varying amounts of ironstone gravel	Wd 7 Wd 9–10 X 14, X 16 Xc 1 Xd 1 Xd 3	Wd 6 Wd 8 X 15, X 17 Xd 2

* Classification used by Northcote ([6]). Atlas of Australian Soils Sheet 5, Perth-Albany-Esperance Area.

Chemical analysis of soil and plant material

Analysis of plant material in 1973 supported the initial observation that manganese deficiency might be one cause of the disease. Element concentrations in the abnormal regrowth showed low manganese and relatively high iron levels, with normal levels of zinc, copper, boron and the macro-elements.

The suspicion that manganese was indeed involved was greatly strengthened by the analysis of material from three sites where contrasting, but adjacent, soil types carried diseased and healthy crops respectively (Table 2).

Manganese content in seeds of diseased plants was again below 10 ppm while seeds from the adjacent unaffected soil types contained about four times as much manganese. Manganese levels in vegetative material showed similar differences. These paired samples confirmed beyond doubt the distinct "soil type" effect and tended to discount the presence of either an insect or a seed borne virus.

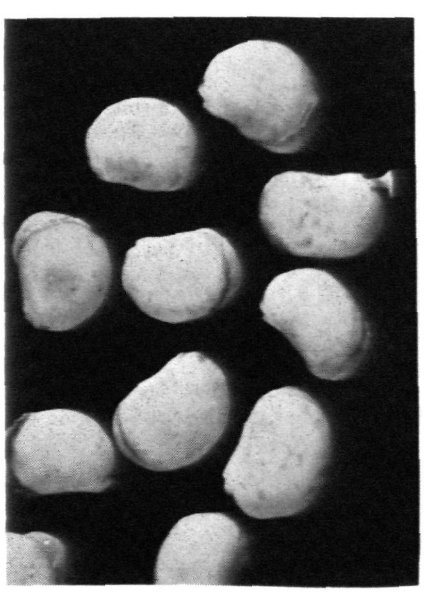
A wider survey of seed nutrient contents (Table 3) also suggested that split seed was associated with low manganese contents. Seed from unaffected crops was obtained from seed certification samples found to be free of the disorder.

Manganese levels from the badly "split" crops were all less than 10 ppm and averaged 7.1 ppm manganese whereas only two unaffected crops contained 10 ppm or below and the 11 sampled crops averaged 20.1 ppm manganese. Such large differences were not recorded for any other nutrient.

Since these initial nutrient surveys, numerous trials have confirmed that manganese sulphate applied to the soil can greatly reduce the incidence of split seed. The results of the split seed research have already greatly benefited lupin producers.

Top left: Regrowth ("regreening") of dwarf leaves at the tips of apical shoots.

Left: Flattened pods containing only damaged seeds, and associated dwarfed growth.



Right: Mature split seed from a harvested sample.

Controlling split seed

Other measures besides the application of manganese sulphate can help to control split seed.

Observations and trials over three years have shown that crops which are well advanced when split seed appears suffer less damage than less mature crops. This is because the seeds of advanced crops are approaching maturity when the disease appears and are either unaffected or may only suffer from a split seed coat. Samples from such crops are unsuited for re-sowing because of reduced germination but feeding value is not affected.

It is therefore most important to ensure that crops mature early on soils prone to split seed. This may be attained by early planting, by using the earlier flowering Unicrop and by using higher seeding rates.

In a trial in 1973 incorporating four times of planting, four seeding rates and the cultivars Unicrop and Uniharvest, early planting was clearly most important in reducing seed damage (see diagrams). Neither the cultivar nor the rate of seeding significantly affected the proportion of split seed in this trial, but Unicrop had less damaged seed than Uniharvest and the higher seeding rates also appeared to reduce the damage, especially at later planting times.

Combining manganese applications with the practices advocated here should allow producers in susceptible areas to avoid large losses from split seed. Early planting and the use of Unicrop are also recommended for maximum yields

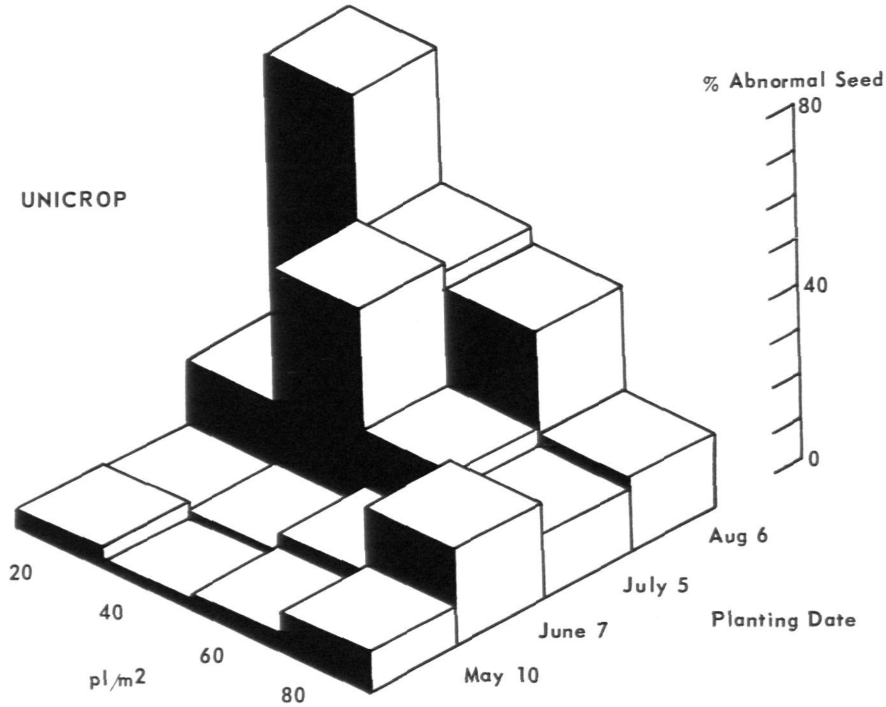
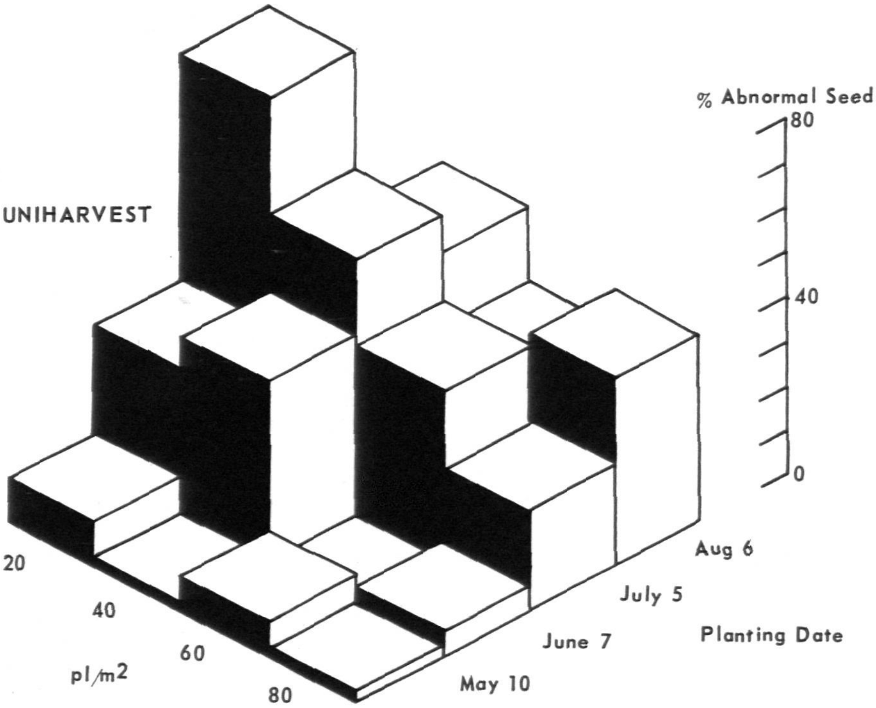


Table 2—Nutrient levels in vegetative material and seed from different soil types in the same locality

Site	Tissue	ppm Mn	Fe	Zn	Cu	Soil type
Dandaragan	Leaf Healthy	1 300	953	75	7·4	Red earthy sand
	Diseased	55	581	51	4·2	Coarse yellow sand
Moora	Leaf Healthy	318	687	35	3·0	Brown fine sand
(Site 1)	Diseased	31	316	34	2·7	Bright yellow-orange sand
	Stem Healthy	16	23	7·3	2·0	
	Diseased	3·1	38	10·9	1·9	
	Seed Healthy	17	57	33	3·5	
	Diseased	4·5	76	76	4·6	
Moora	Seed Healthy	29	82	33	2·5	Red sandy loam
(Site 2)	Diseased	8·2	34	36	3·0	Coarse yellow sand

Table 3—Survey of nutrient levels in whole seed

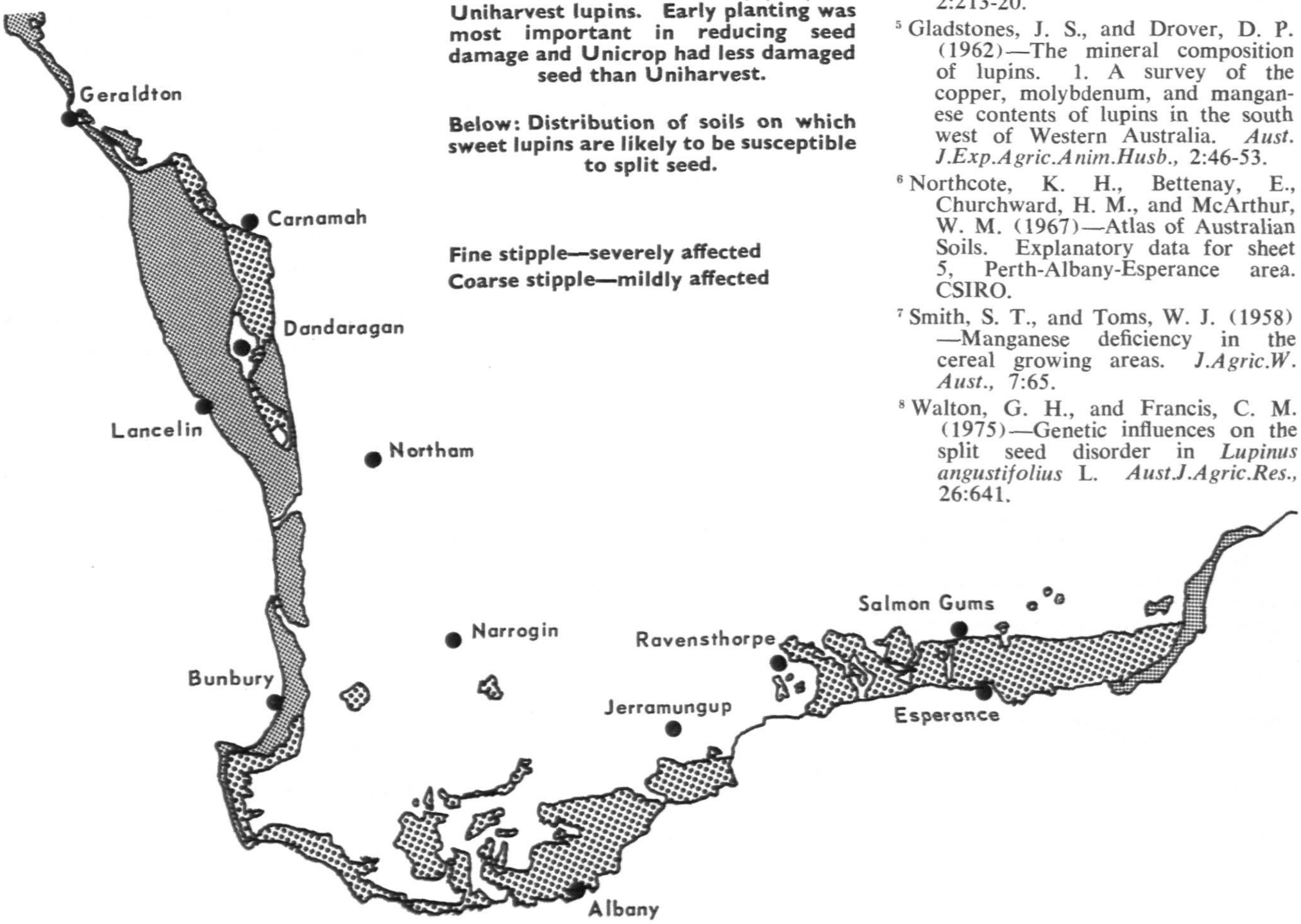
	Cultivar	Mn	Fe	Zn	Cu	B	Ca	Mg	K	P	N	S	Notes
Badley affected crops		ppm	ppm	ppm	ppm	ppm	%	%	%	%	%	%	
Badgingarra	UC	9·2	49	37	2·6	24·9	0·25	0·17	0·79	0·24	5·2	0·26	R. Priest. Grey gravelly sand
Dandaragan	UH	6·6	35	40	4·3	27·3	0·19	0·21	0·92	0·32	4·9	0·27	S. Richardson. Yellow sand
Moondah		9·7	78	56	4·3								
Lancelin	UH	5·0	52	40	4·7		0·26	0·19	1·0	0·26		0·23	Deep yellow silicious sand
Green Range	UW	5·9	37	37	4·0								Warriup Road. Deep grey sand
Moora 11 M West		4·6	76	51	4·6								Bright orange coarse sand
Moora 18 M West		8·2	34	36	3·0								Coarse yellow sand
Mean		7·1	52	42	3·9		0·23	0·19	0·90	0·27		0·25	
Unaffected crops													
Gidgegannup	UH	7	44	34	3·2		0·27	0·20	0·95	0·28		0·28	Experimental seed ex J. S. Gladstones
Manjimup (i)	UH	32	55	34	5·0		0·21	0·20	1·35	0·25		0·14	Seed certification sample (1973) (195)
(ii)	UH	18·1	23	30	4·8		0·23	0·17	0·73	0·22		0·22	Commercial 1972
Bridgetown	UH	15·1	38	30	4·5		0·23	0·18	0·83	0·24		0·24	Commercial 1972
Kojonup	UH	21·3	66	30	5·0		0·17	0·19	0·83	0·22		0·21	Seed certification sample 1973 (202)
Mt. Barker	UH	15	62	41	5·2		0·21	0·23	1·05	0·40		0·25	Seed certification sample 1973 (3997)
Cranbrook	UH	10	38	32	4·2		0·17	0·20	0·87	0·25		0·15	Seed certification sample 1973 (9)
Geraldton	UH	53	50	39	4·7		0·22	0·23	1·22	0·38		0·26	Seed certification sample 1973 (4553)
Boyup Brook	UH	12	40	27	4·2		0·16	0·23	0·97	0·26		0·17	Seed certification sample 1973 (202)
North Bannister	UH	17·3	33	31	3·6								Dept. trial gravelly loam
Moora	UH	20	37	35	3·5		0·19	0·20	0·97	0·30		0·18	Seed certification sample 1973 (4534)
Mean		20·1	44	33	4·4		0·21	0·20	0·98	0·27		0·21	



Above : Three-dimensional diagrams showing the effects of planting date and plant density on the incidence of split and shrivelled seed in Unicrop (left) and Uniharvest lupins. Early planting was most important in reducing seed damage and Unicrop had less damaged seed than Uniharvest.

Below: Distribution of soils on which sweet lupins are likely to be susceptible to split seed.

Fine stipple—severely affected
Coarse stipple—mildly affected



and producers who follow these practices should obtain the benefits of both higher yields and reduced split seed.

Acknowledgments

Many officers of the Department of Agriculture in both the field and the laboratory contributed to the elucidation of the split seed problem. The authors acknowledge their contributions.

References and further reading

[1] Farrington, P., and Gladstones, J. S. (1974)—Effect of genotype on yield of narrow-leafed lupin (*Lupinus angustifolius*) and sandplain lupin (*Lupinus cosentinii*). *Aust.J.Exp. Agric.Anim.Husb.*, 14:742-748.

[2] Gartrell, J. W. (1974)—Western Australian Department of Agriculture, Plant Research Division *Annual Report* (1973/74) p. 22.

[3] Gartrell, J. W. (1974)—Split seed in sweet lupins beaten. *Our Land,* September 1974, p. 12.

[4] Gladstones, J. S. (1962)—The Mineral composition of lupins. 2. A comparison of the copper, manganese, molybdenum, and cobalt contents of lupins and other species at one site. *Aust.J.Exp.Agric.Anim.Husb.,* 2:213-20.

[5] Gladstones, J. S., and Drover, D. P. (1962)—The mineral composition of lupins. 1. A survey of the copper, molybdenum, and manganese contents of lupins in the south west of Western Australia. *Aust. J.Exp.Agric.Anim.Husb.,* 2:46-53.

[6] Northcote, K. H., Bettenay, E., Churchward, H. M., and McArthur, W. M. (1967)—Atlas of Australian Soils. Explanatory data for sheet 5, Perth-Albany-Esperance area. CSIRO.

[7] Smith, S. T., and Toms, W. J. (1958)—Manganese deficiency in the cereal growing areas. *J.Agric.W. Aust.,* 7:65.

[8] Walton, G. H., and Francis, C. M. (1975)—Genetic influences on the split seed disorder in *Lupinus angustifolius* L. *Aust.J.Agric.Res.,* 26:641.