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Cover Page Footnote
Financial assistance from the State Wheat Research Committee for this and other investigations on hard seeds in legume pastures is gratefully acknowledged
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HARD SEEDS IN LUPINS

A study of hard seeds in the W.A. blue lupin is yielding some interesting facts about this important survival mechanism of pasture plants. The knowledge gained will be useful in future pasture plant breeding projects.


Some interesting facts on hard seeds in lupins have come from experiments commenced several years ago. This article outlines the reasons for the experiments and the results with lupins so far. Subsequent articles will cover subterranean clover and techniques for softening hard seeds in both species before planting.

THE VALUE OF HARD SEEDS

Plants have various ways of ensuring their survival. Adaptation over many years has developed some remarkable mechanisms, particularly in wild species. These ensure survival through periods of disease, drought, fire, flood and other adversities. Perhaps one of the best known is the provision of "hard seeds."

What is a hard seed? It is a living seed which will not absorb water when placed in moist soil; it has a waterproof coat. Hard seeds are found mainly in clovers, medics, lupins and other legumes.

To a farmer establishing a legume pasture or fodder crop, hard seeds are more of a nuisance than an asset. A seed which will not germinate for months or years after sowing is of very little value. On the other hand, hard seeds are of vital importance in the survival of an established pasture.

In Western Australia most pastures are based on annuals. They germinate in the autumn, grow through the winter, set seed in the spring, and carry over the dry summer as seed.

If the spring is unusually dry little if any seed forms. Thus the regeneration of the pasture the following year depends on the availability of an adequate reserve of hard seeds in the soil—seeds which have formed in previous more favourable seasons and have carried through the dry year as hard seeds.

The crop rotation system being followed in the cereal and sheep districts makes hard seeds in annual legume pastures even more important. Every three to five years or so pastures are cultivated after the autumn rains and planted to a cereal crop. The process of cultivation destroys most of the legume seedlings and regeneration the following year depends largely on hard seeds.

Last but not least, hard seeds give to a pasture species the ability to survive the effects of spasmodic summer rains. These may be sufficient to germinate seeds but not to carry the seedlings through to the following autumn when the regular rains begin.

Under the extensive system of agriculture operating in Western Australia regular reseeding of legume pastures is neither desirable nor practicable. The species selected for planting should have the ability to survive adverse growing seasons, summer rains, and rotational cropping. Thus "hard-seededness" becomes a factor of prime consideration in the selection and breeding of new pasture varieties. The pasture plant breeder needs to select for hard-seededness just as the cereal breeder selects for straw strength or disease resistance.
Hard-seededness is a very general term. A complete understanding of its development and breakdown under field conditions is essential if new pasture species are to be produced with the correct level for any district.

**THE DIFFERENT LUPIN VARIETIES**

Three varieties of lupins are grown in Western Australia.

The yellow lupin (*Lupinus luteus* L.) and the New Zealand blue lupin (*Lupinus angustifolius* L.) are grown mainly in the South-West. It is unusual to see either of these types survive for more than a few years under typical cropping and grazing.

In the drier more northern districts the main type grown is the West Australian blue lupin (*Lupinus varius* L.). This species, referred to normally as the W.A. lupin, has shown an outstanding ability to survive under all sorts of conditions. It grows as a roadside weed in many places and is very difficult to eradicate. Even if seed formation is prevented prolific crops of seedlings, from dormant hard seeds, will appear for three or four years.

The popularity of the W.A. lupin has declined over the last few years after numerous outbreaks of “lupinosis.” Despite this, its excellent long term survival ability is well worth investigation because it indicates the type of hard seed mechanism required in some of the more desirable pasture species.

**SEED MOISTURE AND HARD-SEEDEDNESS**

In 1954 New Zealander E. O. C. Hyde, demonstrated very clearly a connection between seed moisture content and hard-seededness. With tree lupin (*Lupinus arboreus* L.) and several other legumes he showed that the seed coats became impermeable to water if the seed moisture content fell below 10 to 12 per cent. This impermeability, or hard-seededness was not normally reversible in that seeds were capable of losing water but not regaining it. In dry air the seed moisture content fell; in very moist air it did not rise but remained constant.

Some experiments by J. S. Gladstones at the Western Australian University Institute of Agriculture in 1958, showed a similar connection between seed moisture content and hard-seededness in the W.A. lupin.

**THE DEVELOPMENT OF HARD SEEDS IN THE W.A. LUPIN**

Most farmers in wheat growing districts are familiar with the seeding habits of the W.A. lupin. As the plant reaches full maturity in late October or early November the seeds change from a light green to a speckled brown, the pods split and the seeds fall to the ground. The general ripening process is very uneven, shedding taking place at a fairly constant rate over a period of one or two weeks according to weather conditions.

The moisture content of the seeds drops rapidly as they change colour and approach the shedding stage, where it has a level of about 18 to 20 per cent. After two or three days on the soil surface it falls to 10 or 12 per cent. and the seeds become impermeable to water.

Over the summer the moisture content continues to decline in accordance with the dryness of the atmosphere. Seeds with levels as low as 3 to 4 per cent. are common by the end of the summer.

An interesting feature of the early stages in hard seed development is that for a few days after shedding all the seeds are capable of immediate germination. The question arises as to what would happen if a sudden heavy rainstorm occurred soon after shedding; a not unlikely event in November. Obviously some of the seeds would germinate. However as the ripening and shedding of the crop takes some 10 days and the seed is in a susceptible condition on the soil surface for only two or three days, only a relatively small proportion of the total seed crop could be lost by germinating rains. Thus while uneven ripening is a problem to the farmer harvesting lupins, it does perform a useful role in that it ensures the survival of an adequate supply of seeds.

The W.A lupin develops a very high level of hard seeds. By mid summer some 98 or 99 per cent. of the total crop falls into this category. Thus the species is very well protected against the destructive
Plate 1.—The changing pattern of hard seededness in the W.A. lupin for the first six months or so after maturity. The pictures show the germination from seeds collected—

(a) at the shedding stage (early November)—a complete germination with no hard seeds;

(b) at mid summer (mid January)—only a few seedlings, the remaining seeds being hard and impermeable to water;

(c) just before the opening autumn rains (early May)—about a quarter germinated, the rest being hard seeds.
germinating effects of summer thunderstorms. In this respect it differs markedly from the yellow and New Zealand lupins grown in the South-West, which germinate prolifically with summer rains.

THE SOFTENING OF HARD SEEDS
The soil surface would become rather crowded if plants kept producing seeds which were nearly all hard and not capable of germinating the following year. If none of the hard seeds germinated the plant population would barely reproduce itself, the likely result being a few scattered plants growing in a dense mat of hard seeds. This does not happen; obviously hard seeds do germinate at some stage. What causes hard seeds to soften and germinate, and when do they germinate?

A number of influences are likely to be involved in causing hard seeds to soften. Possibly the ageing of the seed is involved. Soil bacteria and insects may play a part and so also may humidity changes. Under field conditions a sharp daily temperature change is one obvious influence to which hard seeds are exposed.

The Soil Temperature Pattern
The soil surface becomes quite hot on a summer day in the wheat and sheep
districts. On most days temperatures rise as high as $140^\circ$ F. or more, with readings above $160^\circ$ F. not uncommon. At night the temperatures fall to about $60^\circ$ F. just before dawn. A typical soil surface daily temperature pattern for centres such as Wongan Hills or Merredin is illustrated (Fig. 1).

Along the south coast the daily temperature fluctuation is not so marked. Esperance and Albany soil surface temperatures are some $20^\circ$ F. lower during the day.

**The Effect of Temperature Changes on Hard Seeds**

If the softening of hard seeds in the field is caused by heat the obvious question is: —what temperature—high, low or fluctuating, has the greatest effect?

To provide an answer, hard seeds of the W.A. lupin were exposed for five months to constant temperatures of $60^\circ$ F. and $140^\circ$ F. and a daily fluctuating temperature of $60^\circ$-$140^\circ$ F. A germination test was carried out on the seeds at the beginning and end of the five-month period to determine the hard seed content. The results obtained with the W.A. lupin are illustrated (Fig. 2).

This indicates that hard seeds of the W.A. lupin soften the most if they are exposed to a temperature fluctuation similar to that on the soil surface during the summer ($60^\circ$-$140^\circ$ F.). A natural conclusion is that the daily summer soil surface temperature fluctuations are an important and probably a decisive factor in softening the hard seeds of W.A. lupins in the first summer after seed maturity.
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Natural Softening of Hard Seeds

The preceding discussion has covered the formation of hard seeds and has advanced some theories as to why they soften.

What does actually happen to hard seeds under field conditions?

The softening of W.A. lupin hard seeds, shed naturally, was followed at four sites for nearly a year. Samples were collected each month and tested for hard seed content. These results are included in Fig. 3 which shows the pattern of hard seed formation and breakdown for a year after ripening. This pattern is illustrated also by the photographs in Plate 1.

The most striking and important feature shown (Fig. 3) is that some 70 per cent. of the total W.A. lupin seed crop goes through the winter as hard seeds. Thus the survival of the species is assured despite disease, drought or cropping the following season.

This reserve is more than adequate for one year, possibly sufficient for two, three, or four years. This is only an estimate based on field observations. The exact story of lupin hard seeds is not known beyond the first year.

What exactly happens to these seeds in the second and subsequent years will not be known until trials now in progress are completed.
SOME CONCLUDING COMMENTS

While the W.A. lupin has some poor features as a grazing plant it does have a lesson for all: the lesson of survival. It is well adapted to West Australian climatic conditions, perhaps a little too well, since it is a difficult plant to eradicate if this is required.

Once knowledge is more complete on the climatic and other factors which cause the formation and breakdown of hard seeds in lupins and other species, plant breeders will have a better understanding of what is required for survival in the rather extreme climatic conditions of the wheat and sheep districts. They will be in a position to select and crossbreed with that end in view.

ACKNOWLEDGMENTS

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![Graph showing the percentage of soft germinable seeds which can be expected from the W.A. lupin at any time during the year after seed formation. The pattern and values at any specific time are approximations only; site and seasonal differences do occur.](image)