APPLYING AUSTRALIAN TECHNOLOGY IN THE ALENTEJO AND ITS COMMERCIAL ADVANTAGES *

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ABSTRACT

Following a brief report of historical events on Australian agricultural development, this paper presents and discusses the major issues from subterranean clover and superphosphate revolution, ley farming (including either legume pastures or grain legumes in the rotation), long fallow use and minimum tillage practice.

The advantages of the introduction of some of the above referred technical solutions in Alentejo are furtherly enhanced, though some restrictions are pointed out.

RESUMO

Após um breve relato de factos históricos do desenvolvimento agrícola australiano, este trabalho apresenta e discute os aspectos mais relevantes da revolução do trevo subterrâneo e superfosfato, do «ley farming» (apoiado quer nas pastagens de leguminosas quer nas leguminosas para grão), utilização de pousios e prática da mobilização mínima.

Posteriormente, salientam-se as vantagens da introdução no Alentejo de algumas das soluções técnicas atrás referidas, apontando-se-lhe, porém, algumas restrições.

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1 — INTRODUCTION

Over the last 3 years the author had the pleasure of co-operating with the University of Evora and the Regional Directorates of Agriculture in finding the ways and means of transferring Australian agricultural technology to the Alentejo.

But first he would draw the attentions to some Australian historical events and facts which are important to agricultural development in Portugal.

In 1860: Control of wild dogs by strychnine poisoning allowed fencing to be introduced to replace shepherding of sheep.

In 1860: Wild rabbits were introduced into Victoria in Southern Australia.

In 1889: Howard discovered subterranean clover in South Australia.

In 1895: Currel brothers in South Australia discovered that placing superphosphate close to the seed when sowing reduced the quantity of fertilizer required.

In 1907: Mechanical harvesting of subterranean clover seed introduced in New South Wales.

In 1930-1940: Large increase in fertilizing of pastures with superphosphate in Southern Australia.

In 1951: Successful establishment of myxomatosis and the control of rabbits.

In 1955: Davies at Camberra demonstrated the full potential of high stocking rates (number of sheep per hectare) on sown pastures (3).

2 — THE SUBTERRANEAN CLOVER AND SUPERPHOSPHATE REVOLUTION

The phenomena of the subterranean clover and superphosphate combination produced massive increases in productivity and is spoken of as the Sub/Super Revolution.

In the high rainfall zone, i.e., more than 500 mm rainfall per year, the area sown to clover and grasses expanded rapidly and has since plateaued out (7).

Year	Area sown	Cattle n.º	Sheep n.º	Farm area sown to pasture (%)
1950	4.0 MM ha	3.5 MM	32 MM	17
1970	11.0 MM ha	7.8 MM	60 MM	43

In one typical census region of South Australia of 259 km² («binnum» = = 100 sq. miles) the sheep numbers grew primarily due to the use of subterranean clover and superphosphate by a factor of 2 over first two decades, then by a further factor of 2 over the next three decades. That is a fourfold increase over 50 years (table 1). The Alentejo has a similar potential.

TABLE 1 — Hundred of «binnum» South Australia

Period	Sheep n.º	Influencing factors
1900 – 1920	50.000	
1920 – 1930	60.000	– Increased use of subclover plus superphosphate.
1930 – 1940	110.000	
1940 – 1955	150.000	– Introduction of myxomatosis.
1955 – 1970	200.000	– Improved management and higher stocking rates.
1970 – 1980	150.000	– Increased cropping.

Source: Loyd Davis & Meyers, 1985 (7)

Over the last 60 years various workers in Australia have discovered the importance of trace elements to crop, pasture or animal health.

First noted were the responses to ash from burnt-out trees by subterranean clover.

The effect of deficiencies of manganese, cobalt, copper, zinc, molybdenum and selenium were first noted between 1928 and 1950.

Today superphosphate is supplied by fertilizer manufacturers with most of these trace elements added. A list of the products and the 1983 prices is in table 2 and gives some idea of the relative extra cost.

TABLE 2 — Relative costs of trace elements in superphosphate in Australia, 1983, without subsidy

Prices are for bulk fertilizer per tonne at factory door, Kwinana, Western Australia. In bags, prices are approximately plus 20 % (1 A$ = approx. Esc. 100, 1987)	A$
Superphosphate — P 9.1 %, S 10 %	107.15
Super & Copper — P 8.4 %, Cu 0.33 %	126.89
Super & Copper & Zinc A — P 8.2 %, Cu 0.66 %, ZN 0.6 %	142.59
Super & Copper & Zinc B — P 8.2 %, Cu 0.66 %, ZN 0.3 %	129.62
Super & Copper & Zinc & Molybdenum No. 1 — P 8.2 %, Cu 0.66 %, Zn 0.3 %, Mo 400 ppm	145.64
Super & Copper & Zinc & Molybdenum No. 2 — P 8.4 %, Cu 0.33 %, Zn 0.3 %, Mo 400 ppm	135.33
Super & Molybdenum — P 9.1 %, Mo 400 ppm	122.36
Super & Cobalt — P 9.1 %, Co 400 ppm	135.42
5.1 Super & Potash — P 7.4 %, K 7.4 %	124.13
Super & Magnesium — P 7.4 %, Mg 3.8 %	163.95

Source: Nuttall *et al.* (9)

Animal products include cobalt heavy pills for sheep and cattle (cobalt oxide 30%, iron grit 70%), copper injection for sheep and cattle (copper glycinate), selenium pills (elemental selenium 5% iron grit 95%), and selenium drench (selenium selenite 2.5 mg per 5 ml) (1).

The major elements for clover growth are phosphorous (P), sulphur (S) and calcium (Ca) all found in superphosphate, while potassium (K) may be needed in the high rainfall zone (more than 50 mm rainfall).

In order of importance, the nutrients essential for clover growth are phosphorous (P), sulphur (S), molybdenum (Mo), copper (Cu), zinc (Zn) and potassium (K).

It is worth noting that this technology, despite its massive advantages, has a cost. Australian experience shows a decrease in soil pH of 1 unit over 30 years of superphosphate use. This increases available aluminium (Al) and magnesium (Mg) and decreases available molybdenum (Mo).

This increasing acidity of the soil produces problems of persistence and growth of subterranean clover.

The rabbit problem is controlled today, firstly with myxamatosis, but the remaining rabbit population has developed a resistence and so secondly, poisoning with 1080 which is sodium monofluroacate (7).

Annual dry matter yields of subterranean clover based pastures fertilized with superphosphate varies from 0.9 tonnes to 3.6 tonnes per hectare (6).

The pasture legumes of *Medicago* and *Trifolium* in Mediterranean climates produce between 50 and 150 kg/ha per year (8). The authors go on to point out that 100 kg of soil nitrogen is equivalent to 400 kg of ammonium nitrate (26%) which is economically very significant. In Australia 100 kg of soil nitrogen were worth between A$ 58 to A$ 73 in the form of fertilizer at the factory in 1983 (approximate 1987 exchange rate is A$1 = Esc. 100).

In brief, the bringing together of:

— improved sown pastures using subterranean clover and superphosphate,

— low cost high tensile wire fencing,

— extra sheep numbers,

will tend to allow a doubling of sheep numbers and offer a profitable outcome.

3 — LEY FARMING — USING LEGUMES IN CROPPING ROTATIONS

The ley farming system for production of cereals uses a legume pasture or legume crop in the rotation to increase soil nitrogen.

In 1935, Dunne & Shier suggested this system as a solution to poor wheat yields, produced under a bare fallow-wheat rotation. In 1948, Shier & Collunane proved the hypothesis with lupins. In the 1950's the system was repeated with subterranean clover. Today, in the 1980's, the trend in Australia is towards the use of grain legumes, especially lupins (5).

This ley farming system is the established practice in much of the Australian cereal zone which enjoys a Mediterranean climate — cool mild winter, with most of the rainfall followed by a hot dry summer with little or no rain. This is seen in the wheat yields in table 3.

TABLE 3 — Wheat yields in Southern Australian states with Mediterrranean climate (tonnes per hectare)

10 - year mean	Victoria	South Australia	West Australia
1934 – 43	0.92	0.80	0.75
1954 – 63	1.42	1.16	0.96
1974 – 83	1.70	1.18	1.02
Comments:	Some sandy soils, most are medium to heavy texture.	Half the area is light sandy loam soils, balance are heavier soils.	Light sandy soils, low plant densities.

Source: Halse & Wolfe, 1985 (5)

This ley farming system has produced the wheat and sheep zone where farms are virtually always managed combining cereal cropping and sheep breeding.

In the 1970's, the average farm in this zone had the following characteristics:

Area:	1,104 hectares
Land use:	
Improved pasture	39.6 %
Native pasture	32.8 %
Wheat	14.3 %
Other crops	6.8 %
Buildings and unused land	6.5 %
	100.0 %
No. of livestock:	
Sheep	1.690
Beef cattle	93

Source. Reid, 1985 (13)

Perhaps a more typical farm would have half the area under crop in any year and half under pasture, a self replacing Merino sheep flock would produce surplus lambs and wool.

Paddocks would average 40 hectares each and there would be 6.6 kilometres of fence for each 100 hectares. The labour would be 1 owner/operator plus 3-4 months casual labour for the smaller farm, e.g., 600 hectares and 1 owner/operator and 5 to 7 months casual labour for the larger farms.

The rural workforce is about 7% of the national workforce.

In the 26 years to 1984, physical productivity per man has increased threefold when measured by rural workforce to index of volume of rural output.

Over the period 1976/1977 to 1982/1983 some indications of productivity for farms in the wheat/sheep zone are useful.

Productivity indicator	Farm quartile	
	High 25%	Low 25%
Equivalents/ha (DSE/ha)	3.4	2.3
Lambs/ewe mated (%)	78	68
Wheat yield (t/ha)	1.6	0.95

Source: BAE, 1985 (2)

4 — THE LONG FALLOW — DOES IT PAY?

The use of long bare fallows for cereal production is deeply traditional in USA, Canada and to a lesser degree in Australia.

> «The average rainfall throughout the Southern Australian wheat zone is generally less than 425 mm with a marked winter dominance. Growing season rainfall typically averages 200-250 mm and is usually the main factor limiting wheatyields» (14).

Ridge went on to state:

«Fallows are used:

— to conserve moisture and to supplement the crop water requirement
— to regenerate soil nitrogen
— to increase yield
— to minimize crop failures
— to provide more stable farm income

A soils maximum storage capacity for moisture is the field capacity less the extractable lower limit and is stronglly related to clay content.

This maximum storage capacity to 1 metre depth varies from:

Light coarse sandy soils	40-70 mm
Red brown duplex soils	160 mm
Sand over sandy clay loam	160 mm
Uniform friable heavy grey clay	265 mm

The quantity of soil moisture conserved by long fallow varies from 9 mm on coarse textured sandy soils to 60 mm on heavy clay soils.

Over a hot summer, coarse textured of low clay content can lose 80-90% of fallow conserved moisture whereas heavy clay soils lose not more than 40%.

Again the water stored by use of the long fallow of the previous winter (May to September — in Australia) for sand over sandy clay loam soils is 18% and 28% for the heavy grey clays.

The next limiting factor to water is soil nitrogen. A long fallow may add 10 to 50 kg nitrogen per hectare, usually less in the sandy soils and more in the heavier clay soils.

For each tonne of wheat produced some 28 kg nitrogen will be used (4).

For comparison, legumes in one year may produce between 60 and 150 kg of nitrogen (4).

Fallows are usually effective in increasing yields where they increase available water and soil nitrogen. Given the availability of soil nitrogen, wheat yields will increase at a rate of 10-14 kg/ha/mm of available water.

Thus, fallows tend to reduce the seasonal fluctuations in yield of wheat but this is limited by reduced availability of soil nitrogen in wet seasons.

An economic analysis of these long fallows on the sand over sandy clay loam soils and the uniform heavy gray soils compared to short fallows and larger area under crop demonstrated that profits averaged over several years were similar for the 2 systems at the farm price for wheat of A$ 130 per tonne.

However, the long fallow system provided a more stable flow of income. Hence, where the growing season rainfall is low, i.e., less than 260 mm, the soils have sufficient depth — 1 metre plus the clay content is more than 25 % to retain water, fallowing is attractive» (14).

5 — MINIMUM TILLAGE — FOR PASTURES AND CROPS

With the herbicides Monsanto's Roundup (glyphosate) and ICI's Reglone (diquat) and Grammoxone (paraquat) and tillage equipment which permits trash or stubble and straw to remain on the surface, the possibilities for conserving moisture and reducing cultivations for weed control by new methods are greatly enhanced.

These techniques do not increase yields as much as reduce costs.

The indications are that minimum tillage will:

- — improve soil structure
- — maintain large amounts of organic matter near the surface of the soil
- — reduce evaporation losses of soil under crop residues
- — improve winter recharge of soil moisture
- — reduce erosion of soil by wind and water
- — reduce costs of soil preparation for sowing of cereals and other crops
- — reduce costs of preparation for sowing pasture species
- — create new weed problems
- — produce new plant disease problems

Australian cereal farmers have adopted minimum tillage techniques over 20% to 40% of the area under crop (10).

Herbicides are substituting tractor fuel to an increasing degree in Australia. In the 7 years from 1978/1977 to 1983/1984 the usage of herbicides by Australian farmers more than doubled to make up 4% of their costs, while fuel use increased only one quarter to 11.5 % of costs.

Over a similar period the sales of cultivators, disc harrows and disc ploughs fell 65%, 47% and 82% respectively, reflecting both more difficult economic times and a shift to minimum tillage.

Sales of seed drills and scarifiers fell only 30% and 27% while sales air seeders stayed constant and chisel plough sales increased by 20%. All these implements are used for minimum tillage.

As these figures were based on number-of-units, an increase in the size of implements introduces an overstatement of the trend.

It is variously estimated that between 20 and 40 per cent of the cereal area in Australia is now sown using minimum tillage.

Minimum tillage for pasture improvement is usually in the form of special drills used as sod seeders. That is, the seed and fertilizer are son direct into the existing pasture with or without the assistance of herbicides.

Band spraying of herbicide just ahead of the drill tynes is probably the cheapest and most reliable method of sod seeding without complete loss of all existing pastures.

Alternatively, cultivate, spray, seed sequence can be used or occasionallly spray, cultivate, seed is more appropriate.

Australian agricultural machinery manufacturers have long made sod seeders for pasture improvement but the scarifiers and seed drills have been rebuilt to provide better clearance for old stubble and straw and air seeders or pneumatic seeders have been developed in Australia to fit the wider scarifiers commonly used today (10).

6 — APPLICATION OF TECHNOLOGIES TO THE ALENTEJO

There is a shortfall of sheepmeat for self sufficiency in the EEC so it makes good marketing sense for Portugal to increase its sheep numbers.

To achieve this you need an improvement in the pasture quality. One method for this improvement is to use subterranean clover. If sown on neutral to acid soils and provided with annual applications of superphosphate, it will usually permit a 100% increase in sheep numbers.

There are 3 essential elements:

- subterranean clover pastures to provide extra grazing
- fences to better control the grazing of sheep
- extra sheep to consume the extra pasture

plus the element of management of the system by the farmers.

A mixture of clover varieties should always be used to match the differing seasonal conditions.

Updated recommendations of varieties of subterranean clover are in table 4 (8, 11, 12).

The commercial gains from doubling income are self-evident. To gain the increased income an investment in pasture improvement, fencing and extra sheep must be made available.

Soils derived from shales may prove troublesome as they tend to form a hard caked surface as they dry out in spring and subclover must bury its seed to persist as a pasture (12).

The ley farming technique best suits B, C and D class land which is now normally fallowed.

As the growing season rainfall for most of the Alentejo is greater than 260 mm over November to March, then it is likely that an economic analysis will demonstrate that long fallows are less profitable than alternative techniques.

These alternatives include:

- ley farming using subterranean clover pastures
- ley farming using lupins or other legume grain crop
- minimum tillage with or without ley farming
- reduced tillage by discarding deep ploughing and reducing the depth of secondary cultivation to 100 mm
- sowing with a seed drill which cultivates and applies fertilizer.

These techniques have as much relevance to pasture inprovement as they do to cereal production.

All these techniques reduce costs of production.

Much of the cereal crop in Portugal is sown with centrifugal seeders and cultivated into the soil. Use of a seed drill will place the seed at a constant depth with fertilizer. Savings in the amount of seed and fertilizer accrue and the Australian type seed drill will cultivate and seed, and so handle rougher seed beds.

Reduced tillage will reduce cultivation costs by 40% to 50% (University of Evora has experiences of this at Beja). Cultivation at shallower depths allows the same tractor to pull wider implements and complete cultivations in less time. A 50% reduction in depth of cultivation, a doubling of width of scarifier and a halving of cultivation time is practical aim.

TABLE 4 — Recommended subterranean clover and annual medic varieties for the Alentejo

Cultivar	Specie	Days to 1st flowering	Time of flowering	Min. rainfall for seed maturation	Hard seed low and high 1 to 10	Resistence to kabatiella	Oestrogen level
For acid to neutral soils:							
Daliak	T. subterranean	124	End Feb.	350 mm	5/10	9/10	Low
Seaton Park	T. subterranean	133	Early Mar.	425 mm	5/10	1/10	Low
Junce	T. subterranean	138	Early Mar.	450 mm	6/10	9/10	Low
Clare	T. brachycalycinum	144	Mid. Mar.	450 mm	1/10	2/10	Low
Woogenellup	T. subterranean	145	Mid. Mar.	450 mm	3/10	1/10	Low
or							
Green Range	T. subterranean	145	Mid. Mar.	450 mm	5/10	9/10	Low
Mt. Barker	T. subterranean	147	End Mar.	550 mm	1/10	9/10	Low
or							
Karridale	T. subterranean	147	End Mar.	550 mm	3/10	9/10	Low
For alkaline soils:							
Hannaford	M. trincatula	105		250 mm			
Jemalong	M. trincatula	103		300 mm			
Sephi	M. trincatula	96		300 mm		Aphid Resistent	
Circle Valley	M. polymorpha	100		300 mm			
Harbinger	M. littoralis	96		300 mm			

Source: After Quinlivan, 1975 (12); Muslera and Ratera 1984 (8), modified.

Minimum tillage will further reduce costs of cultivation aimed at weed control which is replaced by herbicide. Advantages of better timing of crop or pasture seeding are gained. This is very important for autumn sowings.

Ley farming eliminates the cost of nitrogen fertilizer as this is supplied by the legume in the rotation.

Ley farming requires investment in pastures, fencing and extra sheep and produces extra income from the extra sheep.

Should lupins or other grain legumes be used the harvested grain provides income while the crop residues are good sheep feed and the plant has stored nitrogen in the soil for the next cereal crop.

The author trusts this outline stimulates the use of the techniques.

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