# David Crespo takes C3 pastures the next step to boost soil carbon

David Crespo studied improved pastures programs developed across southern Australia. but instead of stopping at 'sub and super' he looked more holistically at the pasture, soil, livestock system to develop a sustainable. lower input grazing system that is a net carbon sink. Lesley Watson visited Crespo's research farm in Portugal to find out how.

here's a grassroots agrarian revolution sweeping Portugal that is bringing new life to degraded pastures in droughtprone areas, improving farm productivity, and sequestering carbon in soils at the same time. Known as biodiverse permanent pastures rich in legumes or BPPRL, this Portuguese innovation is another example of sustainable grazing in a climatechallenged world

The innovative farmers adopting this unique pasture improvement technique are not only increasing their herd numbers, but are also enriching devitalised grasslands and croplands with a rapid build-up of soil organic matter through carbon dioxide sequestration.

Farmers are gaining permanent pastures that show marked improvements in soil fertility - in structure, cationic exchange capacity, rain infiltration and water holding capacity - and avoiding the need for nitrogen fertiliser. Land under this system is less prone to erosion and flooding, and the risk of wildfire as invasive shrubs are suppressed through intensive grazing.

Better pasture productivity means graziers can easily double or treble their stocking rates, and the health of the animals and their meat and milk productions benefit from the low cost, abundant and well-balanced feed that is rich in condensed tannins and alphalinolenic acid (the Omega-3 of plants)

The environment also benefits from healthier landscapes and ecosystems and, of course, the removal and storage of carbon dioxide from the atmosphere in expanded carbon sinks.

It all sounds too good to be true. Yet research conducted during the past 20 years has conclusively shown the technique achieves everything its proponents claim. BPPRL is now practiced by more than 400 farmers on a total 120,000 hectares in Portugal, many more are about to embrace the concept for carbon farming, and the system is spreading throughout southern Europe to other parts of the world with a similar climate (places with hot dry summers and mild wet winters).

BPPRL started to be developed in 1966 by Portuguese agronomist David Crespo while working for the Portuguese Ministry of Agriculture at Elvas Plant Improvement Station. Even after he left the Ministry in 1985 to take up a position with the UN Food and Agriculture Organisation (Rome, Italy), as a specialist in Mediterranean and subtropical pastures, having worked in Africa, West Asia, Central and South America, he continued to perfect his innovation on

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his family property, the 360 hectares Herdade dos Esquerdos in the Alentejo, central Portugal

He become so convinced of the value of the system, that he started his own seed company (Fertiprado, Sementes e Nutrientes, Lda.) in 1990 to supply selected seed mixes and technical advice to other farmers interested in his system.

Fertiprado has now grown from a farm-based operation to outlets in Spain and Italy with further expansion already initiated in Uruguay. From distributing a couple of container of seeds per year, the business now has a \$7.5 million turnover, supplying 5000 tonnes of seed to clients throughout Mediterranean Europe having also supplied some seeds to North Africa, Japan and Vietnam.

## Sustainable management standards

BPPRL has been the centrepiece of a recent study on environmental and sustainable management systems in extensive agriculture, financed by the European Commissions Life program.

Conducted from 2003-2008, the Extensity Project devised sustainable management standards for livestock producers (sheep for milk and meat, beef cattle and field pigs) in Portugal using the biodiverse permanent pastures in agrosilvopastoral systems (crops and grazing stock among tree crops, olive groves, cork oak forests and

# 1: Happy as a pig in clover... contented black pigs graze lush sown permanent pastures rich in legumes at the Herdade dos Esquerdos in central Portugal. David Crespo contentds that well managed diverse species pastures are permanent and should not need re-seeding, some are up to 30 years old.

2: David Crespo is convinced that pasture species diversity in a mediterraenian climate is not only practical but also beneficial to soil and livestock health. This attitude is in direct contrast to many SE Austarlia advisors who maintain phalaris and sub clover are the most successful combination in such a summer dry region.

woodlands is common practice in Portugal where there is limited cleared land for large scale grazing properties.)

The Extensity project also assessed the capacity for the BPPRL (and non-tillage systems) to sequester carbon. The positive results prompted the Portuguese Government to choose grassland and cropland management for optional carbon sinks to offset the country's  $CO_2$  emissions deficit. Farmers are now signing contracts to install BPPRL and increase carbon in their soils in return for carbon payments from the government. After 40 years of fine tuning his theories and seeing them wide-

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ly adopted, you would think Crespo at age 77 would be content to sit back and reap the rewards of his labours. However, retirement is not a consideration for the scientific director of Fertiprado.

The energetic visionary continues to champion the cause of BPPRL for the sake of sustainable farming practices in an increasingly sensitive environment. When he's not on the lecture circuit explaining the carbon positive system at international seminars, the indefatigable Crespo hosts field days at Herdade dos Esquerdos to share the secrets of BPPRL.

# PASTURE



# SPECIES DIVERISTY

1: Autumn rain trigger the germination of hard seeds from the annual legumes that lie dormant in the ground after spring flowering. Crespo is investigting inoculation of annuals and perennial grasses with Azospirillum bacteria that fix nitrogen. 2: David Crespo hosts regular field days at Herdade Dos Esquerdos to explain the pasture improvement technique.

The Herdade is not only the headquarters for Fertiprado in Portugal, which supplies 64 different seed mixtures to improve pastures, forages and cover crops, and technical support for BPPRL converts, it also grows organic Persian clover seed for export to Germany, produces high quality silage, and supports a flock of 2400 cross-bred Assaf milking ewes and grazing black pigs (70 sows and respective offspring) on its permanent pastures. The organic milk is converted to cheeses under the Qual label at an on-site factory, and the prized pigs supply organic meat for the favoured Portuguese dried cured ham, "presunto".

Crespo explains that biodiverse permanent pastures rich in legumes, as the name suggests, are pastures sown with a diversity of improved and selected seeds offering greater productivity than those in the natural system and renewing themselves on a permanent basis.

"Biodiversity comes from the fact that they are sown with a high number of seeds of up to 20 species/varieties, allowing the pasture to adapt to a particular soil and climate conditions, as well as to weather variations from year to year."

# 20 pasture species sown

At least 30% of the mix for the permanent rain-fed pastures is made up of hard seed legumes, from a range of annual clovers such as Trifolium subterraneum, T vesiculosum, T resupinatum, and nine annual medics (Medicago spp.) to yellow serradella (Ornithopus compressus) and Biserrula (Biserrula pelecinus).

These are complemented with selected perennial grasses such as cocksfoot (Dactylis glomerata), phalaris (Phalaris aquatica), tall fescue (Festuca arundinacea) and annual or perennial ryegrass (Lolium spp), and eventually with other perennial legumes, like lucerne (Medicago sativa), sainfoin (Onobrychis viciifolia), sulla (Hedysarum coronarium), or even other species, such as chicory (Cichorium intybus) or plantain (Plantago lanceolata). The legumes fix nitrogen in the soil making the pastures more productive at a lower cost.

In the year of establishment, the pasture is allowed to grow free of grazing during the period of flowering/seed maturing to build up an abundant seed bank, and then stocked according to the herbage yield, and grazed intensively during summer. The pasture regenerates year after year from seeds and from the summer dormant perennial plants, and most of the root system dies with the arrival of the summer drought, developing a thick mat of organic residues which together with the senescent stems and leaves from the grazed pasture, and the excreta of the grazing animals, contributes to a rapid build up of soil organic matter, which contains 58% carbon.

The hard seeds from the annual legumes lie dormant in the ground until they are ready to germinate with the arrival of the autumn rains. As the seeds of the different species/varieties respond to a range of temperatures, soil types and rainfall levels, they don't all germinate at once or, indeed, every year, but a part remain in the ground as reserves for the future. "Some have an early run, others germinate later, and some can stay in the ground for a few years



without germinating. The ones that flourish are the most adapted to the local situation," Crespo notes.

The permanence of the system is evident in the Herdade's lush spring pastures. The oldest, installed more than 30 years ago, continues to provide abundant growth year after year without need for artificial reseeding. "I planted my first pasture in 1973 and the last in 1996, and they all show high levels of nitrogen fixation and improved soil biology," Crespo points out.

"They went from initial levels of soil organic matter, 0.7 to 1.2%, to 3 to 5.5%. This fertility, accumulated in the soil in the organic fraction, represents carbon put into the soil from the atmosphere. Therefore carbon sequestration through pastures is a natural progression of these biodiverse permanent pastures rich in legumes"

Of course, the success of BPPRL depends on many contributing factors including selection of the best seeds from improved legume and grass varieties, the correct mix for the grazing use - up to 20 different species and cultivars are chosen from 50 species and 150 cultivars of self-reseeding annuals and drought resistant perennials of Mediterranean origin which are adapted to suit the grazing habits of sheep, cattle, pigs, horses and even deer.

### Legume seed inoculation

Every seed is also inoculated with "specific and highly effective" rhizobium strains that enhance symbiotic nitrogen fixation. Fertiprado is also investigating inoculation of annual and perennial grasses with Azospirillum, the bacteria that has been found to fix nitrogen and increase root hairs, encouraging the uptake of water and nutrients.

Ideally, the pastures should be established through minimum tillage or direct seeding at the break of the first Autumn rains, when the soil temperature is above 16° C, but once they are well-established and a good seed-bank is formed, they become resistant to climatic adversities, including prolonged droughts.

Once pastures are in place, their permanence relies mostly on the effective management of the system by participating farmers.

Interestingly, much of the improved legume seeds used by Fertiprado are sourced from Australia. Crespo says his theory was inspired from work being carried out in clover selection and use in Australia in the mid 1960s. "I was there in 1965 as part of a study tour that during three months took me around the world, looking at growing conditions in similar climates to the Mediterranean. I was particularly impressed with the Australians use of legumes that had originally been sourced from the Mediterranean.

"I have a great respect for Australian farmers and scientists in general and how they have solved the problem of farming in a hostile environment with the plants they picked and selected from elsewhere, particularly from Mediterranean countries."

However, Crespo's approach differed significantly from the status quo at the time that favoured grass or legume monocultures in pastures. "I developed the idea that the key to a healthy system was biodiversity to cater for the complex soil and climate conditions we have in Portugal. Indeed if, in this small country, climate is vary variable (rainfall ranges from 300 to 2500 millimetres per year), the soil is also variable, due to different geological formations, often in areas within close proximity'

"For instance on my farm we have four different geological formations - Precambrian schist, granite, limestone and gneiss and this gives me a range of soil pH from 5.1 to 6.8 and different depths of soils."

For BPPRL to work effectively in these situations, farmers may need to lime their soils if pH falls below 5.3. Since phosphorous is generally deficient in the Portuguese soils, the application of this nutrient is also a key issue for the success of these pastures. Eventually in some soils potassium or magnesium fertilisers are also required, as well as missing trace elements, to help establish and manage the pastures correctly. However, a well-managed system does not need any nitrogen fertilisers, which reduces operational costs and also avoids CO2 emissions from the energy intensive manufacture of synthetic nitrogen.

When using BPPRL for carbon farming, the emissions from all these inputs are factored into the equation, yet the system still produces a healthy carbon positive reading.

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In fact, the Extensity researchers found 5.2 tons CO2e could be

sequestered per hectare of BPPRL per year, even after deducting  $CO_{2e}$  emissions from increased methane and nitrous oxide emissions emanating from increased carrying capacity (larger herds), increased N<sub>2</sub>O emissions from the decomposing legumes, and increased CO<sub>2</sub> emissions from liming.

They estimated if 300,000 hectares of marginal and abandoned croplands and degraded natural grasslands in Portugal were converted to permanent high productive grassland based on BPPRL, the total sink effect would be  $1.56MT CO_{2e}$  per year. In their report on The Contribution of Sown Biodiverse Perma-

nent Rainfed Grasslands to meet the Portuguese Kyoto target, the researchers noted " the system ... also contributes to the following objectives: reduction of soil erosion; increase of soil fertility; increase of soil water retention potential; reduction of energy and fertiliser inputs in agriculture and animal production; reduction in management costs. This results in a clear win-win policy between carbon sequestration and other environmental and rural development objectives."

This is high praise indeed for the system devised by the humble agronomist and a welcome recognition of his life's work. "Unfortunately I can't patent the system of using a mix of biodiverse pasture plants," Crespo confesses. "But I am pleased there are enthusiasts out there who are adopting the ideas I have battled during my professional life."

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Portugal

