

Successful Cultivation of Rhododendrons on Limestone



THE YULONG SHAN RANGE IN YUNNAN PROVINCE, CHINA: PURE LIMESTONE, WITH RHODODENDRONS FROM END TO END
DAVID RANKIN

"If that man thinks he can grow rhododendrons around here he has got another think coming!" These were the words of the local plant guru when she noticed that one of the authors, Colin Mugridge, had planted 400 or so rhododendrons after moving them into the garden of his new property in a limestone quarry in North Wales. But he did grow them – with great success. Here you can read how.

CAN I GROW RHODODENDRONS IN A LIMESTONE QUARRY?

When he contemplated moving his family and rhododendrons to North Wales, Colin had no intention of purchasing a house situated in a limestone area, never mind a limestone quarry

with a soil of pH 7.4. But having made the move, he was prepared to give it a go. Like most gardeners, he believed that it was impossible to grow rhododendrons on limestone, but he also knew that Ernest Henry 'Chinese' Wilson had written about discovering rhododendrons and other ericaceous plants growing on limestone in China.¹ Maybe it was just possible to achieve this in his new garden.

And so he started his research. It wasn't encouraging. Modern books and the internet all indicated that it does not matter what you do, the outcome is always the same – the plants will die. Colin faced up to the dilemma: either the great plant hunters were mistaken, or the modern ideas are wrong. What was he to do?

RHODODENDRONS ON LIMESTONE IN THE WILD

E.H. Wilson was just one of many travellers in western China who have commented on the rhododendrons that are so abundant in the limestone mountains. Euan Cox, George Forrest, Frank Kingdon Ward and others all wrote about it, and noted that the plants seemed to be growing in close contact with the limestone. If you visit the area for yourself, a little digging around soon shows that they really are growing in it, and they are thriving. Euan Cox said “I can state positively that most of the rhododendrons I have collected in that region grow directly in, or on, pure limestone”, and he quoted George Forrest as saying “The rhododendron authorities at home talk of the impossibility of growing rhododendrons on limestone. I wish I had them here just now! To see *Rhododendron chartophyllum* and its form *praecox* (i.e. *R. yunnanense*), miles (no exaggeration) of bloom, and every plant on pure limestone, many growing on the bare rock... The above applies to almost all the species on the range.”² But rhododendrons do not in general survive, let alone thrive, in cultivation on limestone or other alkaline soils. So the observations of plant explorers have been explained away: the plants are not actually in contact with the limestone; it isn't limestone, but dolomite or at least dolomitic limestone; the limestone is hard and insoluble; heavy rainfall washes dissolved limestone out of the soil. All without a shred of evidence - and all wrong!



RHODODENDRON RUPICOLA GROWING IN CREVICES ON A LIMESTONE CLIFF
DAVID RANKIN

Our involvement started when one of us (David) visited the Yulong Shan range near Lijiang, in Yunnan Province in western China, and it was obvious that the rhododendrons really were growing in the limestone. He was at the stage in his career (as an academic inorganic chemist) where he could afford to put some effort into a side-line research area. Two big positives: he would have to do research in China in May, when normally he would have to stay at base torturing students by examining them; and such visits could be tax-deductible. It was a no-brainer. So over the next ten years or so two PhD students and several undergraduates did the work under his guidance.



RHODODENDRON YUNNANENSE, *R. VERNICOSUM* AND OTHERS GROWING ON LIMESTONE IN NORTH-WEST YUNNAN, CHINA

DAVID RANKIN



RHODODENDRON TELMATEIUM GROWING WILD, WITH THE SOIL CUT AWAY AT THE ROOTS TO SHOW PURE POWDERED LIMESTONE
 DAVID RANKIN



FINELY POWDERED LIMESTONE WASHED BY SUMMER RAIN FROM GLACIAL MELT CREATES THE SOIL IN WHICH RHODODENDRONS GROW
 DAVID RANKIN

THE CHEMISTRY

First they analysed samples of soil, which confirmed the visual evidence. The rock was real limestone, calcium carbonate, with very little of the magnesium that characterises dolomite. And the roots of healthy rhododendrons were growing in contact with the soil, which was substantially, even almost entirely, limestone, with pH up to 8.4, the maximum possible for calcium carbonate.

Before they could answer questions about how rhododendrons managed to survive in such conditions, they first had to find out why they didn't grow well or at all in apparently similar conditions in cultivation. This work was done by Maria Kaisheva, whose entire PhD thesis is available on line³. Most importantly, she showed, by analysis of leaves and of soil, that unhealthy cultivated rhododendrons usually have manganese deficiency.



COLLECTING A SOIL SAMPLE FROM THE ROOT ZONE OF *R. CUNEATUM* GROWING ON LIMESTONE SOIL
 DAVID RANKIN



THE pH OF SOIL AT THE ROOTS OF MANY WILD RHODODENDRONS WAS MEASURED
 DAVID RANKIN



RHODODENDRON VERNICOSUM STRESSED BY MANGANESE DEFICIENCY SUFFERING FROM FUNGAL INFECTIONS

DAVID RANKIN



AN UNTREATED CULTIVATED PLANT WITH MANGANESE DEFICIENCY IN COLIN'S GARDEN SUFFERING FROM DEFOLIATION

COLIN MUGRIDGE

That was critical, more so than deficiency of iron. That can also occur, but it is usually stated simply that it is lack of iron that is the problem. Both metals become increasingly insoluble at higher pH, and so are less readily available to rhododendrons. Excess of calcium, which is the metal constituent of limestone, is completely irrelevant, and the carbonate is only indirectly relevant, acting to raise the pH of the soil. It also became apparent during this work that plants that are stressed by deficiency of manganese (or iron) are prone to attack by all sorts of pests and diseases.

So how do rhododendrons in the wild avoid suffering from a shortage of manganese? Work throughout the ten-year project involved analysis of various elements in both leaves and soils, in both wild and cultivated plants. Results have been published^{4,5,6} or are available in Maria Kaisheva's PhD thesis³, so we just summarise the crucially important discoveries here.

A big surprise was that healthy rhododendrons (and other *Ericaceae*, and *Camellia*, and *Eucryphia*, but not *Magnolia*) accumulated large amounts of manganese in their leaves. Huge amounts. In most plants manganese accounts for between 30 and 300 ppm of the dry weight of the leaves. Less than that, and they are deficient; more and they suffer from manganese toxicity. But rhododendrons usually have much, much more, up to 5,000 ppm even 15,000 ppm has been reported in blueberries (*Vaccinium* spp.), and accumulation continues throughout the lifespan of individual leaves, which can be up to six years in some species.

Could it be that decaying leaves of healthy rhododendrons act as a slow-release fertiliser for manganese? Our studies showed that plants growing even in the most extremely limestone-rich soils had sufficient manganese (and iron) to survive. Initial establishment of young plants on limestone soil would involve decay of leaves blown or washed in from plants growing nearby, but once there was a healthy population it could become largely self-sustaining. That was our hypothesis. But hypotheses need to be confirmed or rejected by experiments. We needed to plant a field with large numbers of *Rhododendron* plants, mulch some of them with leaves from elsewhere, and vary the soil pH, monitoring the death of the plants. The cost would be enormous – totally impracticable.

Which is where Colin came along – with effectively a field full of rhododendrons, planted in soil with a high pH, due to the limestone in the soil. He had read the early publications about this research and contacted David. Together we thought through the situation, and worked out what we could do. Would treating the plants with a foliar feed of manganese save them? Would mulching them with *Rhododendron* leaves keep them healthy? If so, could they become self-sustaining?

GROWING RHODODENDRONS IN A LIMESTONE QUARRY - UNSUCCESSFULLY

In the years before he came across David's research Colin tried other approaches to saving his plants. Throughout his experiments he left a

group of four plants untreated as a control, i.e. as a standard against which treated plants could be compared.

First he attempted to lower the soil pH from 7.4 by mixing it with peat and adding sulfur pellets, aiming to produce a growing medium of pH 5 – 6.5, which is the normal range for successfully growing rhododendrons and other ericaceous plants. After planting he spread more sulfur pellets on and around the root plate in an attempt to further acidify the soil, but it is difficult to incorporate in the soil after plants are present, so it is best done first. Soil bacteria convert the sulfur to sulfuric acid, thus lowering the pH. Application in spring provided the best results, as the bacteria are active when the soil is moist and warm. The soil temperature needs to be above about 13°C. Aerating the soil and irrigation to maintain soil moisture helped to speed up the process.

Colin cannot say that this technique was particularly successful. The plants survived, but they did not thrive. After a couple of seasons he decided to take a different tack, using aqueous sulfates to lower the pH. Ferrous sulfate reacts rapidly to lower soil pH, but it is more expensive than sulfur and eight times as much is needed. Aluminium sulfate also acidifies soils quickly, but it can be toxic to rhododendrons if high rates are applied.

Whatever he did, after about two years the plants grew poorly and began to show chlorosis. The problem is that if the soil contains limestone, it continues to dissolve. The huge reservoir of calcium carbonate will in time eliminate the relatively small amounts of whatever is added to

the soil. Either the treatment must be continued indefinitely, or the pH will rise and the rhododendrons will suffer from chlorosis and ill health. If the limestone has been covered with a layer of acid soil, eventually diffusion of ground water up into the root zone brings dissolved limestone. Either way, it is bad news; the treatment eventually fails.

If treating the soil didn't work, how about treating the plants themselves? Assuming that it was iron deficiency that was causing chlorosis, iron needed to be provided in a form that the plants would accept. Most soils contain plenty of iron, but at high pH it is predominantly in the form of insoluble oxides, and not available for uptake by the plants. The alternative approach is to make the iron available directly to the leaves, by using a foliar spray during the growing season. Such treatments can produce a quick response, often in a matter of days, but they need to be repeated frequently. Colin sprayed his plants every ten days to two weeks from April to September with the chelated iron fertiliser Fe EDDHA Regular. Chelates hold on to the metal tightly, releasing it slowly to the plants, in contrast to ferrous salts, which have iron immediately available, but are rapidly oxidised in soil to insoluble oxides. As a foliar spray, however, ferrous sulfate can be effective, and it is not expensive.

But providing iron in this way did not solve Colin's problems. The rhododendrons continued to grow poorly, and he decided that now, after nearly four years of setbacks and lack of progress, it was time to abandon his experiments and leave the plants to their own devices. After all,



HYBRID RHODODENDRONS PLANTED IN COLIN'S LIMESTONE QUARRY
COLIN MUGRIDGE



ATTEMPTS TO TREAT THE SOIL CHEMICALLY WERE NOT SUCCESSFUL
COLIN MUGRIDGE

there were over 400 of them. They were now a lot bigger after four years of growth, even though the growth was poor and stunted, and the time and effort involved was prohibitively high. It appeared that the great plant collectors had been mistaken; the current belief that you cannot grow rhododendrons on limestone seemed to be correct. Colin decided to make one more play of the dice. He would google 'growing rhododendrons on limestone' one more time and see what the internet came up with.

GROWING RHODODENDRONS IN A LIMESTONE QUARRY – SUCCESSFULLY

Colin's search took him to an article by David, which summarised the chemistry⁶. *Nonconformist Rhododendrons* was originally written for the Scottish Rhododendron Society and then archived online by the Victoria Rhododendron Society. At that time the chemist had a hypothesis about how to grow rhododendrons on limestone, but needed to experiment on a field full of plants. The gardener had a quarry full of unhappy plants, and wanted to know what to do. And so began a correspondence and a series of meetings, over more than ten years, that has been most productive⁷.



AFTER TREATMENT WITH A MANGANESE FOLIAR SPRAY, RHODODENDRON DECORUM AT LAST GREW HEALTHILY
COLIN MUGRIDGE

Applying the principles set out by David and his co-workers of how rhododendrons and other ericaceous plants are able to succeed in calciferous soils, Colin was able to modify his approach. Previously he had found very little information in any books or any advice that he could take from the internet that indicated the importance of manganese for growing rhododendrons on limestone, but now he realised that it was the most essential element that was lacking. Like iron, but even more so, it gets locked up as insoluble oxides and related compounds at high pH.

He therefore started applying manganese as a foliar spray. He mixed his iron chelate spray with a manganese chelate spray and this combination provided all the nutrients that his rhododendrons required. Within a few weeks the plants became greener and eventually the chlorosis disappeared. In the following seasons the plants were restored to their optimum growing characteristics: green, vigorous and free of disease. Success at last! Then David pointed out that expensive chelate compounds were not essential for foliar sprays and that ordinary soluble iron and manganese salts would be sufficient. Indeed they were. Relatively cheap ferrous sulfate and manganese sulfate were all that were required.

Although Colin had now found the key to growing rhododendrons on limestone successfully, he was not prepared to spend a large amount of garden time tending just rhododendrons. After all it was a large garden (over two acres) and there were many menial tasks to be accomplished. He continued with these sprays throughout that current growing season, but significantly he had largely ignored what was going on in the rest of the garden with the rhododendrons that he had left to cope on their own. Inadvertently he had started the second experiment that was needed.

Colin brought to the garden over 400 rhododendrons, far more than he was able to attend to, with the workload of the spraying that was required. He had no choice but to leave the majority to their own devices. There was only a limited number that he was able to attend to on a regular basis, spraying and feeding. The remaining plants grew poorly, and he was afraid that he was going to lose them all. Fortunately the garden is sheltered, not exposed to the prevailing



ACCUMULATED FALLEN LEAVES DECAY SLOWLY, RELEASING MANGANESE TO RHODODENDRON PLANTS GROWING IN LIMESTONE SOIL COLIN MUGRIDGE

wind. It is also large, and tidying up fallen rhododendron leaves from under plants was not a priority. Consequently, they accumulated underneath the growing plants, eventually breaking down to provide a mulch. This inaction was critical in his eventual success. The following season he abandoned the constant attention of spraying and watering plants, but unexpectedly nearly all the rhododendrons ‘took off’, first the ones in raised beds, then the ones planted in the ground. Even the control plants started to grow well, and it was only with the knowledge that he had gained from David’s research that he was able to realise what was happening. The manganese slowly being released by the decaying leaves was providing what was needed by the growing plants.

Today the garden is full of thriving large rhododendrons, some over 10m high, and Colin has not found a single rhododendron, either hybrid or species, that does not thrive in

COLIN'S QUARRY GARDEN IS NOW FULL OF HEALTHY RHODODENDRONS

COLIN MUGRIDGE



his pH 7.4 soil. He has also had the same success with camellias. The great plant collectors were correct – you can successfully grow rhododendrons on limestone!

GROWING HYBRIDS

Colin started breeding rhododendrons some 40 years ago, but with limited time while he had a full-time aviation career, his early attempts only produced two or three good hybrids. Since his retirement in 2000 he has had more time, which he has devoted to producing some good hybrids, carefully choosing parents and being ruthless in culling poor

offspring⁸.

He made ten crosses shortly after retirement; nearly 20 years later he is still seeing these plants coming into flower, and there are still some to show their qualities in future years. These ten crosses produced about 3,000 seedlings. Ten trays containing about 300 seedlings each don't occupy much space, but ten years later and still waiting for many to flower would involve 3,000 large plants in pots. He does have land available, but entrusting so many seedling rhododendrons to

the limestone soil would be too much of a risky experiment. So he decided to grow them all in pots rather than in the open ground, and deal with the watering, the repotting every year and nematode application to prevent vine weevil infestation.

Of every 100 seedlings, no more than five or six were worthy of registration and naming, leaving an almost endless supply of hybrid rhododendrons to experiment with. Their numbers were reduced by waiting until they flowered, then selecting the best to plant out in raised beds on the limestone where they were carefully looked after using the methods we describe in this article. A by-product of rejected plants was their leaves, which were used as mulch in the new beds to create a manganese-rich environment. Four rejects were used as control plants. It really did not matter if they died, as there was no expense involved.

Colin produced some good hybrids and was encouraged by friends and family to register and name some as well as enter the RHS competitions. He did rather well and in 2017 won the national competition and was awarded the Crosfield Challenge Cup for three hybrids raised in the garden of the exhibitor. He has continued to produce some high-quality hybrids and decided to donate his collection of hybrids to the Royal Horticultural Society. They kindly accepted his offer, and they are now planted out in the new RHS Garden Bridgewater, which is due to open in May 2021. Bridgewater have named one of his hybrids after the garden and called it 'Bridgewater Beauty'.

RECIPE

Growing young plants in pots. Nothing special needs to be done. You can buy ericaceous compost, including peat-free, or you can make your own. Colin makes his from garden compost of pH 5.0–6.5, mixed with composted *Rhododendron ponticum* leaves. Rhododendrons do not require much fertiliser so



ALL COLIN'S HYBRIDS GROW WITHOUT DIFFICULTY AND WITHOUT TREATMENT

COLIN MUGRIDGE

there is no need to add more. Grow plants in the usual way until they are ready to plant out.

Planting. There is no need to prepare the underlying soil except for a light forking. Place the rhododendrons on top of the soil, not in it. But you want a mulch of rhododendron leaves to collect around and on the root plate, so ideally plant at least three rhododendrons and preferably more, so that there is at least a level surface between the plants where the mulch will be retained. If you plant a single rhododendron then a mound is formed, so create a low barrier around it so that leaves collect around the root plate. Spread your compost mixture around the plants so that the surface is level with the top of the rhododendron root balls and firm the mixture around them.

Mulching. While the plants are establishing, mulch them with rhododendron leaves spread around and over the root plate. Eventually they should take care of themselves, but you can always top up the mulch. Colin used *Rhododendron ponticum* leaves from local wood clearance, but be aware of *Phytophthora*. Otherwise you can use clippings from overgrown rhododendron plants. One surprising source of manganese is used tea bags. Tea is made from the leaves of *Camellia sinensis*, and camellias, like rhododendrons, are manganese accumulators. Whatever you use, it is helpful to



A SELECTION OF COLIN'S MANY NEW HYBRIDS
(TOP, LEFT TO RIGHT): 'EMILY FISHER'; 'FERN'S FAVOURITE'
(CENTRE, LEFT TO RIGHT): 'REASTY HILL'; UNNAMED HYBRID
(BOTTOM, LEFT TO RIGHT): 'BRIDGEWATER BEAUTY'; 'WHISPERING GIANT'

COLIN MUGRIDGE

spread twigs and other debris around the plant base to prevent the wind dispersal of the decaying leaves. In this way, manganese-rich leaf mulch will build up and the recycling of the leaves ensures continued healthy growth.

Spraying. No further intervention should be required, but if plants show signs of chlorosis, then apply a foliar spray of a 1% solution of manganese sulfate and a 1% solution of iron (ferrous) sulfate every few weeks during the growing season. They can be mixed. You only need to spray enough to wet the leaf surface. Adding washing-up liquid to the solution helps this. Manganese sulfate comes as its monohydrate, $MnSO_4 \cdot H_2O$, and ferrous sulfate as its heptahydrate, $FeSO_4 \cdot 7H_2O$. Do not confuse manganese sulfate ($MnSO_4$) with magnesium sulfate ($MgSO_4$ – Epsom salts). Current proprietary brands of ericaceous fertilizers are not recommended because they contain very small amounts of chelated manganese, which is not released fast enough in sufficient quantity for this purpose.



CLIPPINGS FROM OVERGROWN RHODODENDRON PLANTS CONTRIBUTE TO THE MANGANESE-SUPPLYING MULCH
COLIN MUGRIDGE

CONCLUSIONS

Our experience has shown that problems associated with growing rhododendrons (and camellias) on limestone can be overcome. We have not found any that can't be grown. Limestone-induced manganese deficiency can be treated by mulching with decaying leaves from healthy rhododendrons, eventually becoming self-sustaining, and/or by foliar feeding.



BEFORE AND AFTER: (LEFT) PART OF THE GARDEN BEFORE PLANTS HAD BECOME ESTABLISHED IN THE MANGANESE-RICH LEAF MULCH; (RIGHT) RHODODENDRONS ESTABLISHED IN MANGANESE-RICH LEAF MULCH
COLIN MUGRIDGE

We have only done this one experiment, although on a large scale over many years. We hope that other people will be encouraged to 'give it a go'. Keep records and photographs, and please report both successes and failures. Chalk soils may well be trickier. They are often very dry, and that causes additional stress to the plants; maybe enough to tip them over the edge. Please let us know how you get on.

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is a retired RAF pilot and British Airways captain. Colin has won many awards for his hybrids including first prizes at Ness Gardens, Harlow Carr and Rosemoor, and 'Best in Show' at Ness. In 2017 he was awarded the prestigious Crosfield Challenge Cup at Rosemoor for three of his hybrids. An historic collection of his hybrids is to be established at the new RHS Garden Bridgewater, near Salford, Manchester cmtc.mugs@btinternet.com