Combined Proceedings IPPS 74:152-161. 2024.

Understanding Evolutionary Biology of Lavender for Successful Nursery Production

Clive Larkman

Larkman Nurseries, 7 Jurat Rd, Lilydale VIC 3140, Australia

clive@larkmannurseries.com.au

Keywords: *Lavandula*, physiology, origin, adaptation

Summary

For success, operators of plant production nurseries need to understand not only the morphology, but also the physiology, evolutionary biology and genetics of the plants they grow. This aspect is discussed in relation to flowering and production of lavender flowers and oil. The main cultivated species are *Lavandula angustifolia*, *Lavandula latifolia* and their naturally occurring hybrid *Lavandula x intermedia*. These species originated in the northern Mediterranean in southern France under a dry temperate climate with drought conditions in the summer. Soils are low in nutrients except for high levels of calcium. How the understanding of evolutionary biology of lavender and its adaptation can help increase lavender flower production in nurseries is discussed with examples from author's own experience as well as from a field experiment.

INTRODUCTION

I have been involved in a wide range of industries since my teenage years. The majority have been micro to small enterprises and from entry level employee to owner and managing director. It is well accepted that to make anything a success takes hard work but what is often overlooked is that it also takes understanding, wisdom and clear thinking.

There have been millions of reviews as to why some organisations fail and others succeed. The key ingredient is the ability to analyse, understand and interpret the basic principles of the main component of the business. This is independent of industry, industry sector, product or service. It is most important for small, new and emerging industries – like lavender.

Lavender produces three major products – fresh flowers, stripped and dried flowers, and oil. The demand for oil and stripped and dried flowers is building within Australia, and shortages are regular occurrences. There is a worldwide demand for lavender oil and stripped lavender flowers which can be counter seasonal to Australian production. Australia currently imports large quantities of both products creating a market opportunity for both export and import replacement.

As mentioned above the path to success in small business is the base level of understanding. In horticulture this means that a solid understanding of the biology of the key plants is critical but often overlooked. Not just the morphology but the physiology, the genetics and the evolutionary history. All add up to give a connection to the plant.

TAXONOMY, BOTANY AND PHYSIOLOGY OF *LAVANDULA*

The genus *Lavandula* belongs to the Lamiaceae (or Labiatae) family commonly referred to as the mint family. Lamiaceae is a member of the Division Magnoliophyta, Class Magnoliopsida and the Order Lamiales. The family consists of more than 236 genera and has been stated to contain 6900 to 7200 species (Xu and Chang 2017). These are from all parts of the world with the greatest number occuring in the Mediterranean.

Lamiaceae includes plants that are of some economic importance around the world as sources of aromatic oils and for their culinary uses. The majority are aromatic shrubs. The stems are quadrangular with simple, opposite or occasionally whorled leaves. The main genera are; *Teucrium, Salvia, Mentha, Origanum, Thymus, Rosmarinus* and in Australia *Westringia* (the native Rosemary) and *Prostanthera* (the native Mint Bush) (Upson and Andrews, 2004). Some species of Lamiaceae are shown in **Fig 1**.

As an evolutionary botanist I have a passion for why plants grow where they do. I often say that 'plants grow in the area of greatest adversity'. This means that many plants grow in the harshest conditions they can tolerate better than other plants. The other key concept for plant growth is that we should treat all plant species as a smart human with one purpose; to produce strong viable offspring and this is best done if they can control when and where their seed germinates. The aim of each plant is to produce viable seed that germinates when the local environment is most conducive to successful growth.

Figure 1. Some species of Lamiaceae. **A**) *Thymus longicaulis*, **B**) *Salvia officinalis* and **C**) *Salvia rosmarinus* [syn: *Rosmarinus officinalis*].

Taking these two concepts on board, it is possible to understand the best conditions for plant growth and seed production. Even asexual propagation is influenced by these parameters. It involves timing that is directly related to the movement of nutrients, water and hormones around the plant. Also timing so that cuttings are not taken when a plant really wants to flower. It is this solid understanding of plant physiology and plant evolution that is critical to developing the highest yielding plants. Indeed it is the best option to ensure plant survival in less than ideal conditions. Like humans, plants need a program of good conditions, good food and the right inputs to perform at their best. When well fed they are better able to grow through poor conditions and less susceptible to pests and disease.

The genus *Lavandula* is divided in to three subgenera: *Lavandula*, *Fabricia* and *Sabaudia*. These are in turn divided into eight sections. Some are large and well known and some are small and rarely seen. Subgenus *Lavandula* is of significant economic value to the horticultural industries. It includes the three sections that produce all the commercial oil forms, all the cut flower forms and most of the ornamental and pot varieties i.e. Sections Lavandula, Dentatae and Stoechas.

The section with real commerical concern is *Lavandula* and it is by far the most important. All the forms have narrow, lanceolate leaves with entire margins. The flowerheads are borne atop long slender peduncles. Most of them have small florets arranged in whorls in long flower spikes with oil sacks at the base of each floret. These oil sacks are why lavender is grown in such large quantities and it is the composition of that oil that determines the value and use of the plant.

EVOLUTIONARY BIOLOGY OF *LAVANDULA*

The main cultivated species are *Lavandula angustifolia*, *Lavandula latifolia* and their naturally occurring hybrid *Lavandula x intermedia* (**Fig. 2**). With thousands of years of cultivation it is surprising there is so little known about the biology of these species. They come from a small geographical range on the northern side of the Mediterranean in southern France. The only geographic variance between the three is the altitude they prefer to grow at and thus their preferred temperature range. The natural growing region is the area called Provence on the Italian/French border along the Mediterranean sea (**Fig. 3**). The region runs from the sea to the Haute Alps in the north along the Rhine river in the west and the Italian border in the east. High points are Mt Ventoux at 1900m in the Sault region and the Maritime Alps at 3500m (Demasi et al. 2021).

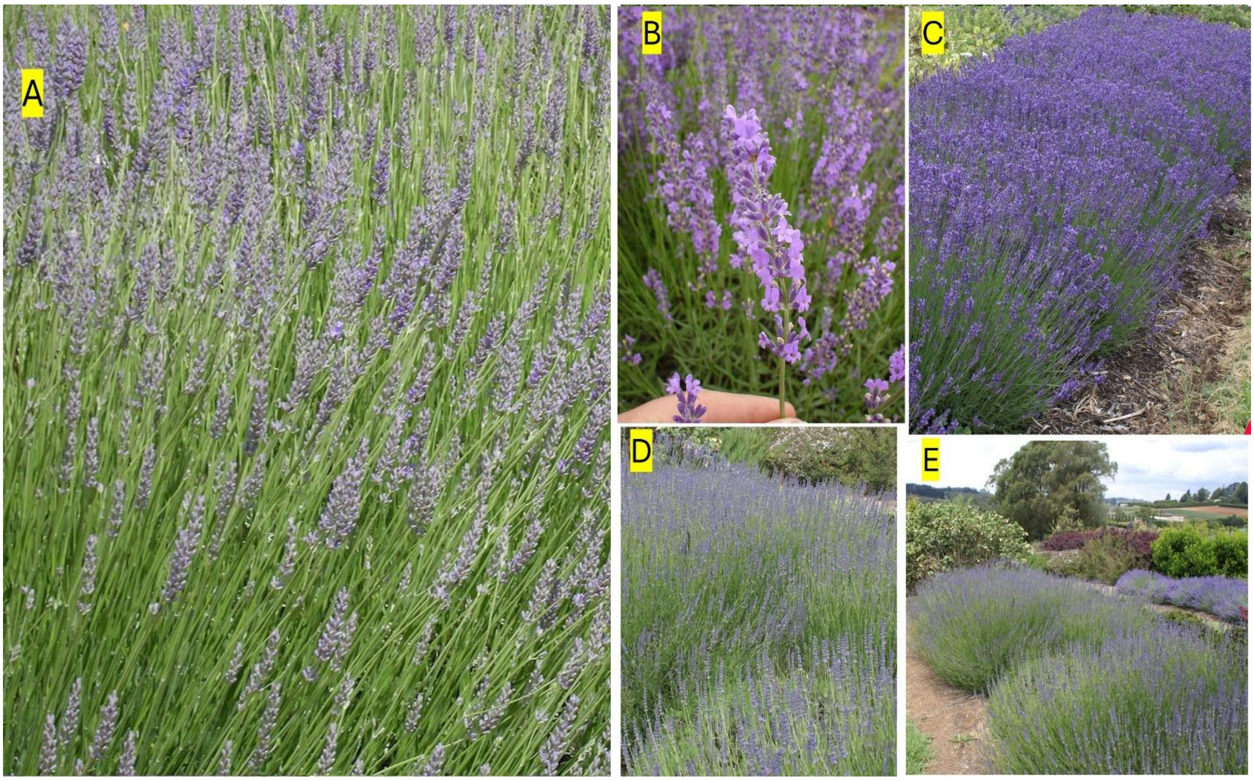

Figure 2. Three common Australian cultivars of the three *Lavandula* species: **A**) *Lavandula latifolia*, **B**) and **C**) *Lavandula angustifolia*, and **D**) and **E**) their naturally occurring hybrid *Lavandula x intermedia*.

Figure 3. Geography of origin of cultivated lavender, showing Provence, the historical province and geographical region in southeastern France that is almost the same as the modern administrative region of Provence-Alpes-Côte d'Azur (PACA). PACA is also known as Région Sud, which means "Southern Region".

The climate here is dry temperate with drought conditions over the summer period. The winters are generally mild and there is lots of intense sun – especially during summer and autumn. In a rough generalistion *L. angustifolia* comes from above 1000 m, *L.latifolia* comes from below 1000m and *L. x intermedia* from a band around the 1000 m contour. Although the lines are quite distinct in Provence the plants will all grow under similar climatic conditions elsewhere.

The environment is referred to as a Mediterranean Climate and can be summarised as hot dry summer days, cool dry summer nights, wet winters in low altitudes and heavy winter snows in higher altitudes. The summer dry goes from mid spring until late autumn and although there maybe some heavy rains over the period it would never be called wet at anytime. The summer day length is long – around 15 hours in mid summer. The winter low temperatures are well below zero in the upper valleys but milder in the lower valleys and along the coast. The mean temperature and precipitation in this region is given in **Fig. 4**.

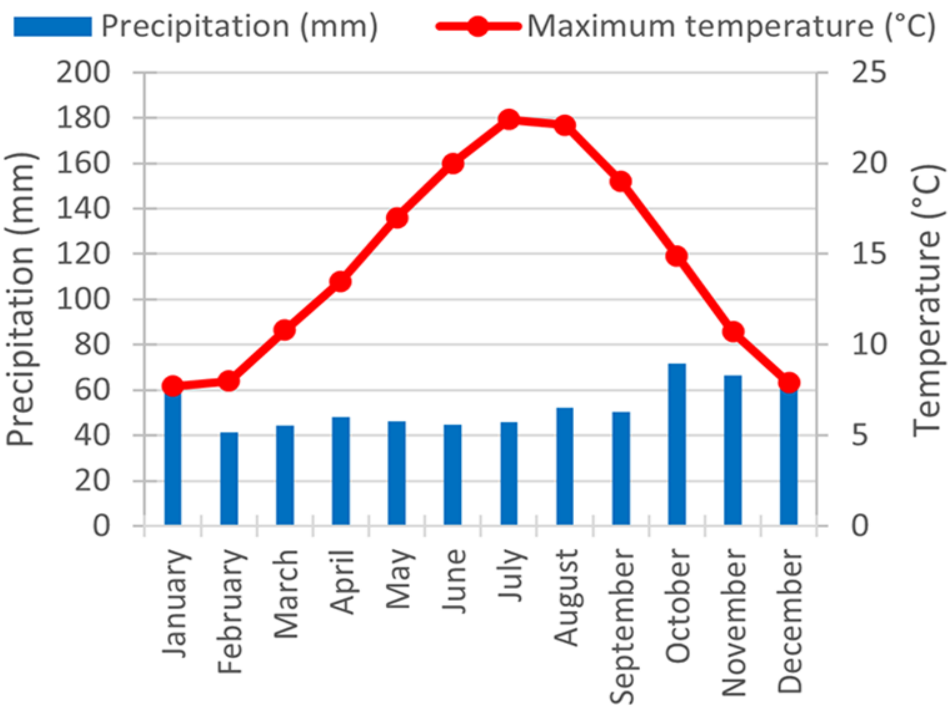

Figure 4. The mean temperature and precipitation in the in Provence region in southern France where cultivated lavender originated,.

The high mountains adjacent to the sea with large interior plains to the north create the perfect conditions for regular, strong dry winds. In this part of France they are called the Mistral and basically blow cold dry air from north to the south. They help to keep the humidity low and the sky clear. They are at their strongest in late winter and early spring which is when most temperate regions have the highest humidity. The winds can clear a cloudy, overcast sky in a matter of hours and leave clear sunny skies. It is thought that this region can have up to around 3000 hours of intense sun per annum. This added sunshine and dry air brought by the Mistral have an important effect on increasing the dryness. The light volumes and dry air have created a unique environment that has given lavender, rosemary and similar plants a world of their own.

As light and rainfall are critical for plant growth so is the substrate in which they set roots. The geology of Provence is unique and sometimes it is hard to understand how anything grows there. As mentioned above the evolution of plants is an interesting science and can be quite convoluted. The physiology of lavender (and other Provencal plants) has its origins in the Jurassic Period when the super continent Pangea started to split up. Over 150 million years the earth went from one super continent to the seven continents we know today (**Fig. 5**). The mountains of

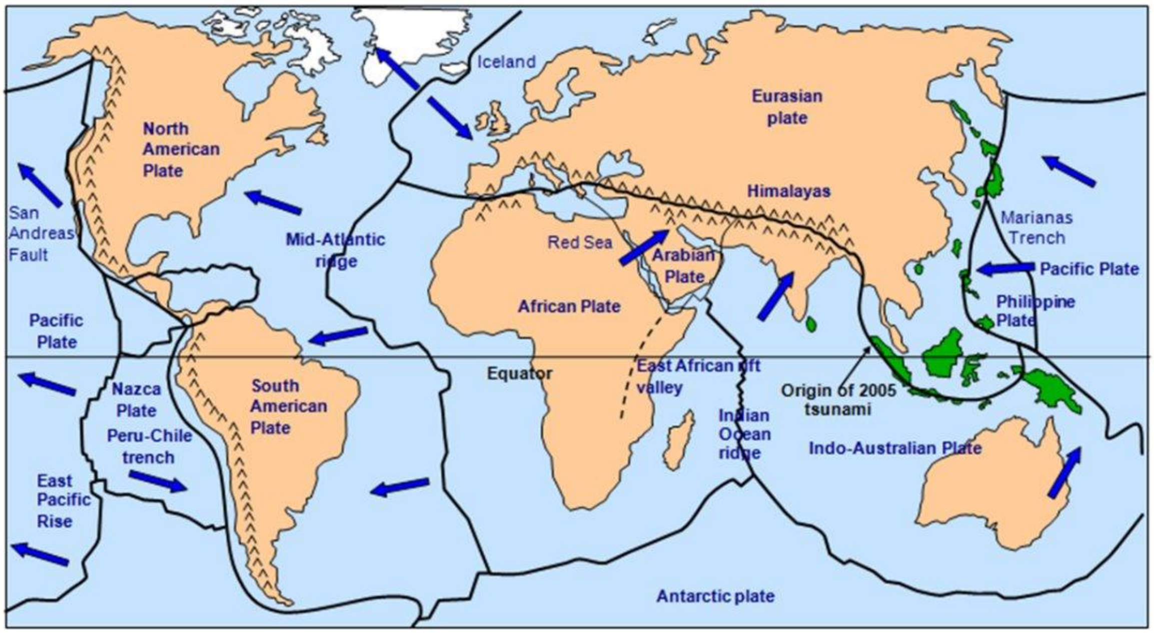

Figure 5. Formation of continents and forces that drifted continental plates.

Provence were created from several 'crashes' of land from Africa into Southern Europe. They forced up land that had been underwater for tens of millions of years and was rich in calcaerous fossils. This created the calcium rich mountains of the region.

The geology of the hills and valleys of Provence is the complete antithesis of what we feel is good growing soil. It is basically straight limestone with an overlay of more limestone. The substrate is solid rock and the topsoil is very gravelly. The type of gravel varies across the region and for some plants the variations are important (e.g. grapevine) whereas for others they have little effect. The gravels range across sandstone, shale, gypsum, lime and some clay – none of which are high in nutrients. All except the clay are very well draining and add to the dry growing conditions. The ground lavender grows in is basically the white calcareous gravel which reflects the intense light back up on the plants. This situation increases the dryness and produces even higher light volumes meaning even more stress on the local plants.

Understanding the geography and geology of lavender details the world this specialised plant has adapted to. In summary, it is an environment of very high light levels, dry air and soil, defined seasons, low soil nutrition and extremely high Calcium levels. As stated above plants evolve to live in the area of greatest adversity. This means they don't prefer these conditions in which they exist but can deal with them better than other plants.

HOW CAN WE APPLY THE KNOWLEDGE TO GROW A SUCCESSFUL LAVENDAR CROP?

To develop the best lavender farm the grower needs to address each of the issues discussed above in a balanced approach. Some need to be replicated (e.g. sun, dryness) and others need to be adjusted for (e.g. Calcium, low nutrients) so as to get optimum growth – and yield. These two approaches are not the same and in some cases are actually contradictive. For best yields per acre it is imperative to understand all the inputs for good growth and how they affect yield.

For decades it was assumed that lavender needed high pH to grow. In reality it needs very high levels of Calcium with a period of wet soils and dry air. Without these it will have low Calcium levels in the plants meaning weak cell walls and thus subject to fungal diseases.Also, calcium exhibits a dual function, both as a structural component of cell walls and membranes and as intracellular messenger. Once mature, lavender needs minimal levels of fertiliser. If oil is the end product and all the discharge from the still is put back on the farm; the levels are in the 100s of grams per acre.

Another key input for healthy and productive plants is light. Unlike humans that need light for vitamin production and psychological health, plants need it for their very existence. There are very few plants that have been able to adapt to very low or zero light. Both plants and animals respire or breathe and expel CO_2 and water, but only plants photosynthesise to absorb CO_2 and produce O_2. It is this balance between the production of CO_2 through respiration and the absorption by photosynthesis that keeps the earth in sync.

Light has the greatest influence on when and how a plant grows. Too little and a plant will "stretch" to get more, too much and the plant will "burn". Unlike every other input into plant growth, light is not simply there or not there. Granted there is the blunt observation that a plant needs light and without it there is no growth. However, there is more to a plant than just growing or not growing. There are a range of growth styles and these have a range of controlling inputs. To start with there is light and then there is light strength, light periods and light volume. Each of these have a major effect on the plant growth cycle depending on the plant and where it comes from. Before looking at how light controls lavender growth we need to understand the parameters that define how light determines plant behaviour. In summary there are three major criteria, the length of daylight, the volume of light received by a plant each day and finally the intensity or strength of that light.

The length of daylight or photoperiod has its own set of criteria that are complex and affect various components of the plant's growth cycle. These are actual daylength – i.e. the number of hours in the day that the sun is 'shining' compared with the number of hours of 'darkness'. The ratio of day to night, termed as short or long daylength and finally the changes in daylength. This can be referred to as increasing or decreasing daylength. Some plants respond to the relative daylength or the changes in daylength. The options are complex and varied.

Then there is the strength and volume of the light. For some plants a certain intensity of light is required for growth or flowering whereas others require a minimum number of light units per day. This can occur in two hours or ten - independent of the daylength. Two hours of clear skies may yield the same volume of light as ten hours of partial cloud cover. This is what controls flowering in lavender. Plants flower earlier and better when the spring skies are clear compared with an overcast spring. Lavender grows in a region with distinct seasons with definite changes in daylength and high light levels – when the sun is shining.

There are also distinct humidity variations between seasons and regular temperature ranges. As mentioned above the mountains and valleys of Provence are subject to the strong early spring winds. They do two things; they create clear blue skies in early spring and also blow away any residual humidity from the wet winter and the melting snows.

TESTING OF OUR UNDERTANDING OF *LAVANDULA* EVOLUTIONARY BIOLOGY IN A FIELD TRIAL

In 2019-2021 we undertook some research in conjunction with Latrobe University. The aim was to analyse the application of different fertilisers in conjunction with the changing seasons. This was done at a farm with poor soils northwest of Melbourne, Victoria, Australia. We were also collecting and growing plants at the University to trial some of the fertilisers in a controlled environment. There was a range of plants across the three groups mentioned above. Half in a polyhouse with 100% environmental control and half in a shade house with natural humidity levels. There were very similar light levels in the two spaces.

We observed the plants in the high humidity were just entering bud whilst those in the low humidity shade house were in full flower. This was strange as the expectation would have been for the plants in the poly house, with a small amount of extra light would flower first. What was more surprising was that as soon as the plants were moved into the shade house they came into flower. The question is why? The assumption by most people is that lavender flowering is initiated by daylength or photoperiod. Problem is that if this was the case the flowering period for a lavender farm would be almost identical every year and independent of cloud level. For a given latitude/longitude the day length cannot vary. The light intensity may vary causing the plant to have small changes in flowering time. Also, we often observe that sometimes lavender flowers at completely odd times after potting. We have some plants in quarantine that are budding up now in May – probably due to them coming from the northern hemisphere in March. However, as mentioned earlier the key to plant success is to think about the plant and where it originates. As a species these plants know that the best time for the young seedlings to start life is early autumn when the summer heat breaks and the autumn rains come. The seed takes three months to ripen after the flowers being on the plant for one month. The flowers need three months to bud and grow. This means that the young buds need to initiate seven months prior to the rains which is the end of winter. At that time the air is suddenly becoming dry and the sky is clear. The plant knows that when the air dries out it is time for the flowering organs to start forming then when sufficient light is accumulated the buds can form and the flowering stems can grow. This results in seeds falling in late summer and germinating in early autumn.

This is conjecture and the laboratory experiments need to be conducted to prove or disprove it. However, assuming it has some substance it shows how important it is to understand where a plant comes from, what the environment does in that region and how you can replicate it to control flowering (or not to prevent flowering) and plant growth. The concept is understood and managed with some crops like poinsettias and is part of the breeding for other plants like strawberries but not used in the production of most plants.

The message here is that this understanding of plant evolution can have a significant impact on the bottom line and should be part of our thinking when planning plant production.

LITERATURE CITED

Demasi, S., Caser, M., Lonati, M., Gaino, W. and Scariot, V. (2021). Ornamental traits of *Lavandula angustifolia* Mill. are affected by geographical origin and cultivation substrate composition. Acta Hortic. 1331: 49-56. doi: 10.17660/ActaHortic.2021.1331.6

Upson, T., and Andrews, S. (2004). The genus *Lavendula.* Botanical Magazine Monograph. Royal Botanic Gardens, Kew, UK.

Xu, Z. and Chang, L. (2017). Lamiaceae. In: Xu,. Z. and Chang, L. (eds) Identification and Control of Common Weeds: Volume 3. Springer Singapore, Singapore, pp 181-265. doi: 10.1007/978-981-10-5403-7