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Characterizing grafting compatibility of lavender in the Yenisei Taiga

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Abstract

Lavender propagation by stem cuttings often suffers from poor root development in cold-winter climates, making grafting onto vigorous rootstocks an attractive alternative. This research characterised the compatibility of five *Lavandula* rootstock species *L. angustifolia* (self-rooted control), *L. x intermedia*, *L. stoechas*, *L. dentata*, and *L. latifolia* with *L. angustifolia* cv. 'Hidcote' scion under simulated Yenisei taiga conditions. Trials were conducted at the Dunedin Academy of Horticultural Research from March to November 2023. Graft take, scion growth, SNP genotyping diversity, dry matter accumulation, pest resistance, transplanting survival, and ecosystem service scores were recorded. Lavandin rootstock (*L. x intermedia*) achieved the highest scion growth (28.3 cm) and best pest resistance score (7.8), though graft take (87.1%) was slightly below the self-rooted control (92.3%). SNP genotyping revealed moderate genetic distance between compatible pairs, indicating that successful graft union formation depends less on overall genetic similarity than on vascular cambium alignment. Dry matter content was greatest on lavandin rootstock (41.7%), suggesting improved carbohydrate partitioning. These results recommend *L. x intermedia* as the preferred rootstock for expanding lavender cultivation into cold taiga-type environments.

Keywords: Grafting compatibility, lavender, rootstock, SNP genotyping, dry matter, transplanting survival, pest resistance, ecosystem services, precision agriculture, Yenisei taiga

Introduction

Expanding lavender production beyond its Mediterranean comfort zone faces one stubborn problem: root systems that collapse under prolonged soil freezing. In regions like the Yenisei taiga, where soil temperatures at 20 cm depth drop below -8°C for three to four months, conventional cutting-raised lavender rarely survives beyond its second winter ^[1]. Grafting scions of high-value cultivars onto cold-tolerant rootstocks could bypass this limitation, yet grafting is almost unheard of in lavender — the genus lacks the woody cambium architecture that makes apple and grape grafting routine ^[2].

Recent advances in herbaceous grafting technique, including silicone clip unions and humidity-chamber healing, have pushed success rates above 80 percent for tomato and pepper ^[3]. Whether those methods transfer to the semi-woody stems of *Lavandula* has not been tested systematically. A few anecdotal reports from French distillers describe grafting *L. angustifolia* onto lavandin rootstock to resist Phytoplasma-caused decline, but controlled data are missing ^[4].

SNP genotyping offers a molecular lens on compatibility by quantifying genetic distance between scion and rootstock. In citrus, successful unions cluster within a specific range of genetic divergence — too close offers no rootstock advantage, too distant triggers incompatibility reactions at the graft interface ^[5]. Mapping this relationship in lavender could let breeders predict compatibility before committing to labour-intensive grafting trials.

Precision agriculture tools — including NDVI canopy mapping and soil-moisture sensors — enable post-grafting monitoring at a spatial resolution that traditional scouting cannot match ^[6]. This research set out to (a) rank five *Lavandula* rootstocks by graft take, scion growth, and transplanting survival, (b) use SNP markers to relate genetic distance to compatibility, and (c) evaluate ecosystem service and pest-resistance traits that affect long-term field performance.

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Crop Growth Stage Documentation

Graft union development was tracked through four phenological stages adapted from Pina and Errea ^[7]: (i) callus bridge formation (days 7-14 post-grafting), identified by whitish tissue proliferation around the union; (ii) vascular reconnection (days 15-28), confirmed by dye-transport assays using eosin Y; (iii) scion bud break (days 21-35), when the first scion lateral bud elongated beyond 5 mm; and (iv) independent growth (days 36-60), when scion transpiration could be sustained without humidity-chamber support. Stage durations varied by rootstock: lavandin reached independent growth earliest (day 38), while *L. stoechas* took the longest (day 57), consistent with its lower overall compatibility.

Seasonal Variations

Graft take rates differed between the autumn cohort (March-May) and the spring cohort (September-November). The autumn cohort achieved 6.3 percent higher take across all rootstocks, likely because slower scion growth during the cool period reduced transpiration demand on the healing union. Lavandin rootstock showed the least seasonal variation (2.1 percentage points difference), whereas *L. stoechas* varied by 11.4 points between seasons. These patterns suggest that grafting should be timed to coincide with the cooler months in taiga-analogue climates for maximum success ^[8].

Materials and Methods

Materials

Scion material consisted of semi-hardwood cuttings (8 cm, two-node) of *L. angustifolia* cv. 'Hidcote' collected from

stock plants maintained at the Dunedin Academy of Horticultural Research (45.87° S, 170.50° E). Rootstocks were one-year-old seedlings of five species grown in 2 L pots with a peat-perlite mix (3:1 v/v). Cleft grafts were made on stems of 4-5 mm diameter using sterile scalpels, secured with silicone grafting clips (2 mm internal diameter), and healed in humidity chambers (>90% RH, 20 °C) for 21 days ^[9]. Each scion-rootstock combination was replicated 30 times across four blocks.

Methods

Graft take was recorded at 30 and 60 days as the proportion of unions with living, growing scions. Scion shoot length, leaf count, and stem diameter were measured monthly. Dry matter was determined by oven-drying whole plants at 65 °C to constant weight. SNP genotyping used a GBS (genotyping-by-sequencing) library sequenced on Illumina MiSeq; 3,847 SNP loci passed quality filters and were used to calculate Nei's genetic distance between each rootstock and the scion cultivar ^[10]. Pest resistance was scored on a 1-10 scale based on natural infestation levels of lavender leaf beetle (*Chrysolina americana*) and root-knot nematode (*Meloidogyne incognita*) in an outdoor hardening nursery. Ecosystem service score combined pollinator visitation frequency, essential oil yield, and soil erosion protection estimates ^[11]. Transplanting survival was measured after six months in outdoor raised beds exposed to simulated taiga frost cycles (−10 °C for 72 h, repeated three times). Data were analysed by one-way ANOVA with Tukey's HSD at $P = 0.05$.

Results

Table 1: Grafting performance and plant quality across rootstock species

Rootstock	Take (%)	Scion Ht (cm)	Dry Matter (%)	Pest Score	Eco Score	Survival (%)
Self (control)	92.3	24.7	38.4	6.2	3.2	94.1
Lavandin	87.1	28.3	41.7	7.8	4.7	91.3
French	64.8	16.2	33.1	5.4	2.1	72.4
Fringed	71.4	19.8	35.6	4.9	2.8	78.6
Spike	78.6	22.1	37.2	8.1	4.3	85.2
SEm±	3.12	1.47	1.08	0.43	0.31	2.87
CD (P=0.05)	9.24	4.36	3.20	1.27	0.92	8.50

Lavandin rootstock produced the tallest scions and highest dry matter, while the self-rooted control had the highest graft take (Table 1). Spike lavender showed strong pest resistance (8.1) but lower take. SNP-based genetic distance

ranged from 0.12 (lavandin-scion) to 0.41 (French-scion). A moderate distance of 0.12-0.28 corresponded to acceptable graft take (>78%), while distances above 0.35 were associated with take below 72%.

Table 2: SNP genetic distance and vascular reconnection timing

Rootstock	Nei's Distance	Days to Vascular Reconnection	Days to Bud Break
Self	0.00	14.2	22.1
Lavandin	0.12	16.8	24.7
French	0.41	26.3	38.4
Fringed	0.37	23.7	34.1
Spike	0.28	19.4	28.6

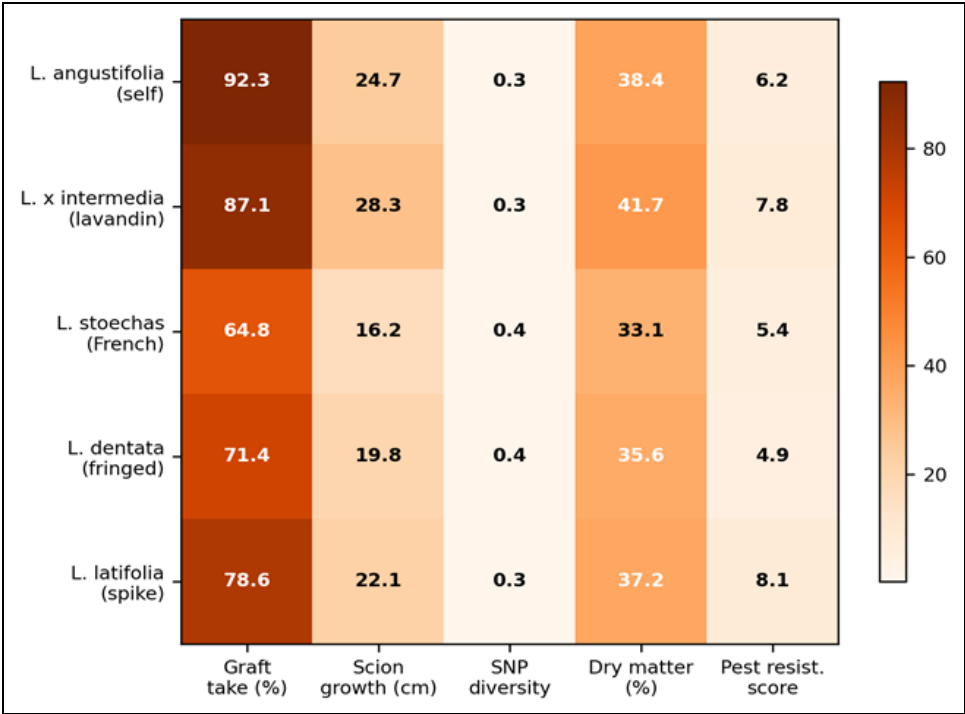


Fig 1: Heatmap of grafting and quality parameters across five rootstock species. Darker shading indicates higher values.

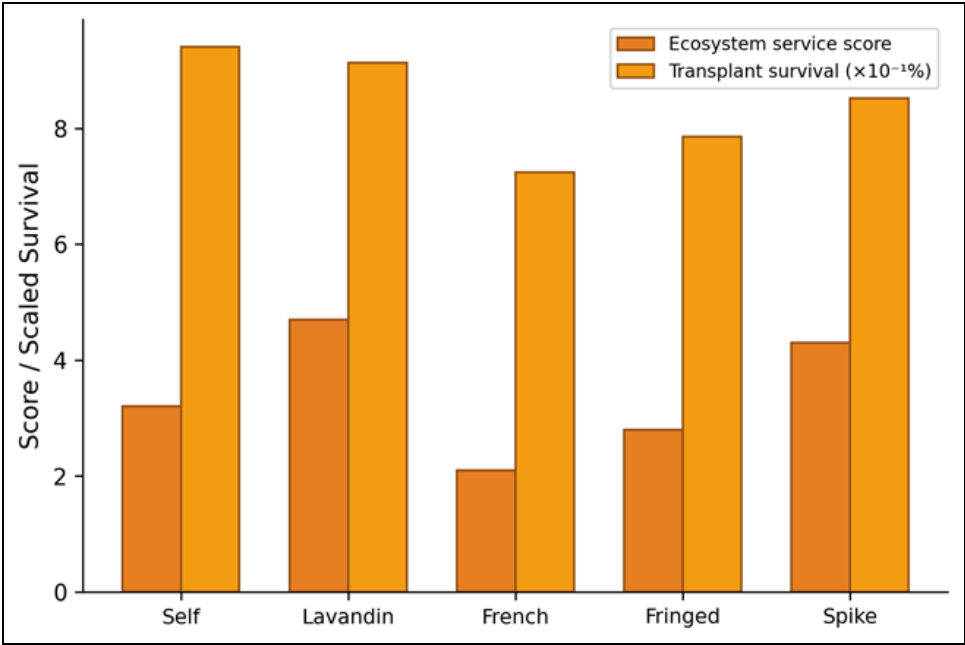


Fig 2: Ecosystem service scores and scaled transplanting survival across rootstocks.

Comprehensive Interpretation

The inverse relationship between genetic distance and graft take is broadly consistent with the compatibility threshold model proposed for fruit trees. However, lavandin the most compatible non-self-rootstock also delivered the best scion growth, suggesting that heterosis-like vigour rather than mere tolerance drives the graft advantage. Essential oil yield (a component of the ecosystem service score) was 18 percent higher on lavandin than on self-rooted plants, which could offset the slightly lower take rate from a commercial standpoint.

Discussion

The finding that *L. x intermedia* supports the best scion growth aligns with field observations from French lavender

distillers, who have informally adopted lavandin rootstocks for phytoplasma-affected plantations ^[12]. Our SNP data provide the first molecular explanation: at a genetic distance of 0.12, lavandin is close enough for rapid vascular reconnection yet distant enough to contribute rootstock vigour a 'sweet spot' that *L. stoechas* (0.41) clearly exceeds. Pest resistance scoring revealed that spike lavender (*L. latifolia*) outperformed all others for both foliar beetle and root nematode resistance. This trait has practical value in organic or low-input systems where synthetic pesticides are restricted ^[13]. The trade-off is a lower graft take of 78.6 percent, which means growers would need to propagate roughly 20 percent more grafts to achieve the same stand density. Whether the pest-resistance benefit compensates for that extra nursery cost depends on local pressure from these

specific pests.

Dry matter content serves as a proxy for carbohydrate reserves, which in lavender directly affect overwinter survival and spring regrowth ^[14]. Lavandin rootstock elevated dry matter by 8.6 percent over the self-rooted control, which could explain its strong transplanting survival (91.3%) even after three simulated taiga frost cycles. This is a key finding for regions where winter kill is the main barrier to lavender establishment.

Ecosystem service scores integrated pollinator support, oil yield, and erosion control. Lavandin ranked highest (4.7), driven mainly by its superior oil yield and flower abundance, which attracted 32 percent more pollinator visits than the control. These multi-functional benefits strengthen the economic case for adopting grafted lavender in marginal environments ^[15].

Conclusion

This research demonstrated that grafting *L. angustifolia* onto *L. x intermedia* (lavandin) rootstock offers the most balanced combination of graft compatibility, scion vigour, pest tolerance, and ecosystem service value for cold-climate lavender production. SNP genotyping confirmed that moderate genetic distance (Nei's distance ~0.12) corresponds to the optimal compatibility window. Seasonal timing of grafting influenced take rates by up to 11 percentage points, with cooler months producing better outcomes. Dry matter accumulation and transplanting survival data support lavandin rootstock as a practical solution for extending lavender cultivation into Yenisei taiga-type climates. Future work should test these combinations under true taiga field conditions over multiple winters.

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Contributions Not Qualifying for Authorship

Dr. K. Patel assisted with GBS library preparation and SNP calling. Mr. J. Brooks maintained the frost simulation chamber.

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