Meeting requirements for natural, high performance plant care solutions

Comparing the performance of plant-based fertilizers/biostimulants from Roquette with synthetic alternatives

Ensuring that plants have all the nutrients and minerals necessary for optimal growth is a common goal, for those working in green-houses and orchards, for landscaping and commercial turfcare, and, crucially, to meet global food requirements. Fertilizer use is essential, with estimates suggesting that global food crops would be around half their current levels without the addition of synthetic nitrogen\(^1\). However, nitrogen fertilizer manufacture is currently dependent on fossil fuels and responsible for around 1 - 2% of global greenhouse gas emissions\(^2\). Efforts towards greater sustainability increase demand for plant care solutions that support optimal plant growth with less environmental impact.

Roquette, a global leader in the development and manufacture of plant-based ingredients, has developed a range of solutions for plant nutrition and protection. Developed in collaboration with external partners and experts, these products have been refined for specific applications, conditions, and crops. They allow customers to substitute mineral and chemical fertilizers and biostimulants for natural alternatives that offer balanced, optimized NPK (nitrogen, phosphorus, potassium) in combination with organic acids, vitamins and other trace minerals. Here we focus on fertilizers, illustrating performance via comparative case study data from trials at Iowa State University (ISU - Ames, Iowa, US). The results demonstrate the ability of Roquette plant-based products to deliver comparable performance to that of synthetic fertilizers when used in tomato transplant and turfgrass cultivation, and at the same time highlight opportunities for further study of their complementary potential as biostimulants.

A different route to plant health

Developed in the early 1900s, the Haber-Bosch process for ammonia production remains the cornerstone of modern fertilizer production, supplying the nitrogen which so often limits yield. In this highly energetic ‘nitrogen-fixing’ process, ammonia forms from the reaction between nitrogen in the air and hydrogen from natural gas. The reaction of ammonia with by-product carbon dioxide produces urea, the world’s most used nitrogen fertilizer.
Global moves towards greater sustainability make the dependence of synthetic fertilizer production on fossil fuels increasingly problematic, stimulating interest in alternative solutions. One option is to switch to ‘green’ hydrogen, produced via the electrolysis of water, depending on the availability of renewable energy\(^2\). Another is to reduce use. Going forward, it is predicted that farmers will progressively ‘apply more knowledge per hectare’ using technology and IT to monitor and understand nutrient use efficiency and drive precision farming\(^3\). There is scope to more effectively target fertilizer use, adding only as and where required, to reduce environmental impacts while sustaining yields\(^1,3\).

However, these are mid- to long-term strategies. New solutions are needed now. In the US, synthetic fertilizers are already banned in some municipalities. For example, South Portland City Council (Maine) approved a citywide ban of synthetic fertilizers in November 2020\(^4\). Consumers are eager for change in the way that food is grown, that public spaces and amenities, such as golf courses are cultivated, and with respect to day-to-day domestic landscaping services. Alternative, non-synthetic sources of nitrogen are important, now and into the future.

Plant proteins hold nitrogen in their constituent amino acids. Plants can therefore be processed to create fertilizers/biostimulants, and other plant care solutions, using some or all of the following processing steps:

- Solubles extraction, via steeping (extended contact with water)
- Fermentation
- Enzymatic hydrolysis
- Separation, including filtration and centrifugation
- Concentration, notably low temperature drying.

Such processing calls for relatively benign operating conditions and uses no solvents. The carbon footprint associated with making plant-based products is therefore low. The resulting fractions are complex mixtures rather than the single chemicals manufactured via chemical synthesis but as a result offer multiple benefits for plant health and protection. For example, products that act as a valuable source of nitrogen may also exhibit biostimulant properties, improving plant tolerance to environmental stress, quality traits or nutrient-use efficiency. Progressive refining enables the isolation and formulation of products tailored to specific plant cultivation applications.
Figure 1: Roquette creates fertilizers/biostimulants and other plant care solutions from plants such as maize, wheat, potato and pea via a process of progressive refining that extracts starch, proteins and other valuable ingredients.

It is vital to distinguish products made via the specific (often patented) and well-controlled processing of plant-based feedstocks, as manufactured by Roquette, from traded plant-derived by-products such as corn steep liquor (CSL). CSL is a by-product of the corn wet-milling industry and represents a low-cost source of nitrogen and other nutrients. However, it exhibits substantial variability, from manufacturer-to-manufacturer, and even from batch-to-batch. This variability translates into unpredictable outcomes for product use. Conversely, controlled processing eliminates the inherent variability associated with plant feedstocks to deliver a uniform, consistent product with good stability. This is a critical benefit for growers looking for dependable performance. Furthermore, the known provenance of Roquette feedstocks enables the production of a number of fertilizers that are OMRI (Organic Materials Review Institute) compliant, making them suitable for use in organic production and processing.

The following case studies demonstrate the performance of Roquette plant-based products, showing how it compares with conventional synthetic fertilizers.
Case study 1: Comparing the performance of plant-based fertilizers/biostimulants with synthetic NPK for tomato transplant growth

“Overall, the results are very promising. The Roquette products in their relatively complex forms did exceptionally well when compared to synthetic salt-based fertilizers, clearly demonstrating the potential to significantly influence transplant growth and development” Dr Ajay Nair, Associate Professor and Extension Vegetable Specialist, ISU.

Table 1 shows summary data from a trial to evaluate the performance of a series of Roquette products relative to synthetic NPK fertilizer (the industry standard), with respect to the growth, health and quality of tomato transplants. The trials were carried out by researchers at ISU using a randomized complete block design (RCBD) with four replications. 25 tomato seedlings (‘German Johnson’; organic pelleted) were subject to each treatment making 100 seedlings per treatment in total. Seeding was into a peat-based organic growing medium with seeded flats subsequently subject to temperature control (70°F day/ 60°F night) and a constant photosynthetically active radiation level of 250 µmol.m\(^{-2}\).s\(^{-1}\). Treatments were applied during week 3, 4, 5, and 6 after seeding, on the basis of nitrogen equivalence, with an additional basal dose of NPK (20-20-20 balanced fertilizer) applied to all treatments excepting the control at Week 3. Irrigation was provided as required; beneficial insects were used to manage thrips and aphids. All data were subject to Analysis of Variance (ANOVA) to confirm statistical significance.

Table 1: Data for tomato transplants illustrate the ability of plant-derived products to deliver comparable performance to synthetic NPK fertilizer.

Results are shown for six Roquette products, representative of different raw material extracts. Overall the more complex, plant-based products perform extremely well compared with the
synthetic fertilizer. Notably, Products A and B give rise to transplants with good stem diameter and height; Product B performs best of all of the plant-based solutions with respect to plant height. Products C and D are especially beneficial with respect to root growth, while Products E and F promote the growth of transplants that combine the very longest roots with, high dry weight and SPAD (Soil Plant Analysis Development) values. Dry weight is a valuable indicator of total plant biomass; SPAD values quantify chlorophyll and are a commonly used diagnostic tool for monitoring the nitrogen status of crops.

Figure 2: Root images show that plant-derived products promote root growth, relative to no treatment, to a comparable level to synthetic fertilizers.
In summary, these initial results are highly encouraging for the use of plant-based products in this application, especially given the considerable scope for dose optimization. Further trials are already underway to determine the dose required to establish equivalency with the synthetic fertilizer with the expectation of delivering performance on par with established industry standards. More specific assessment of the biostimulant properties of the Roquette products is also a potentially beneficial avenue of research.

**Case study 2: Comparing the performance of plant-based fertilizers/biostimulants with urea for turfgrass cultivation**

“We are super excited about these products which performed better than many conventional fertilizers we’ve tried. These results indicate that with plant-based solutions we can achieve better rooting and improved above-ground growth relative to urea, a major gain.” Dr Adam Thoms, Assistant Professor and Extension Turfgrass Specialist, ISU.

Tables 2, 3 and 4 show summary data from a second trial at ISU, this one evaluating the performance of Roquette products relative to urea, for the cultivation of turfgrass. Trials were carried out using a
RCBD with six replications, with treatments applied to Kentucky bluegrass established in sand-based rooting tubes. Sand was selected to minimize the number of compounding variables in the trial. It supports low microbial populations and holds limited nutrients, thereby providing a testing screen of treatment nutrition. A basal dose of 75 ppm NPK (10-10-10 complete fertilizer) was applied at seeding to all treatments except for the control and tubes were subsequently maintained on a 23° angle to help monitor root growth. Treatments were applied monthly for four months at a standardized nitrogen rate (½ lb. N/1000 ft2 ) with irrigation and additional light provided to maximise growth. As in the preceding trial, all data were subject to ANOVA; further analysis generated least significant difference values (LSD) for all parameters. These quantify the smallest statistically significant difference between two datasets and are included in the tables.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Week 2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
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<tbody>
<tr>
<td>Roquette Product A</td>
<td>26.7</td>
<td>41.7</td>
<td>53.2</td>
<td>72.5</td>
<td>70.9</td>
<td>76.6</td>
<td>47.1</td>
<td>77.2</td>
<td>75.1</td>
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<tr>
<td>Roquette Product B</td>
<td>25.0</td>
<td>43.3</td>
<td>63.3</td>
<td>76.6</td>
<td>86.7</td>
<td>78.8</td>
<td>52.8</td>
<td>98.2</td>
<td>85.1</td>
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<tr>
<td>Roquette Product C</td>
<td>21.6</td>
<td>24.7</td>
<td>44.6</td>
<td>59.9</td>
<td>59.8</td>
<td>66.9</td>
<td>44.3</td>
<td>72.1</td>
<td>62.6</td>
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<tr>
<td>Untreated</td>
<td>27.8</td>
<td>51.1</td>
<td>35.8</td>
<td>29.9</td>
<td>23.3</td>
<td>35.2</td>
<td>4.5</td>
<td>12.0</td>
<td>6.0</td>
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<tr>
<td>Urea (N only)</td>
<td>18.6</td>
<td>30.0</td>
<td>29.8</td>
<td>35.7</td>
<td>36.0</td>
<td>22.3</td>
<td>8.2</td>
<td>23.9</td>
<td>19.7</td>
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<td>Least Significant Diff (LSD)</td>
<td>5.7</td>
<td>8.8</td>
<td>16</td>
<td>16.3</td>
<td>16.2</td>
<td>20.6</td>
<td>12.8</td>
<td>14.9</td>
<td>14.1</td>
</tr>
</tbody>
</table>

Table 2: Percentage green cover values for turfgrass samples demonstrate the superior performance of plant-based products relative to urea for above ground growth.

Percentage green cover (table 2) is measured by digital image analysis. With this technique leaf orientation can impact the picture, giving rise to variability in the data; there was also a camera issue in Week 14. Generally though, higher values are associated with broader leaves, new shoots and a more upright structure, indicating improvement with respect to in-use performance. The results show that Products A and B deliver consistent, statistically significant improvement over urea at all timepoints substantially enhancing above ground appearance relative to the industry standard. Product C also shows substantial improvement relative to urea. The poor results towards the end of the trial for certain seedlings illustrate the poor retention qualities of the sand, highlighting the dependence of the growth in the other samples on the treatment received.
Table 3 (upper) and Table 3A (lower): Root and shoot data provide further evidence of the superior performance of plant-based products relative to urea (% change data are relative to urea).

Root and shoot data for the turfgrass (tables 3 and 3A) provide further evidence of the superior performance delivered by Products A, B and C. Product C is especially high performing, delivering substantial gains in all root and shoot metrics, notably in root biomass and shoot biomass. The results demonstrate plant-based products have substantial potential to outperform urea in the cultivation of turfgrass, with respect to both above and below ground performance. Again, further trials are planned to investigate optimum addition rates and to evaluate the biostimulant properties of the plant-based products with respect to stress tolerance, for example protection against drought.
Figure 4: Images illustrate the high potential of plant-based products for turfgrass cultivation (left to right): untreated, urea, Product A, Product B, Product C.

In conclusion

Plant-based plant care solutions have considerable potential to meet societal requirements for more sustainable, low environmental impact alternatives to synthetic fertilizers. The results presented here demonstrate this potential, providing evidence of the ability of Roquette fertilizers/biostimulants to match and even outperform synthetic NPK fertilizer and urea in the cultivation of tomato transplants and turfgrass respectively. Inherently more complex than synthetic products, plant-based products simultaneously support growth via multiple mechanisms, for example, acting both as a nitrogen source and biostimulant. Those leading the way in plant-based chemistry are working to develop an increasingly sophisticated range of highly consistent products that capitalize on this inherent complexity to produce solutions tailored to specific crops, environments and cultivation requirements. Going forward these solutions have an important role to play in helping growers maintain healthy plants and land productivity while minimising the harms associated with synthetic chemical use.
A comprehensive plant-derived portfolio for plant care

Roquette has a comprehensive, established portfolio of plant-derived products for plant nutrition and protection. These help customers to provide key nutrients and growth factors, increase nutrient absorption, enhance stress tolerance, improve germination and stimulate growth while reducing the use of synthetic chemicals. Specific products for the formulation of plant nutrition solutions, solid- or liquid-based include:

**SOLULYS®, GLUTALYS™, NUTRALYS® and TUBERMINE®**: Derived from corn (SOLULYS® and GLUTALYS™), peas and potatoes respectively these fertilizers are all sources of nitrogen with various additional features. For example, SOLULYS® is OMRI compliant and available as a liquid product, for formulation as a water-based spray or drip.

**NEOSORB® and PEARLITOL®**: These cereal-derived polyols offer humectant, stress reducer and biostimulant properties and are used as formulation excipients to help plants resist abiotic stress.

**Dextrose**: Supplied in liquid or powder form, in a range of free-flowing grades, this nutrient and carrier is particularly valuable as an energy/carbon source for microbial solutions.

**Gluconic acid, Sodium Gluconate, BIOSUCCINIUM®**: These organic acids and salts are used as progressive acidifiers and complexing agents to increase the uptake of minerals and metal ions, particularly in neutral and alkaline soils.

To find out more about these products and how they can help you formulate an optimized plant care solution for your needs: Check our website and contact us.

References

1. H. Ritchie and M. Roser ‘Our World in Data: Fertilizers’ Available to view at: https://ourworldindata.org/fertilizers
2. A. Valentini ‘Decarbonising the fertiliser industry: is green ammonia the answer or should we focus elsewhere?’ 19th May 2021. Available to view at: https://www.argusmedia.com/en/blog/2021/may/19/decarbonizing-the-fertilizer-industry-is-green-ammonia-the-answer-or-should-we-focus-elsewhere