Project Proposal Form – 2020 entry

<table>
<thead>
<tr>
<th>Project Title</th>
<th>OU13: Siliceously deficient? Are UK crops missing out on silicon and can cover crops help?</th>
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<tr>
<td>University (where student will register)</td>
<td>The Open University</td>
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<tr>
<td>Which institution will the student be based at?</td>
<td>As above</td>
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| Theme (Max. 2 selections) | Climate & Environmental Sustainability ☒  
Organisms & Ecosystems ☒  
Dynamic Earth ☐ |
| Key words | sustainable agriculture, soils, plant silicon |
| Supervisory team (including institution & email address) | Supervisor: Dr Julia Cooke  
(The Open University, julia.cooke@open.ac.uk)  
Co-supervisor: Dr Jacqueline Hannam  
(Cranfield University j.a.hannam@cranfield.ac.uk) |
| Is the project co-designed by a student? | Yes ☐  
No ☒ |
| Is the PhD suitable for part time study? | Yes ☒  
This is a requirement of NERC |

Project Highlights:
- Field and glasshouse experiments to answer applied questions
- Join a growing and dynamic international community working on plant silicon
- An opportunity to contribute to food security

Overview:
Silicon (Si) has been described as a silver bullet for plant stress. It can mitigate impacts of herbivory, drought, salinity and heavy metals to increase plant growth and agricultural crop yield (Cooke and Leishman 2016). All plants take up some silicon but some species accumulate large amounts. Many of these hyperaccumulators are agriculturally significant crops (e.g. rice, wheat, sugar beet, sugarcane, corn, and barley) and can take up large amounts of Si (0.5 and 4.1% dry mass). Plants take up silicic acid from the soil solution and deposit it in tissue as amorphous silica bodies or phytoliths. However, repeated cropping can reduce the amount of plant available silicon because the removal of harvested biomass means phytoliths are not returned to the soil and recycled. The decreased availability reduces the capacity of plants to manage stress. Soils in parts of Europe, Southern Africa and Asia are now shown to be deficient in plant available Si (Vandevenne et al 2012, Carey and Fulweiler 2016) and as a result are heavily fertilised (Carey and Fulweiler 2016) to compensate.

Measurements of archived samples from a long term (1883 to 1994) wheat field at Rothamsted (UK) showed a decrease in phytoliths in both topsoil and wheat straw, yet we do not know if Si deficiency is widespread in soils across the UK. In the same study, topsoil phytolith abundance was increased
through reforestation in an adjacent area, indicating that Si depletion can be reversed though land use change. There are a variety of land management practices in arable systems that could increase the input of biogenic Si to compensate for Si removed during crop harvest. In arable agricultural contexts these include the implementation of cover crops between winter and spring sown crops that could potentially provide a source of biogenic Si to close the Si cycle.

The project will investigate the following research questions:

1) Are agricultural soils in the UK deficient in plant available Si?
2) Could yields be raised and stabilised by increasing the availability of this beneficial nutrient?
3) Could cover crops be used to increase plant available Si in soils?

Figure 1. Silicified stomata and epidermal cells.

Methodology:

The project will involve field surveys and glasshouse experiments. To determine if agriculture has depleted phytoliths and plant available silicon in the UK and to what extent, soil plant available silicon (CaCl₂ extraction) in agricultural soils will be compared to those in adjacent uncropped areas (meadows, woods, hedgerows etc). Different soil types will be measured to explore how this effects Si availability as well as land-use history. We will use the national soil database at Cranfield University to select candidate field locations.

Glasshouse experiments will measure the potential of cover crop (both diverse mixes and single species from different families) to increase the amount plant available Si for subsequent crops and increase crop yield. Both the total Si uptake of cover crops, and abundance and solubility of the phytoliths produced will be measure at the state of the art chemical analysis lab at The Open University. We will use the unique facilities at the Agri-tech innovation centre at Cranfield University. The controlled glasshouse environment has a sensor platform to also enable plant phenotyping to detect early onset of stress to different Si and environmental conditions.

Training and skills:

Students will be awarded CENTA2 Training Credits (CTCs) for participation in CENTA2-provided and ‘free choice’ external training. One CTC equates to 1/2 day session and students must accrue 100 CTCs across the three years of their PhD.
Through this project a student will gain a suite of skills in both soil science and plant physiology, though field surveys, a glasshouse experiment, and associated soil and plant chemical analysis all using state of the art facilities. A student will develop statistical analysis skills, particularly multivariate analyses, using the R language and environment. The student will liaise with the project partners (Agrii- TBC) and present their research at knowledge exchange events for non-academic audiences in the agricultural sector (e.g. events such as GREAT soils organised by the levy boards and attended by agronomy companies and growers).

**Partners and collaboration (including CASE):**

A leading UK agronomy company will provide in-kind contributions of cover crop seeds for the trails. Cranfield University has a strong links with businesses in the agricultural sector and this represents an excellent means by which further collaborations can be developed during this PhD project.

**Possible timeline:**

Year 1: Literature review. Identify candidate field locations and conduct field soil survey and sampling. Soil chemistry analysis to determine Si availability in a selection of soil types and land uses. Glasshouse experiment planning and set up initial pilot study. CENTA training focused on foundation modules, project management and selected masterclasses.

Year 2: Develop glasshouse experiment based on outcomes of pilot study and devise appropriate statistical design and replicates. Maintain and modify experiment. Harvest and analysis of soil and plants from glass house experiment. Repeat measure or expansion of field survey as appropriate. Manuscript preparation. CENTA training focused on masterclasses, research writing and methods, non-academic communication and engagement.

Year 3: Second round of glasshouse experiment utilising the unique plant phenotyping platform in the glasshouse. Manuscript preparation and conference attendance. CENTA training focused on advance courses and work placement.

Year 4: Manuscript completion and national/international conference attendance.

The student will be registered at the OU but during the PhD there will be a significant time spent at Cranfield (e.g. during the glasshouse experiments) where they will have access to facilities and also desk space with the Agrifood doctoral cohort. The Co-supervisor will be responsible for embedding the student at the supporting institution.

**Further reading:**

Further details:

Students should have a strong background in plant biology, soil science or agronomy. A strong interest in both the theoretical and applied aspects of research and experience of field and laboratory work are highly desirable. The project would suit someone who enjoys fieldwork and interacting with stakeholders. A driving license would be an advantage. The successful student will join a well-established team researching plant biology at The Open University and soil processes at Cranfield University and a vibrant postgraduate community at the Open University.

Please contact Dr Julia Cooke, julia.cooke@open.ac.uk or Dr Jacqueline Hannam, j.a.hannam@cranfield.ac.uk for further information.

Applications should include:

- a cover letter outlining why the project is of interest and how their skills match those required,
- an academic CV containing contact details of three academic references
- a CENTA application form, downloadable from: http://www.centa.org.uk/apply/
- and an Open University application form, downloadable from:
  http://www.open.ac.uk/students/research/system/files/documents/Application%20form%20-%20uk-eu_0.docx

Applications should be sent to STEM-EEES-PHD@open.ac.uk by 12pm (noon) on Friday 10th January 2020.