Project Title: Removal of atmospheric nitrous oxide (N2O) using Photocatalytic Technology

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Date: January 17, 2023

Reviewers: Ned Horning, Gisel Booman, Sam Bennetts, Rebecca Harmon

Ned feedback: The author's response is detailed and compelling. I suggest we recommend that they develop a methodology. I encourage the authors to include some of their responses to our comments in the methodology. I do not have response-by-response comments.

Gisel feedback: We need some expert with more specific chemistry / food safety/ environmental safety background for this.
Is this a Nature Based Solution? What about the production cycle itself. whether it's manufacturing could generate local problems to health for instance.

Collectively the team feels that this is a strong Concept Note and that Crop Intellect should move to develop the methodology. We will support this going through Peer Review and once that is done we can decide if this fits the definition of Nature Based Solution as noted on the Regen Registry. This methodology is not a straightforward fit to our standard definition as noted in the Regen Registry Guide but could arguably qualify using the IUCN definition.

Depending on the Expert Review the options would be:

1. We accpet the method within our registry and proceed as we normally would. In this scenario I think it's worth calling in third party expertise to help review the concept note and method
2. We don't accept the method within the Regen Registry but still facilitate them starting their own credit class / method such that they could use the ledger to track their credit pipeline, but treat them as a stand alone registry to some degree.

Question	Crop Intellect Response	Reviewer Response
Is there any potential undesired side effect to biota or environmental health	The photocatalyst used is titanium dioxide (TiO 2). It is one of the most common metals on earth and mined asilmenite. It is chemically inert and used in many industries including cosmetics, paints and as a food ingredient (E171). More than 9 million tonnes are mined yearly. We have developed a process which allows the TiO 2 to work as a photocatalyst under normal light levels. The process doesn't change anything fundamental to the mineral, so it is not considered as a different structure or a new mineral. The material has been well characterised with use of standard lab equipment to enable its assessment. The formulated product has an MSDS which is attached for your information. This clearly shows that there is no toxicity to biota, and it does not bioaccumulate. It is further important to note that we are not using nanoscale material and it is recommended at 1kg/hectare per year. There are several publications demonstrating the safety of the material for marine, fresh water, soil and other environments. Most of these focus on nanoscale material as they have been associated with more concerns than larger particles. This case is not specific to TiO 2 but many other materials at nanoscale. We are happy to reference several studies and reviews performed on the safety of the material to biodiversity and the environment if requested. Overall, the safety profile of the TiO 2 and considering the higher than 1µm particle size used in our technology and the amount (1kg per hectare per year) is safe for the soil biota, plants, and the environment. See attachment file: R-Leaf MSDS No Nutrients	What citations support statements around lack of toxicity and bioaccumulation of TiO_2 and in what types of soil chemistries? For instance, in particularly lower pH soils, are the other materials in RLeaf chelating other ions that would cause macronutrient limitations for plants? The report addresses safety to humans and how to use but not biota and environmental activity.
How is the environmental cost of production factored in	We have validated the benefit of R-Leaf to the environment due to the removal of N 2 O by using a well-defined and recognised program run under the European Innovation Council called Climate Impact Forecast tool. Their experts trained us to use the system which links to a global database for the latest figures of carbon dioxide equivalent for raw materials, energy, transport, and others. The full report with details and references is attached for your information.	In the Validation report, the production quantification is for the processing of TiO_2; I do not see mining emissions noted. Is there more information on the mining process and impacts on ecosystems?

	See attachment files CIF validation process and Validation report Crop Intellect Ltd - R-Leaf	
Is there any composite that could threaten humans' health when consuming the products? Hard to evaluate, as it seems to be a secret recipe	As described in the answer to a previous question, the ingredient (photocatalyst) is titanium dioxide. As part of over 5 years of development prior to commercialisation stage, we have looked in detail at the regulatory profile of the ingredient. Concerns have been raised in the EU for the material used in nanoscale as a food ingredient. Our technology does not use nanoscale and furthermore we are not adding it to food but during growth in agriculture. We have further performed work to ensure that the material doesn't alter the chemical profile of plants, does not affect any crop protection chemistry, and also does not end up in the parts of the plant that are consumed by human or animals (mainly focused on wheat). An example to put this into perspective. In the US the average adult uptake of TiO 2 through food ranges from 0.7 to 5.9mg per kg bodyweight per day. Assuming an average of 60 kg weight of a person and an intake of 1mg of TiO 2 per day, we have 60mg/day or 21,900mg/yr or 21.9g per year. R-Leaf is applied at 1000g per hectare. Taking lettuce as an example; there are 60,000 lettuces per hectare (minimum), therefore, 0.0167g per head or 16.7mg of TiO 2 if consumed straight after spray. Therefore, 1,300 lettuces must be consumed per year to reach the average consumption taking the lowest numbers possible into account. This is 3.5 lettuces per day or if we take the average of these numbers, it is closer to 12 lettuces per day. However, we are targeting impact with R-Leaf which comes from broad acre crops such as wheat where we have analysed for TiO 2 confirming that it is not absorbed by the plant, and it doesn't result in the seed. See attachment file Yordas Regulatory Assessment R-Leaf	
What is the potential toxicity of R-Leaf	Please refer to previous questions and the MSDS: R-Leaf MSDS No Nutrients	
What happens to all of the nitrogen removed from the atmosphere?	The technology in R-Leaf has been selectively chosen to work with nitrous oxide (N 2 O) capture, which is one of the most potent greenhouse gases. The breakdown components are N 2 and O 2 which are inert. There is no Nitrogen removal from the atmosphere and no other	Is this intended to be effective for a particular type of nitrogen amendment over others (urea, nitrate,

My concern is that nonpoint source nitrogen pollution is already a huge concern so I wonder if this exacerbates that problem?	components produced by the breakdown of N 2 O that are considered as an issue. We have further performed studies to show that if NOx (i.e., NO and NO 2) are converted, they produce inert by-products and nitrate. The nitrate being itself a source pollutant, is taken up by crops. This is a great synergy where whilst farmers spray crops anyway, they add R-Leaf to the foliage. R-Leaf in turn breaks down the harmful nitrous oxides that fertilisers release and further converts NOx to nitrate on the leaves supporting growth and the potential to reduce nitrogen inputs. The validation of R-Leaf confirms 5.4tn eq. of CO 2 removal per hectare using 2lt of R-Leaf. If farmers are recommended to reduce their input by c. 25% this equates to c. 250kg of CO 2 , which is miniscule compared to the benefit of direct N 2 O removal. Typically, the farmer will be given the recommendation to balance their nitrogen application. This cannot be standardised however, as it differs with crop, soil and source of N used. The dose typically ranges from 150-250kg so a standard recommendation would be agronomically incorrect. Furthermore, to be able to claim the benefit of the nitrogen reduction in carbon equivalent credits would add a significant amount of work for the farmer and the project developer. These are the reasons for not making a documented recommendation, but we can train the agronomists who will administer the technology to provide that suggestion in detail. Furthermore, we envisage to produce an App that will incorporate the location and the background levels of NOx that governments already measure (in UK), taking into account the R-Leaf dosage and provide an estimate of the amount of nitrate that R-Leaf will produce to enable a better agronomic recommendation if a reduction is desired.	ammonium)?
On the toxicity side they might be taking the "dilution is the solution" approach since application rates are quite low but it would be good to know for sure. I'm not qualified to answer my concerns	We have performed high-rate applications on several broadacre crops including our main target, wheat, and we have not caused a phytotoxicity at 10lt/ha sprayed regularly. A higher rate will produce a higher benefit however it has to be balanced with compatibility in the spraying tank as farmers use low rates of water and the cost-benefit balance. The rate of 1lt/ha may sound low, but we have performed a lot of work to produce	

without significant study so I don't think this should be a show-stopper.	the formula containing 500g per litre of the photocatalyst (1.5 specific gravity) so that the product doesn't contain much water to be shipped around the globe as many other products do. Any phytotoxicity that may be caused at a higher rate will come from the formulation aids and not the photocatalyst. The ingredients used in the formulation are all approved for use in agriculture.	
Could we have access to the first publication they reference? It's behind a paywall and I can't access it.	See attachment file: Photocatalytic decomposition of N2O over TiO2g-C3N4 photocatalysts heterojunction	
It doesn't fully align with our mission to regenerate via natural processes but I think it important all the same and we shouldn't necessarily be the gatekeepers on it.	The technology is well defined and has a significant positive impact to the environment. The material, although processed, are naturally occurring and used in huge quantities by other industries. We therefore see this as an opportunity where it can promote the uptake on other regenerative options, making farming more sustainable and profitable.	Applicable farming practices would need to be considered, ie not degenerative cropping practices
What is the intended use and expectations around the methodology?	We envisage to group farmers by certain criteria including location, crop, farm size, practices etc. that will enable projects to be created. Although R-Leaf is unique currently, there is potential for other technologies based on photocatalysis to be produced and be able to utilise this methodology. We are expecting the methodology to allow us to create projects that will encourage farmers to adopt R-Leaf as a solution for removing nitrous oxides produced in farming and be incentivised to do so whilst benefiting from nitrate production, with potential to reduce their synthetic nitrogen inputs.	What is the cost estimate per hectare for RLeaf use?
Are they planning on using it for some of their own projects? Do they have those projects?	The intention is to develop our own projects but also make the technology available to others. These include multinationals whom we are already in discussions with, such as FMC, Corteva, Cargill and furthermore, with supermarkets (TESCO and M&S) who are interested to turn specific food lines into net zero. Projects will also be developed by distributors within agriculture. This is the sector we understand best and as the user will be the farmer/landowner, we aim to start	

	with those stakeholders directly. We are in discussions with several other players in the cloud, concrete, and logistics spaces where the technology can be sponsored for the development of such projects with the benefit being further enhanced for the farmers to adopt the use of the technology.	
Are they committing to using Regen Registry to develop a credit class and become a project developer or to develop it for royalties?	We are exploring both potential ways for working and evaluating the feedback from collaborators. This will be clearer when we can have a value creation for the environmental benefit, so that we can translate this to an incentive for the adoption of the technology and how projects can be created globally.	