Premature marketing of a biofilm bio-fertilizer without proper testing?

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I was surprised to read a "comment/rebuttal" of some aspects of an article written by me (Island, 12th Nov. 2021) where I had named Dr. Kulasooriya in SUPPORT of my words of caution on the use of microbial applications in agriculture. However, now I find that what Dr. Kulasooriya has written in his scientific papers is at variance with what he says in his marketing statements regarding biofilm fertilizers.

My posting was a reaction to extreme claims for essentially replacing nitrogen fertilizers by nitrogen fixing micro-organisms by a Mr. Chris Dharmakeerthi whose views seem to be endorsed by Dr. Kulasooriya. Dharmakeerthi claimed to get 200 to 300 % MORE nitrogen THAN what is needed in paddy cultivation using a pre-planting of a legume! Then he went on to bemoan that microbial soil enhancement technologies developed by various associates of his have been ignored by the Dept. of Agriculture in Sri Lanka.

I replied that most such proposals (even to produce adequate level of soil nitrogen for paddy) are still on the drawing board. I stated that if plantation mangers and small farmers have not taken up the technology, it is possibly because a reliable, simple inexpensive and SAFE procedure for replacing N fertilizers with microbial alternatives is lacking.

Nitrogen-fixing nodules on plant roots (credits, Wikepedia)

Dr. Kulasooriya has risen to Dharmakirthi's defence. I have known Dr. Kulasooriya since his undergraduate days (when I supervised his first-year chemistry practicals) and know his scientific work well. When I left Sri Lanka in 1975 I was working for the SJP University (then Vidyodaya) as a professor of Chemistry, while also working as a scientific advisor to the Minister of science and technology, Mr. T. B. Subasinghe. As the chair of several technical committees we reviewed many proposals. Even after I left Sri Lanka, I informally continued to review dozens of scientific projects for successive ministries for over a period of 50 years, as colleagues continued to contact me to participate (always free of charge, unlike many local and foreign experts).

So I have a long-standing awareness of technical issues faced by Sri Lankan science ventures. Although my work in the West is mostly on the quantum physics of nanostructures, lasers, inertial fusion and so forth, I have keenly followed the agricultural and environmental topics in the context of Sri Lankan scientific issues. I have maintained for nearly two decades a web-based compendium of most plants in Sri Lanka.
(https://dh-web.org/place.names/ot2sinhala.html)
Their use in bioenergy, fertilizers, alternative medicine, as nitrogen fixers, food etc., as well as aspects of ethnobotany have been summarized for each plant. So it is counter-factual for Dr. Kulasooriya to claim that I am not even aware that *Salvinia* is not a nitrogen-fixing weed.

I have myself published relevant research in international journals at no cost whatever to Sri Lanka, on topics of environmental chemistry, fertilizers, chronic kidney disease, renewable energy etc. I was also well aware of Dr. Kulasooriya's recent views on the subject, e.g., published jointly with Dr. Magana-arachchi, entitled "*Nitrogen fixing cyanobacteria: their diversity, ecology and utilisation with special reference to rice cultivation* in volume 44 of the National Science Council Journal. So, by no stretch of imagination did I include Dr. Kulasooriya with the Natha-Deviyo-Arsenic-Glyphosate group that is linked with the late Ms. Senanayaka and Dr. Nalin de Silva of Kelaniya University. However, I am told that the biofilm biofertilizer promoted by Kulasooriya *et al.* has been sponsored through Ven. Rantana who got glyphosate banned during President Maithripala Sirisena's tenure.

In the following I will quote from Dr. Kulasooriya's review article to show that my views are quite in line with his published scientific work on the use of nitrogen-fixing micro-organisms and in supplying fertilizer to the farmer.

1. Referring to long-standing work in India, Dr Kulasooriya et al say (page 120): “this low cost technology … has been successful only in a few areas in India ….Despite these modifications, the yield increases recorded in field experiments … ranged from 12 to 19 %, which were not higher than the previously reported values.
2. The application of cyanobacterial biofertiliser technology in Sri Lanka was successful only up to the stage of pot experiments. Most of the cyanobacterial inoculants added to the rice fields could not overcome consumption by the rice field micro-fauna and …
3. More recently it has been demonstrated that N2 fixing species of cyanobacteria could be incorporated with certain eubacteria and fungi to form biofilmbiofertilisers and preliminary field trials with such mult-imicrobial biofertilisers have given *encouraging* results with rice (Kulasooriya & Seneviratne, 2012).

Here biofilmfertilizers (BFF) are said to give *encouraging* results. “Encouraging results” in experiments are very different to successful market applications. Yet, In Dr. Kulasooriya’s rebuttal/comment (2021) he states that:

4. “The results were very convincing and it was very easy to transfer this technology to the farmers as they themselves participated in the conduct of the field trials. Ever since 2010 up to date Plenty Foods PLC had been one of our principal customers for inoculants.

How can one allow farmers to “test a product” unless phase one tests at the DOA have been done and approved?

If in 2010 “the technology” was already “successfully used” by farmers, why did Dr. Kulasooriya say in 2012 and 2016 that the technology is “preliminary” and only “encouraging”? Can Dr. Kulasooriya blame the scientific readers of his publications if they accept what he has written to be valid? Dr. Kulasooriya says that “At present we are working very closely with the Government Department of Agriculture” (DOA). If the DOA has not yet (in 2021) accepted the BFF how was it marketed in 2010 *prior to testing*?

If tests are being done, why did Mr. Dharmakeerthi imply that the DOA scientists are a barrier to adopting this technology? I have come across publications of a Chris Dharmakeerthi who works on electric vehicles and PV technologies working in Australia, but know of no such agricultural scientist.

Furthermore, Dr. Parakrama Waidyanatha (a veteran agricultural scientist) questioned the claimed efficiency of the Bio-film fertilizer introduced by IFS scientists. His article entitled “Toxin-free Agriculture and Microbial Fertilizer Technology Efficacy” dated 4th March 2017 appeared in the Island newspaper, A senior scientist who was a Director General of agriculture also felt that the BFF work needs to be independently evaluated. *Apparently, the Director’s annual report of the Maha Illuppallama Agriculture*

Research station for 2015 contains an entry showing that the trials of the BFF conducted there failed to show any fertilizer action. So, should I not be cautious even if Dr. Kulasooriya's associates have been selling the untested product since 2010?

Regarding claims made by Kulasooriya *et al* in the 2021 publication "Post Covid-19 agriculture" we need reconfirmation by other scientists using independent field trials. Given the stated position of the Kulasooriya et al reviews in 2012, and 2016 where the results were claimed to be *merely encouraging*, and the contradictory 2021 claim that it has been successfully sold to farmers since 2010, we need some caution with those who are marketing a product. In every scientific research it is normal to ask if the authors have a "conflict of interest". If Dr. Kulasooriya is involved in selling BFF there would indeed be a conflict of, and we as independent scientists await re-confirmation of such claims.

It is also very troubling that scientists employed at the Institute of Fundamental Studies (IFS) and paid by the tax payer are working for a private company, Lanka Bio Fertilisers (Pvt) Ltd to further their product? We can only hope that proper memoranda of understanding and payments to the IFS for services rendered have been set up. Unfortunately, the relationship of these scientists with the bio-fertilizer company is not "arm's length", but direct and complete.

In the rest of Dr. Kulasooriya's comment/rebuttal he agrees with me regarding the poor potential of *Azolla Pinnata* or *Salvinia* as sources of fertilizer. However, he says that "the comparison of "Azolla "with "Salvinia" by Chandre is another instance of his limited knowledge on these plants because "Azolla" is a N2-fixing plant, while "Salvinia" is not.

I must humbly request Dr. Kulasooriya to read the entries on *Salvinia molesta, Hydrilla verticillata, Nymphaea stellata, Azolla pinnata, Ceratopteris sp., Scirpus sp., Cyperus sp., and Utricularia reticulate*, and other weeds discussed in my plant website (https://dh-web.org/place.names/bot2sinhala.html) that has existed for some two decades, to see the plants that I list as nitrogen fixers.

What Dr. Kulasooriya, a veteran on blue green algae research ignores is that even though *Azolla Pinnata* makes nitrogen, while *Salvinia* does not, when the nitrogen content of their dry weight is determined they both do not contain more than 2-4% of nitrogen. The physiology and biochemistry of plants, irrespective of whether they fix nitrogen or not, is such that they do not generally exceed more than

25% in protein in the best of circumstances. So, in regard to use as bio-fertilizers, other factors are more over-arching. Making manure from aquatic weeds is costly; if made, they are best used as soil remedying agents, and NOT as fertilizers (as with most types of un-enriched compost). The likely use of these weeds is more in bio-gas energy applications.

Canada is a leader in cultivating legumes and in nitrogen fixation. Even the "parippu" (lentils) eaten in Sri Lanka comes mostly from Canada. While legumes may generate even 90% of the Nitrogen needed for themselves, they do not produce additional 200-300% of the nitrogen needs of a subsequent rice crop.

In fact, the more sensible way to use BBF and microbial techniques is to use them *together with* conventional fertilizers, to obtain the advantages of both, instead of trying to yank the N output of a virgin *Mung* plantation even into a non-fertilized paddy land. But before that, the BFF must be shown to work in scientific trials, and not via mock trials conducted via complicit farmers.

Microbial activity in soils release soil-bound heavy metals (HM), phosphates etc., making them bio-available for themselves and plants. Non-toxic soil-bound arsenic is there by converted to toxic arsenic compounds. So it is imperative that microbial approaches do not increase the HM content in crops. The results of field tests are location dependent, making generalizations difficult. So, such pre-use trials should be mandatory for each location**. Surprisingly, the publications of Kulasooriya, Seneviratne and others on microbial fertilization are totally silent on this crucial issue; and yet the technology has been marketed to farmers?**

The website:
https://theconversation.com/from-flask-to-field-how-tiny-microbes-are-revolutionizing-big-agriculture-67041 says:
Beneficial microbes have long been used in agriculture. Farmers have been adding nitrogen-fixing bacteria to their legume crops and symbiotic fungi called mycorrhizae that help plants acquire nutrients for decades. But many older products contain undefined mixtures of microbes and make broad claims about how they enhance plant growth. They've largely earned a reputation as agricultural snake oil. And that history makes it hard to convince farmers to adopt the next generation of beneficial microbial technology.

In conclusion, I have shown that my references to Dr. Kulasooriya's work are entirely consistent with his own scientific publications; especially those with at least a few years' exposure to the scientific community. However, we now know that they are at variance from his marketing pitch.