CROP PRODUCTION IN SRI LANKA: CHEMICAL OR ORGANIC ?

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[This document carries comments on it by Chandre Dharma-wardana, referred to here as CDW]

I am writing this article after reading the exchange of views between two erudite personalities, Mr. Chris Dharmakirthi who has returned to serve his motherland after having had his tertiery and postgraduate education entirely in the U.S and having served in several international organizations, and Prof. Chandre Dharmawardhana who had the benefit of free education in Sri Lanka and having served the Vidyodaya University as its Vice-Chancellor, left the country in difficult times during the late 1980s and is now domiciled in Canada.

[Note by CDW: After my studies in the West I returned to Sri Lanka at the behest of Ven. Walpola Rahula that I met at the Sorbonne, Dr. Neil Jayasuriya, and P. W. Epasinghe who also wrote inviting me to join them. I put my positions in the West on hold without resigning from them (but returned every summer to attend to my research projects there, at no cost to Vidyodaya), and worked for nearly a decade at Vidyodaya where I established, for the first time, courses on food science, environmental science, development studies and other applied topics. I also worked as a science advisor to the Ministry of science in the 1970s, and to many Government Corporations. Even after I left Sri Lanka I continued to partcipate in many project reviews for government minstries. Most recently, I have enaged myself in research into Chronic Kidney Disease of unknown aetiology. But these personal details are IRRELAVANT to the topic at hand which must be judged solely on scientific merit and

supporting data. I sign myself as Chandre Dharma-wardana or CDW and I hope that is sufficient.]

I was tempted to respond because my name is mentioned in their writings. While Chris Dharmakirthi cites my education, knowledge in the area of soil microbiology and experience gained while working overseas as well as in Sri Lanka, Chandre Dharmawardena appears to give the impression that we local scientists are followers of mythical beliefs and categorize us together with *Jathika Chintanaya* groups who take instructions from 'God Natha'.

[Comment: Article by Chandre DW: https://island.lk/organic-fertilisers-and-so-called-fertiliser-mafia/ has only the statement "**Kulasooriya and others have reported preliminary studies**" (on using N-fixing algae in biofertilizers) and none of what is being alleged here. Nowhere it is said that Dr. Kulasooriya supported the claims of the Kelaniya group on CKDu and fertilizers.]

This unfortunately shows the complete ignorance of Chandre of the research work we have carried out staying back in Sri Lanka under difficult conditions and yet demonstrating the possibilities of utilizing local natural resources to strenghten our food production adopting eco-friendly agriculture. I for myself have not proposed complete organic agriculture and certainly not overnight. On the otherhand I like to present in Figure 1 drawn by my scientific colleague Prof. Gamini Severatne based upon data reported by the Sri Lanka Department of Census and Statistics, on national rice production from 1955 to 2020. It is evident from this figure that in the 1959/60 Maha season our national rice production was low (around 1.5 t/ha). Introduction of new high input responsive hybrid rice varieties together with the application of synthetic chemical fertilizers and other agro-chemicals was done in

Sri Lanka at this time under the 'Green Revolution'. These gave dramatic yield increases which more than doubled to 3.5 t/ha by 1998/89. This was because chemicals were added to soils rich in organic matter accumulated over centuries of organic agriculture. Thus the added chemicals were retained in the colloidal organic moiety. Such soils also had heavy populations of active microorganisms which converted them and provided them to be efficiently absorbed by the crop plants. However such increases did not continue and the curve tends to bend down. From 1989/90 to 2004/05 Maha seasons the yield had increased only by 0.7 tons to reach a national average of 4.2 m.t. This national average had not changed during the past 15 years and the curve remains flattened until 2020. These results indicate that out of the chemicals added only a very small portion really gets into the crop and the rest contributes largely to environmental pollution.

[The above results in Fig. 1, or mere associations of one curve with another, do not indicate any of these details mentioned by Dr. Kulasooriya. However, extensive studies on N, K, P dynamics in soils are available from since the 1960s to show all this and more.]

Therefore the question is, are we to continue importing synthetic fertilizers and add them without any increases in yield or scientifically understand the lack of response to chemical fertilizer application and alter this unsustainable sytem ? In fact it is generally accepted that only 20 to 30 % of the N-fertilizers added is absorbed and the rest is lost aggravating environmental pollution. This is not peculiar to us. Even the following publication by Iniesta-Pallerina et al (2021) cited by Chandre in his write up, has reported that 60% of the synthetic fertilizers applied to rice fields in Spain gets washed off.

[**So why does Dr. Kulasooriya assume that Chandre DW supports simple-minded usage of urea? Where has he said that?**]

https://www.mdpi.com/2076-3417/11/10/4628/htm

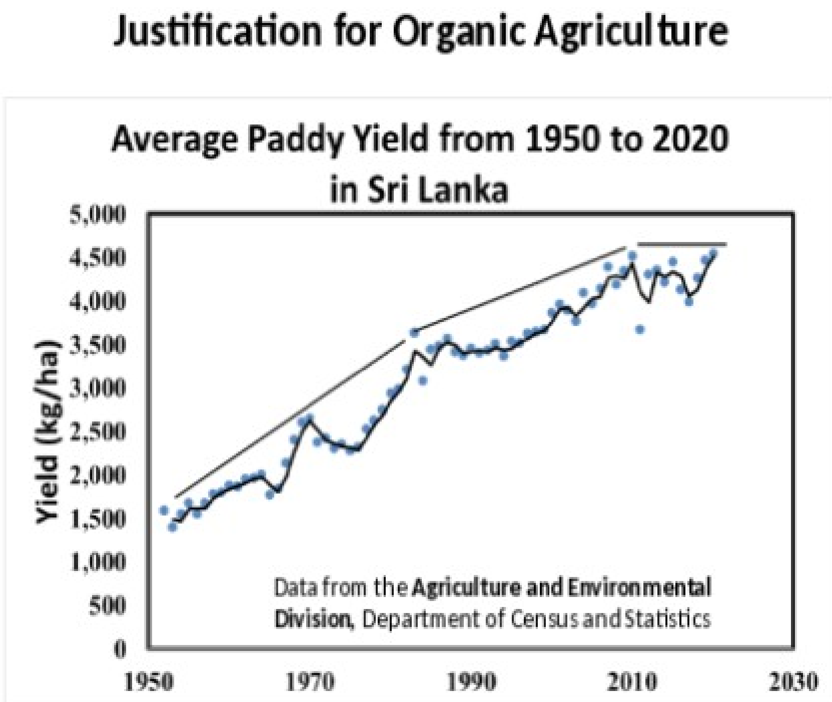

Figure 1: Rice production in Sri Lanka from 1959 to 2020

[**Comment by CDW. This graph is NOT a justification for Organic agriculture. It merely shows that fertilization without simultaneous soil remediation is a failure, a well known fact, mentioned even in text books a half century ago. Furthermroe, if organic agriculture is adopted, the yield curve will easily drop to a third or fourth of what is shown here.**

Should we remind Dr. Kulasooriya the paper "Long fallow periods: The key to sustenance of soil fertility, by MAP. De Silva, SA. Kulasooriya & RP. Gunawardane, *Plant and Soil* volume 135, p 297 (1991)?

The pressure for food production led to the bandonment of having three-year fallow periods for soil remediation. Hence methods based on external inputs (e.g., use of biochar) typical of Green-revolution methods are needed to restore the soil as compost and humic inputs are in short supply.]

All these synthetic fertilizers are imported utilizing our foreign exchange earnings which are so precious today to our debt ridden country.

[The Foreign exchange spent is an investment and produces food as well as exports, the total value of which far exceeds the investment. It is these false claims that the chemical fertilzers can be replaced by organic fertilizers that has misled the government. Only a few years ago, when Dr. Adrain Mueller of the Swiss Organic Agriculture Research institute published a *Nature Reports* article on all this, I

replied to him and Dr. Kualsooriya is invited to read it: https://www.dh-web.org/green/CD-Mueller-OrganicL.pdf

Captain Robert Percival spent many years in Sri Lanka at the end of the 18th century and at the start of the 19th century just befor the time when Kanda-Udarata fell to the British. In his book "An account of the Island of Ceylon" he discusses the practice of indigenous agriculture in the Kandyan kingdom (the part of the Island that had not been invaded by the Portuguese, the Dutch or the English until then). His estimates of the low yields of those virgin soils (unaffected by the additon of chemical fertilizers) are consistent with today's estimates of the poor potential of organic agriculture to feed modern Lanka.]

It is therefore incumbent upon all of us to conduct research studies and develop technologies to minimize such losses and also look for alternative systems to restore and improve soil fertility which is not simply the supply of N, P & K to cultivated crops. Therefore I would advocate that all of us genuinely contribute to restore the lost fertility of our arable lands instead of engaging in frivolous arguments.

[**What are the frivolous arguments?]**

After obtaining a PhD degree from the University of London following postgraduate research on Biological Nitrogen Fixation (BNF), I have more than 50 years of research experience, part of which had been gained by spending time at the International Rice Research Institute (IRRI) in the Philippines, the International Atomic Energy Agency (IAEA) in Vienna the Weizmann Institute of Science in Israel, Washington State Univeristy and San Jose State Univeristy in the USA.

[In CDW's article in the Island Newspaper etc., no details of his carrer etc., were stated. In judging a scientific question, only the data must

be consided, and all the personal details are unnecessary and prejudicial to a proper evaluationof the matter at hand.

What is needed to reveal is if A CONFLICT OF INTEREST IS INVOLVED. For instance, what Dr. Kulasooriya needs to reveal is his commercial interests in any of the products being discussed, if any. Such an interest has not been stated or in any of the publications.]

All my research studies were aimed at examining biological alternatives to minimize the application of chemical N-fertilizers in crop production. This had been a common goal internationally and included in the UN sustainable development goals (SDGs) on N-management. While I emphasize on the application of our research findings mostly from field studies conducted in Sri Lanka, a few examples from overseas work are also included.

Having examined the impacts of adopting BNF on agriculture, it was realized that rhizobial inoculation of legume crops had been the most successful. This technology is 125 years old being patented in the USA in 1896 by Nobbe and Hiltner (quoted by Aurora et al 2017).

Aurora et al (2017) Rhizobium Bioformulations: Past, Present and Future. https://www.researchgate.net/publication/318841916. DOI: 10-1007/978-981-10-4862-3-4.

The Department of Agriculture (DOA) had not adopted this technology after the failure of an initial attempt in the early 1980s of applying a NiFTAL inoculant (Nitragin S) under a USAID program. Our research group initiated the development of this technology at the Institute of Fundamental Studies (IFS at that time) to conduct basic studies on BNF, followed by applied research at the Department of Botany, University of Peradeniya in 2005 under a grant awarded by the Council for Agricultural Research Policy (CARP). Having completed basic studies of isolation, purification and authentication of rhizobia from soybean we used modified coir dust as a carrier material in the development of rhizobial inoculants to be transferred to farmers for application. Initial demonstration field experiments conducted at the Horticultural Development Research Institute (HORDI) of the Department of Agriculture were very successful and clearly showed that our inoculants could completely replace the application of urea to soybean without any reduction in crop yield.

[Comment by CDW: This says 100% replacement of chemical ferttilizer? Can Dr. Kulasooriya please provide references and comparative yield data from HORDI or publication sources? If the material has not been published openly in peer-reviewed journals, how can the scientific community know about it or scrutinize it?]

Then we moved out to conduct agronomic scale field trials in farmers' fields making use of a group of outsourced farmers of the private company Plenty Foods Limited. We engaged the farners themselves to carry out the inoculation trials under our guidance. 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 upto date Plenty Foods PLC had been one of our principal customers for inoculants. Subsequently we have extended the application of different crop specific rhizobial inoculants to mung bean (*Vigna radiata*), vegetable bean (*Phaseolus vulgaris*), groundnut (*Arachys hypogea*) and the forage crop clover (*Trifolium repens*), completely replacing the application of urea Kulasooriya et al (2021).

[Comment by CDW: "*Nitrogen fertiliser replacement by single and multi-strain rhizobial inoculants for black gram, green gram and soybean cultivation in Sri Lanka*" C.S Hettiarachchi et al., J. NSF, vol. 49. So, this work, published only in Septem,ber 2021 proves what was stated in the CDW's comment that this is still in the research and development stage. A result has to be confirmed by repeating it, esp. by other independent scientists.]

This year (i.e. 11 years later) until end August, we have supplied rhizobial inoculants to cover 14,750 acres of legume crops and more than half of them were provided to the Central and Provincial Departments of Agriculture. Three weeks back we received another order from the Central Province Agriculture Department for 10,000 packets of inoculants for vegetable beans. The cost of our inoculants are kept low so that the resource poor farmers can afford to buy them. A 250g packet of inoculants recommended for one acre of soybean, mung bean and groundnut is marketed at Rs.400/- and a 100g packet recommended to be used for the inoculation of 1kg of vegetable bean seeds is sold at Rs.120/-. This should convince any sensible person that our inoculants have gained confidence among the end users. It is therefore disappointing to find that Sri Lankan scientists living abroad are ignorant of our work and trying to ridicule our attempts to minimize the use of chemicals in agriculture. At present we are working very closely with the Government Department of Agriculture because they have accepted the fact that a significant reduction in the application of chemical N-fertilizers can be achieved by the use of our rhizobial inoculants.

[If this process has been sold to farmers for the last 11 years, there must have been adequate green house data and field data already in 2010 to justify selling it to the public. Can Dr. Kulasooriya provide refernces to the relevant data from that period?]

Kulasooriya et al (2021) Post Covid-19 agriculture: The way forward, pp 387 - 394 In: Senaratne, R., Amaratunga, D., Mendis, S. & Athukorala, P (eds) (2021), COVID 19: Impact, Mitigation, Opportunities and Building Resilience "From Adversity to Serendipity", Perspectives of global relevance based on research, experience and successes in combating COVID-19 in Sri Lanka, Vol. 1, National science Foundation, Sri Lanka: ISBN 978-624-5896-00-4

The suggestion by Chris to make a recommendation to grow a N_2 fixing mung cultivation as an intercrop between two rice crops is worth examing instead of rejecting as suggested by Chandre.

[So it is only a suggetion by Mr Dharmakeerthi who stated it as a matter of fact. However, he can research the literature and confirm for himself the Indian work , as well as latin American and other work on these topics which show that what he says is not true in practice.]

This inter cropping is already in practice by farmers from the Hambantota District in Southern Sri Lanka. During the last 5 years those farmers have adopted a practice of broadcasting mung seeds to the stubble of the rice crop immediately after its harvest. In this manner they overcome the period of 60 to 70 days necessary for the maturation of the mung crop prior to land preparation for the succeeding rice crop. This season some of the farmers of Southern Sri Lanka are applying our rhizobial inoculants to their inter cropping mung to see whether soil fertility could be further improved in this manner.

[Inter-cropping with a legume is nothing new and has been practiced for thousands of years, e.g., in MILUPA farming in meso-America, and in may other communities. What Mr. Dharmakirthi suggested was that Mung Bean be planted before the rice crop, and that it will leave behind 200-300% more N than the paddy would require. It is those unsubstantiated exaggerations that I rejected.]

Under Chris Dhamakirthi's coordination what we are planning to do is to conduct an inoculated intercrop of mung following a rice crop in comparison to an uninoculated one, in the Mahaweli organic zone and estimate the soil N accumulations. It should be realized that at least part of the nitrogen obtained by an inoculated legume comes from atmospheric N_2.

[Good, do the experiments first, and then make the claims afterwards.]

We have demonstrated such gains using isotopes of nitrogen during my work at the IAEA and the Weizmann Institute. Such experiments using soybean had shown that at least 65 to 70% of the N had been derived from the atmosphere. It should be realized that a nitrogen fixing plant not only obtain a good part of N from the atmosphere but also saves a significant portion of soil nitrogen during its growth and incorporating the crop residues will further improve soil fertility. Chandre had cited a couple of recent publications to strengthen his argument that the use of N_2-fixing legumes to improve soil fertility is still at what he calls a 'drawing board status'. His reference to Yin et al (2018) is on a study to work out a more efficient N, P & K chemical fertilizer application schedule on the yield components of a mung bean variety in China and has nothing to do with rhizobial inoculations. The other paper by Farero et al (2021) on mung bean is an exhaustive study applying modern molecular techniques to understand the roles played by root associated microbes that function in conjuction with rhizobia. This is a novel area of research after the recent (last decade) findings that all plants roots have communities of rhizosphere microorganisms aptly termed 'microbiomes'. Such microbiomes have been shown to provide the hosts not only with a multitude of growth promoting and biocontrol attributes against pests and pathogens, but also strengthens the host's ability to withstand adverse environmental conditions. This is the latest trend in research studies in soil microbiology and we ourselves are engaged in similar studies in order to develop multi-microbial inoculants (including biofilm biofertilizers). All I can say to Chandre's suggestion that 'we should wait until such studies are completed' is to cite the remark made by John Kerry at the recently concluded climate change conference COP 26 in Glasgow, 'You can't let the perfect to be the enemy of the good'.

I would agree to a certain extent with Chandre that the use of N_2- fixing cyanobacteria and *Azolla* (an aquatic fern with a N_2-fixing cynaobacterium as an endosymbiont) have limited potential in large scale crop production. I say this with my experience at IRRI where we did an exhaustive literature survey reading through thousands of publications on cynaobacteria in the preparation of the book entitled *Blue-Green Algae and Rice* co-authored by me with Dr. Pierre Roger published in 1980. I also conducted pioneering studies on the application of *Azolla* for rice cultivation in Sri Lanka. Such studies were done in the late 1970s to mid 1980s. From these studies it became evident that use of such organisms has potentials, but to realize them on a large scale it would be necessary to overcome limitations including the regimentation of farmers which would be nearly impossible under a democratic government. Nonetheless, I would not completely write off their application because there are limited success stories coming from certain countries like Myanmar, Vietnam, Thailand, Philippines, Costa Rica, Bangladesh and China (prior to modernization).

However the comparison of *Azolla* with *Salvinia* by Chnadre is another instance of his limited knowledge on these plants because *Azolla* is a N_2-fixing plant, while *Salvinia* is not. These aquatic plants including *Eichornia* are known to accumulate heavy metals, but that depends upon where they are grown.

[**Although I have read most of Dr. Kulasooriya's relevant papers, I am afraid that Dr. Kulasooriya may probably not have read even a single of my papers, or even the website on Sri Lankan plants that I have maintained almost ever since the world wide web came into being. Please see my entry on *Salvinia* in** https://dh-web.org/place.names/bot2sinhala.html]

So far my focus had been on the adoption of materials and techniques to minimize the application of synthetic chemical fertilizers in agriculture because 70 to 80% of the added chemicals get washed off and lead to environmental pollution. It is of equal importance to take steps to minimize such pollution reaching our water resources and it is incumbent upon our scientists to explore all possibilities to achieve this objective. Soluble inorganic chemicals do not move down with water in the form of dissolved ions. They get adsorbed to collidal clay particles and move along streams and rivers until they reach stagnant water bodies like ponds, reservoirs, irrigation tanks etc. These water bodies thus undergo eutrophication and hyper eutrophication and the end result is the formation of algal blooms. Such blooms in Sri Lanka are dominated by toxigenic cyanobacteria and these toxins have been implicated in the prolifertion of non-communicable diseases like cancer, heart ailments, liver and kidney failures. Our studies covering some 65 such stagnant water bodies in Sri Lanka (Kulasooriya 2017 and Kulasooriya et al 2014) have revealed that their phytoplanktons are dominated by *Microcystis* and *Cylindrospermopsis* and occasionally *Anabaena*, all toxin producing genera. Therefore while attempting to reduce the use of chemical fertilizers in agriculture, let us also look at ways and means of minimizing environmental pollution.

Kulasooriya, S. A. (2014) Amelioration of pollution of inland freshwater bodies in Sri Lanka. In: Illeperuma, O. A., Priyantha, N., Yatigammana, S. K., Madawala, H. M. S. P., & Wijesundera, C (eds) Symp Proc. 3rd International Symposium on Water Quality and Human Health: Challenges Ahead, 27 & 28, June, PGIS, University of Peradeniya. Keynote Paper: 3 – 6.

S. A. Kulasooriya, S. A. (2017) Toxin producing freshwater cyanobacteria of Sri Lanka. Ceylon Journal of Science **46** (1): 3 – 17, DOI: http://doi.org/10.4038/cjs.v46i1.7413 (Review paper)

One of the foremost attempts should be to consolidate our streams and river banks and reduce top soil erosion to water ways. The collosal amounts of collidal clay particles moving down the Mahaweli river is illustrated in the photo reproduced below.

Fig 2: Colloidal clay flowing down Mahaweli river

A concerted effort should be made to strengthen stream and river banks by growing suitable flood tolerant trees together with reeds and grasses along them. Bamboos (including the giant green species) are ideal for the high and midcountry wet zones while Kumbuk (*Terminalia arjuna*) is the tree of choice for the dry zones. For lagoons and bays close to the coast, mangrove plants as well as Bimpol (*Nypa fruticans*) can be introduced. I have personally seen 100ds of kilometers of such *Nypa fruticans* strengthened stream banks in Vietnam. Moreover that country is using such water ways for recreational purposes and tourism. Such micro-vegetations would also enable the establishment of algal grazing zooplankton like micro-crustaceans, copipods, daphnids etc that will consume most of the cyanobacterial propagules that would otherwise flow on to the stagnant waters. These projects should be initiated and promoted by the Ministry of Environment on short, mid and long term plans. Regulations have to formulated and strictly enforced on sand mining from stream and river banks. Permission should be given for sand mining only from areas where eroded soils get deposited in the flat plains. Incentives should be provided to the plantation sector to streghten the areas bordering their water ways. The plantations would benefit immensely by restoring and saving their fertile top soil which is non-existant today. A few years back late Prof. Aries Kovoor commenced a tissue culture project of bamboo and successfully established a tissue culture laboratory under a trained Research Officer but this was abandoned after he left the IFS. Such projects should be revived and given priority to produce enough planting material within a short period.

[**These are unnecessary arguments as Dr. Kulasooriya is wasting time by telling us about eutrophication. I am sure every soil scientist or environmental scientist is aware of all this. Furthermore, if Dr. Kulasooriya would go back into the Island Newspaper archives, he will see what CDW has written on this topic. One of those articles was written by CDW and co-authored by Dr. Sarath Amarasiri, a past Director General of Agriculture and well known in soil science.**]

With all sincerity I wish to conclude this write up by proposing that all of us Sri Lankans whether living in this country or domiciled overseas should contribute in whatever manner to improve the living conditions of the vast majority of our poor people rather than to waste time in engaging in unnecessary arguments.

[**Indeed, Prof. Kulasoorya need not engage in unnecessary arguments. What was said by Chandre DW is that "Kulasooriya and others have reported preliminary studies" (on using N-fixing algaein biofertilizers) and this is not an incorrect statement or an unnecessary argument, as confirmed by Kulasooriya's 2021 paper and his 2016 review apper.**

Instead Dr. Kulasooriya can provide refernces to his quantitative data that show that his inoculants, when added to the soil significantly increase the bio-available nitrogen content.]