Agric. Sci. Digest., 38(4) 2018: 310-312
Print ISSN:0253-150X / Online ISSN:0976-0547

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com

Voltage production using metabolic activities of *Azatobacter* species and other soil microbial flora in rice field using microbial fuel cell and microbial solar cell technology

Aboli Chimurkar, Vaidehi Chandorkar* and Ashok Gomashe

Department of Microbiology,
Shivaji Science College, Congress Nagar, Nagpur-440 012, Maharashtra, India.
Received: 23-06-2018 Accepted: 22-10-2018 DOI: 10.18805/ag.D-4780

ABSTRACT

The voltage generation from metabolic reactions of bacteria due to exudates in rhizosphere of rice crop was demonstrated by Azatobacter *species* and natural soil microbial flora using microbial fuel cell. It was observed that voltage generated by microbial fuel cells increased from 0.5 V to 98.0 V till 60th day of the crop for one square feet area of rice field in laboratory conditions and on 90th day of the crop voltage was 1V maintained during day time. The range of increase in voltage was dependent on the intensity of sunlight. It was estimated that if one square feet of rice plantation can produce 1V after 90th day by this method, then in case of one acre of plantation 43560 V could be generated on the 90th day of the crop on each successive day. That might produce rice and enough voltage in an eco-friendly manner.

Key words: Azatobacter, Microbial fuel cell, Microbial solar cell, Rice crop, Voltage generation.

Nowadays worldwide energy crisis is one of the great problems. The interest in renewable energy has been revived over last few years, especially after global awareness regarding the ill effects of fossil fuel burning. The use of renewable energy technology to meet the energy demands has been steadily increasing for the past few years, however, the important drawbacks associated with renewable energy systems are their inability to guarantee reliability and their lean nature.

Many researchers studied energy analysis to de-termine the energy efficiency of plant production, such as potato in India (Yadav *et al*. 1991), sug-arcane in Morocco (Mrini *et al*. 2001) and Loui-siana (Ricaud 1980), rice in Malaysia (Bockari- Gevao *et al*. 2005), and cotton in Greece (Tsatsarelis 1991).

Biomass includes all biologically synthesize paths to Sustainable Energy chemicals, primary by photosynthetic organisms using sun light as the energy source and carbon dioxide as the raw material (i.e., the biological primary production). It is also known that the geochemical energy is also available for the synthesis; this process involves bacteria, called chemolithotrophs that use the chemical energy conserved in reduced inorganic chemicals to synthesize organic compounds from carbon dioxide. Biomass is the most abundant carbonaceous material at the surface of our planet, and the total amount has been estimated to be approximately 75 billion tons. Although the combustion of biomass also generates carbon dioxide, this is considered to be a part of carbon cycling on our plan*et al*ong with the biological primary production. In this sense, the use of biomass as an energy source is regarded as the "carbon neutral process". Accordingly, scientists and engineers are recently keen in developing technologies for utilizing energies conserved in biomass; these include the production of bio-ethanol (Gray *et al*. 2006), bio-hydrogen (Levin *et al*. 2004), and bio-electricity (Logan *et al*. 2006; Watanabe 2008). As described, we expect that the solar light and biomass will become important energy sources in the 21th century, and biological energy conversion (BEC) processes will be widely used in association with this energy shifts. In such processes, organisms (in particular, microbes) are catalysts that convert energy forms (e.g., the solar energy into the chemical energy) and chemical species (e.g., biomass into ethanol). A representative example is a photosynthetic organism that conserves the light energy as organic compounds rich in the chemical energy (Gust *et al*. 1993). In another case, bacteria ferment biomass chemicals, such as starch, to produce bio-ethanol (Gray *et al*. 2006). Besides, recent studies have found that some bacteria convert chemical energies in organic compounds into electricity (McConnell *et al*. 2010). Accordingly, we can say that we have a large repertoire of energy conversion processes, if biological systems are used. There are advantages of BEC processes over chemical processes; these include (I) they are environment friendly, (ii) the diversity of catabolic capacities expands a range of chemicals that can serve as fuels, and (iii) they are self-sustaining. Based on these advantages, BES processes are also able to use waste biomass as energy sources to generate

*Corresponding author's e-mail: abolichimurkar@gmail.com

fuel gases (hydrogen, and methane) and electricity. Such a process must be impossible, when we use chemical catalysts. This chapter introduces technologies for generating bio-electricity from the sun light and/or biomass, particularly those that use in rice paddy fields (RPFs). Since electricity generation in RPFs is a process that is a combination of microbial solar cells (MSCs) and microbial fuel cells (MFCs), these BEC processes are explained before describing RPF electricity generation.

Combined application of microbial fuel cell and Microbial solar cell was introduced in this research exploration.The entire experimental process consists of two parts. Both these parts are explained here briefly. Let these parts be named as Part A and Part B respectively.

Part A: It was the first part of experiment and consisted of germination of seeds and prepared small plantlets of rice for plantation. Initially the seeds of rice were soaked in water for about three days, till it germinates effectively. After three days, the germination of seeds was observed properly by removing seeds from the water. Now, the plastic tray was taken which consisted of 40 % vermin compost and 60% of black garden soil in it. Both the components were mixed thoroughly with hands. Now, 4 % of powdered inoculums of *Azatobacter (*4 gm in 1 kg) were added to this mixture. That mixture is again mixed thoroughly by hands for about 5 minutes.

After five minutes, the mixture was layered properly in the tray in such a way that flat surface of mixture was made in it. After making this assembly ready for seeding, small holes were made at distance of about 1.5 cm from each other in vertical and horizontal direction to form a crossword like shape (Fig 1). In the next step, these tiny holes were filled with germinated seeds of rice and covered with soil again. That tray was watered appropriately and kept in sunlight and other atmospheric conditions. The tray was watered every day once and observed. After 3-4 days, small grass like structure was evident in the tray (Fig 2). It was watered regularly and observed also. It was allowed to grow in size for about 8-10 days to form a plantlet of rice which is about 20-25 cm in length and can be transferred to the field. At the time of transplantation, the bunch of three plantlets was made.

Part B: In the second part of experiment, initially prepared first set up was attached to the second tray that contained saturated salt solution. Salt bridge was prepared by placing cotton rope of length 30 cm and diameter of 1.6 cm in water bowl submerged for 2 Hour. Both the trays were combined with the help of salt bridge (cotton rope). The electrode was made from stainless steel spoon which was submerged in the salt solution container. The solution in the container was aerated with the help of another spoon. After the fixed time interval, the voltage generated was measured using multi-meter. The data obtained from multi-meter was recorded.

For the proper growth of rice plantlets, specific notional media for rice crop was essential, this media should include all the required micro and macro nutrients. Hence the following composition made. This composition includes 8% biofertilizer (Azatobacter species), 31% vermicompost and 62% of soil.The voltage was recorded after 24 hours in 30 successive days. Voltage increase as the day progresses as depicted in Graph 1.

The major purpose of performing this research work was to find out eco-friendly technology and sustainable technology which will benefit the society by fulfilling its energy demands. This technology is now at very preliminary stage, but it is expected that in coming days this technology could be one of the most affordable and eco-friendly technology for power generation. This technology can be useful to empower the Indian farmer who cultivate rice in the wet lands and benefit him financially by power generation in the rice fields along with rice production. It will help to maintain food security as well as energy security of the country in easy and eco-friendly way.

In this research work, it was found that steady voltage of about 1V-1.5 V can be obtained per square feet area of rice after 30 days of plantation and availability of intense sunlight in the area. In the same way the concentration of oxygen in cathode compartment containing water is also essential to be higher in order to get desired voltage. Voltage generated by microbial fuel cells increased from 0.5 V to



Fig 1: Electrode mash containing set upforrice plant.

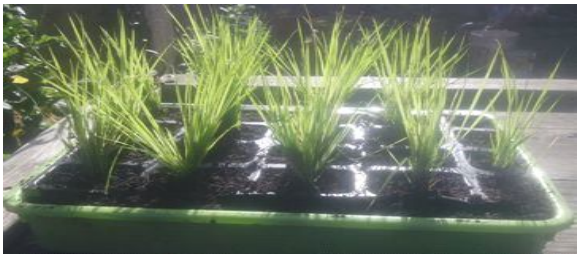
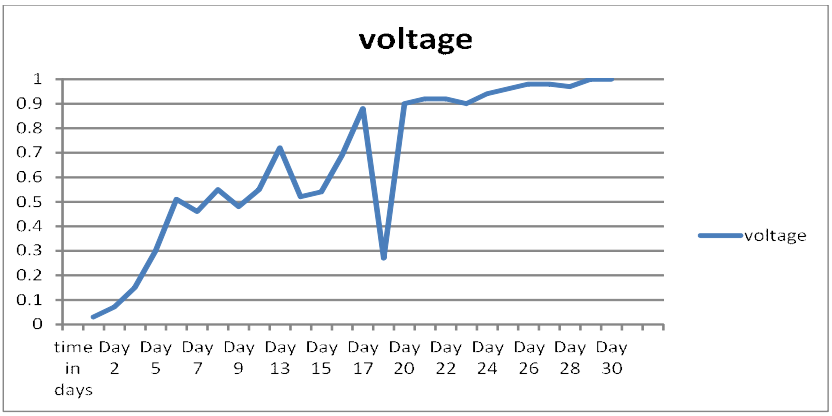


Fig 2: Plant growth after 1 weak of seed germination.



Graph 1: The graph displays the voltage generated by the system on each successive day from Day 1 – Day 30.

98.0 V till 60th day of the crop. This demonstration was done for one square feet area of rice field in laboratory conditions. Hence the Voltage obtained was per square feet on 90th day of the crop was 1 V and it was maintained during day time. The range of increase in voltage was dependent on the intensity of sunlight. It was estimated that if one square feet of rice plantation can produce 1V after 90th day by this method, then in case of one acre of plantation, 43560 V could be generated on the 90th day of the crop on each successive day. In order to know more about the feasibility of this project, it is necessary to perform this work on field in pilot scale.

Before two years, similar research work was performed by Dutch Scientists called Helder *et al* (2013). They found products demonstrating charging of mobile phone with the help of green electricity from plants.

The research work performed in that research exploration was cheaper and sustainable. The amount of voltage generated by that method was dependent upon salt concentration in the water present in cathode chamber.

According to the readings it was found that voltage generated by that system was directly proportional to the sunlight intensity till some extent and after specific extent, steady voltage was observed. The amount of voltage was also dependent on the amount of soil born microbial flora in different growth phase.

The voltage was more when maximum microbes in rhizosphere were in exponential phase of growth. At the same time oxygen concentration in aerobic chamber of microbial fuel cell or cathode chamber was also responsible for steady voltage. The voltage was more when water in cathode chamber was highly aerobic. The anaerobic condition was essential in rhizosphere of rice field in order to proceed the voltage generation in the microbial solar cell and microbial fuel cell. Still there is not much work done in this subject as it is very novel and emerging technology.

REFERENCES

Bockari-Gevao S.M., Wan Ishak W.I., Azmi Y., Chan C.W., (2005). Analysis of energy consumption in lowland rice-based cropping system of Malaysia. *Science Technology*, **27:** 819–826.

Gray, K.A.; Zhao, L. and Emptage, M. (2006) Bioethanol. Curr. Opin. *Chem. Biol.* **10:** 141-146.

Gust D, Moore T.A , Moore L.A (1993). Molecular Mimicry of Photosynthetic energy and electron transfer. *Accounts chem.Res* **26:** 198-205.

Helder M., Strik, Timmers R., Buisman C., (2013). Resilience of roof top plant-microbial fuel cells during Dutch Winter. *Biomass and Bioenergy*, **51:**1-7.

Levin, D.B.; Pitt, L. and Love, M. (2004). Biohydrogen production: prospects and limitations.

Logan BE, Regan JM (2006) Electricity-producing bacterial communities in microbial fuel cells. *Trends Microbiol.* **14:** 512-518.

McConnell, I.; Li, G. and Brudvig, G. W. (2010). Energy conversion in natural and artificial photosynthesis. Chem. Biol. **17:** 434-447.

Mrini M., Senhaji F., Pimentel D., (2001). Energy analysis of sugarcane production in Morocco. *Environmental De-velopment Sustainability*, **3:** 109–126.

Ricaud R., (1980). Energy input and output for sugarcane in Louisiana. In: Handbook of Energy Uti-lization in Agriculture. [Pimentel D. (ed.)], Boca Raton, CRC Press: 135–136.

Tsatsarelis C.A., (1991). Energy requirements for cotton production in the central Greece. *Journal of Agricultural Engineering Research*, **50:** 239–246.

Watanabe, K. (2008). Recent developments in microbial fuel cell technologies for sustainable bioenergy. *J. Biosci. Bioeng*. **106:** 528–536.

Yadav R.N., Singh R.K.P., Prasad S., (1991). An economic analysis of energy requirements in the production of potato crop in bihar sharif block of Nalanda district (Bihar). *Econ Affair Kalkatta*, **36:** 112–119.