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Suitability of Nigerian Weather Conditions for Cultivation of Microalgae

Ali, F.U. and Ogbonna J. C.
Biotechnology Department Ebonyi State University, Abakaliki

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Abstract

This work evaluates the suitability of Nigeria weather conditions for cultivation of microalgae species. Meteorological data from different locations were analyzed and compared with optimal conditions for cultivation of various species of microalgae. Average solar radiation in various parts were 1439.9±5μmolm^2/s for Jos; 2837.1±4μmolm^2/s for Kaduna, 1783.3±5μmolm^2/s for Ikeja, 2368.4±5μmolm^2/s for Benin; 2516±3μmolm^2/s for Emene; 2540.6±5μmolm^2/s for Independence layout Enugu; and 2038.5 ±4μmolm^2 /s for Owerri. In order to establish if these solar radiation values are suitable for cultivation of photosynthetic cells, *Chlorella sorokiniana* was cultivated under sunny (2816±5μmolm^2/s), partially shaded (2243±2μmolm^2 /s) and shaded (1468±5 μmolm^2 /s) conditions within Abakaliki. The result showed high growth rate under full sunlight, followed by medium and low growth rate for partial shade and shade. Thus Kaduna and Enugu would support better growth of *Chlorella* than Jos and Owerri. The results of average hours of sunshine showed that Jos has the lowest number of hours of sunshine whereas Kaduna has the highest number of hours of sunshine for the areas investigated. The results showed that the cell growth rate of *Chlorella sorokiniana* and *Euglena,* final cell concentrations increased with increase in the number of hours of sunshine. Mean temperature in the meteorological stations ranged from 21. 8±4 ^{0}C in Jos to 28.2±5^{0}C in Kaduna. Temperature stratification in ponds within Abakaliki was investigated and found to be conducive for cultivation of many species of photosynthetic cells, (22-41^{0}C) in stagnant; (22-28^{0}C) in mixed ponds. There was an interaction between temperature, time and distance from the surface to bottom of the pond. The result of effect of inoculation volume on the growth of *Chlorella sorokiniana* and *Euglena* showed that these species can be cultivated in Nigeria.

Key words: *Chlorella sorokiniana*, *Euglena gracilis* , Weather Condition, Microalgae

Corresponding Author: alifredrick@ yahoo.com

Introduction

Micoalgae were amongst the first life forms on our planet. They are responsible for fixing massive amounts of carbon dioxide while producing and sustaining the atmospheric oxygen that has allowed that miraculous evolutionary blossoming of all forms of higher life. When cancer and other diseases have reached epidemic proportions, many people are instinctively turning to these original life forms for nutritional healing (Dubinsky and Achituv, 2003). These super foods are easily cultivated and have been suggested as the answer to the disturbing question of how we will feed the starving masses of our ever increasing world population (Ronald *et al.,* 2003). Small amounts of microalge like *Chlorella* and *Spirulina* provide an exceptionally tremendous quantity of nutrients that are essential to health. They are ideal for those preferring a simple whole food supplement over dozens of artificial vitamin and nutrient sources. The unique nourishing and healing properties of *Chlorella* and *Spirulina* truly complement one another. Any one can benefit from consuming a little of those original foods each day (David *et al,.* 1995). The world suffers from food shortage especially of protein foods. The United Nations food and agricultural organization (FAO) estimates that the world requires 65 million tonnes of animal protein by the year 2020 and an estimated population increase of 70 million persons each year requiring a yearly amount of 2 million tonnes of additional protein. It is therefore, difficult to meet up with this demand by the current conventional agricultural practices of cultivation and animal husbandry, which may require at least 40 million hectares of land (Smith, 1996). Also due to the increase in land prices especially in developed regions, places where it is economical to use large areas of land for conventional farming is decreasing steadily (Smith, 1996).

Microalgae would seem to be the ideal source to fill this food gap between the industrialized and less industrialized parts of the world (Green *et al.,* 1980). Microalgae solves these problems faster possessing certain distinct advantages over higher plants. They grow at a faster rate, are easier to manipulate in open ponds or closed reactors for production of desired metabolites and generally possess a higher photosynthetic efficiency, uses CO_2 and solar energy more efficiently. The land use efficiency is also better than that of higher plants (David *et al.,* 1995). Green algae such as *Dunaliella* (glycerol producer) and *Botryococcus* (hydrocarbon synthesizer) are potential sources of energy rich fuels. Some of the primary and secondary metabolic products of microalgae are high value biochemical and pharmaceuticals (Cress well *et al*., 1989; Richmond, 1986).

This work was done to ascertain the suitability of Nigeria environment for cultivation of microalgae species. This study will enable investors both local and foreign to invest in the cultivation of microalgae and production of its by products. Thus, this will also enable us to determine parts of Nigeria that is most favourable for cultivation of a particular species of microalgae since environmental factors influence their production.

Materials and Methods

Chlorella sorokiniana. and *Euglena gracilis* were obtained from seed culture maintained at OGB Biotechnology Research and Development Center Enugu, Nigeria . The medium is the liquid fertilizer produced by CANDEL company Ltd, Lagos which consist of 20% N, 20% K; 0.1% Mg; 0.15% Fe; 0.075% Mn; 200 ml of water was measured with measuring cylinder into bioreactor. Liquid fertilizer (5 ml) and 195 ml of stock culture were added. This was cultivated to log phase and 500ml of the culture was used to inoculate each of the 3 (2000 ml) bioreactors.These were cultivated under full sunlight (3167 µmolm^2 /s), partially shaded (2243 µmolm^2 /s)and shaded (1468 µmolm^2 /s), respectively. Cell growth rate was determined by cell counting using a haemocytometer with light microscope (Philip Haris) daily.

Chlorella sorokiniana and *Euglena gracilis* were cultivated under sunlight for different length of time to investigate the effect of hour of sunshine on their growth. Three bioreactors, each containing 2000 ml of the culture medium were inoulcated with 195 ml of the seed culture. The cell concentration in the seed culture was $5.7x10^8$ cells /ml. These were cultivated for 5 hours, 8 hours, 10 hours and 12 hours respectively. After the desired hours of cultivation, the cultures were covered with basket to mimic those locations with short or long hours of sunshine and also to determine the feasibility of growing microalgae species in different locations in Nigeria with different hours of sunshine.

Effect of inoculum volume on the growth of *C. sorokiniana* under 5 hours of sunshine was determined. Four bioreactors were used for the experiment. Each of the four bioreactors, containing 2000ml of the medium, concentration $3.5x10^8$ cells/ml was inoculcated with 100 ml, 200 ml, 300 ml or 400 ml of the seed culture of *C. sorokiniana* . These were cultivated under 5 hours of sunshine. Cell growth rate was determined daily by cell counting using a haemocytometer with light microscope. This was done to evaluate possible interaction between hours of sunshine and inoculum volume.

A 30 cm by 20cm hole was dug in the ground and 30cm bioreactor was placed inside it. The bioreactor was filled with water to the brim, to determine strata distribution of temperature in open ponds. A 35cm stick was marked from the surface of the water: surface, 5 cm, 10 cm, and then 30 cm (bottom of the pond). The laboratory thermometers were placed along the stick at different depths and held in position by a masking tape. The stick was placed inside the pond and help in position by a support to determine temperature stratification of the pond at different times of the day. The readings were taken at 6am, 11am, 1pm, 3am, 4:30pm and 7pm everyday. Mixing experiment was also conducted in which the pond was stirred at an interval of one hour with a stirrer.

Furthermore, meteorological data from various geographical locations in Nigeria were also collected for a period of 11years (1993-2003). These locations were North (Kaduna and Jos), South West (Ikeja and Benin) and South East (Imo and Enugu State) . The data were compared with the optima for growth of various species of microalgae.

Results

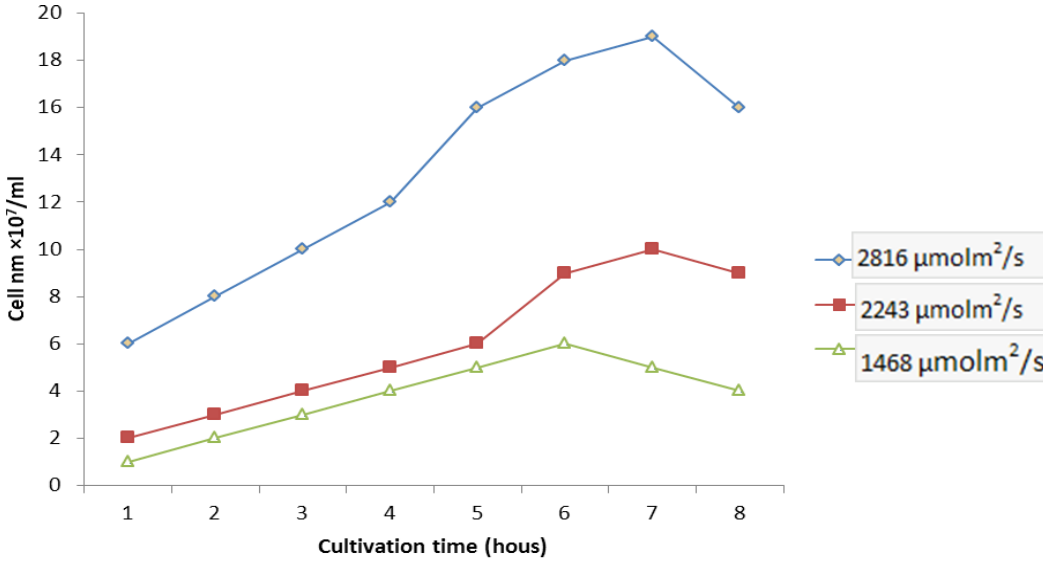

Fig 1: Growth rate of outdoor cultivated *Chlorella sorokiniana*

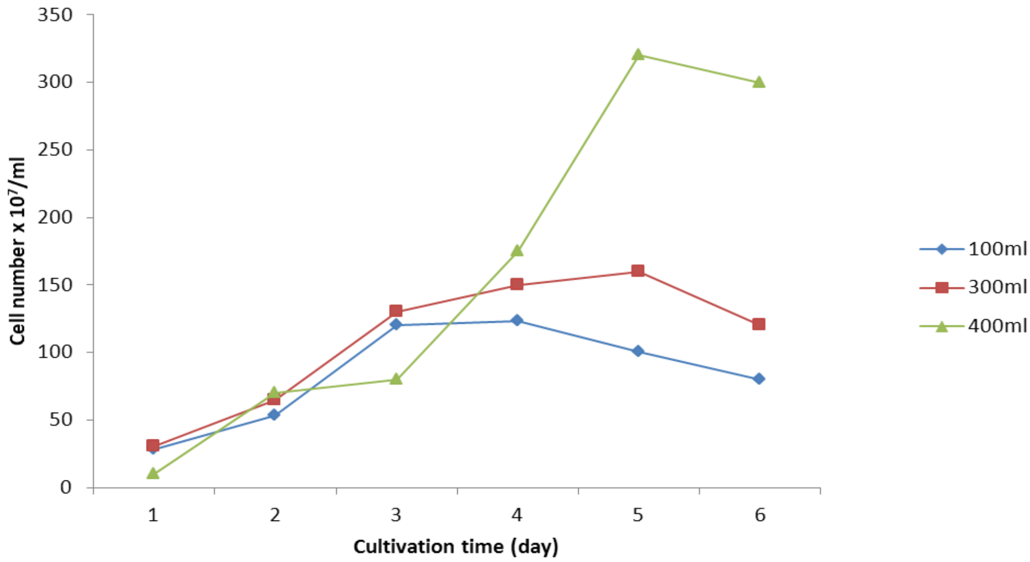

Fig 2: Effect of inoculum volume on the growth of *Chlorella Sorokinia*

Table 1: Temperature distribution in mixed pond

Distance/Time	Top Surface	5cm	10cm	30cm	Confidence Limit (±)
6am	29	2825	29	22	3
11am	32.5	30.75	30	32.5	0.1
1pm	34.5	32.5	31.25	33.75	3
3pm	35.75	33.25	31.75	33.25	2
4.30pm	32.5	30.25	31	31	5
7pm	32.5	31	30.25	29.25	3
Mean	32.7	31.1	30.5	29.9	2.6

Table 2: Effect fo hour of sunshine on the cell concentration of C. sorokiniana

	Cell concentration ($x10^7$ cell/ml)				
Days	5hours	7hours	10hours	12hours	Confidence Limit (±)
1	5.4	7.6	8.9	10.7	2
2	8.9	11.5	16.9	28.2	1
3	10.8	13.4	25.9	30.2	4
4	14.2	14.8	32.2	55.4	5
5	21.3	22.8	37.1	82.6	3
6	24.9	25.9	42.8	126.8	5
7	42.8	60.2	81.9	263.6	4
8	37.1	50.2	70.5	201.4	1
9	32.3	42.8	54.0	192.9	5
10	28.6	39.4	50.4	153.9	6
11	26.3	34.2	48.4	136.7	2
12	22.8	32.9	39.0	125.2	5

Discussion

This study evaluated the suitability of Nigerian weather condition for cultivation of microalgae. The rationale being to establish a base line for the commencement of commercial microlagae cultivation in Nigeria.

Microalgae occupies an important position in the world economy, most especially in the area of diets, production of useful metabolites, and environmental bioremediation, it is necessary to establish a cultivation facilities in Nigeria. The first step in establishing industries producing microalgae in Nigeria is to identify species which can grow in various parts of Nigeria. Temperature profile in various parts of Nigeria revealed that many species of microalgae can be cultivated in various parts of Nigeria all the year round. Experiment on temperature stratification in stagnant ponds showed that temperature in open pond was stratified from top to bottom and it changed with the time of the day. Thus there was an interaction among temperature, distance and time of the day (Table 1). Optima culture depths for different species of microalgae in different location varies. Shallow pond is preferred for microalgae that have high temperature optima (Ogbonna *et al,* 1994). *C. sorokiniana, C. valgaris* and *Chlorogonium* will perform better in Kaduna, whereas mixing of culture ponds will result increased productivity and improve movement of cells between the zones of low temperature and high temperature. This is in line with Ogbonna *et al.,* 1994).

The result of *C. sorokiniana* cultivated under three different solar intensity within Ebonyi State, showed high growth rate under high light intensity (figure 1). Better supply of light may be the reason for high growth rate showed by *C. sorokiniana* under high light intensities. Low light intensity results in light limitation (depending on light utilization capacity of the species) which in turn causes the cells in the culture to stop dividing (Ogbonna *et al*., 1994).

Solar light absorption capacity varies among different species of microalgae ((Ogbonna,1998).Some have high absorption capacity for solar light (eg *ChIorella*) and can be cultivated in locations with high solar intensity like Kaduna whereas other species (eg *Spirulina*) can utilize low light intensity more efficiently and can be cultivated in locations with low light intensity like Benin. The light adaptation mechamisn of algae varies within algal group. (Ramnus, 1983; Larkum and Berret, 1983).

Apart from solar light intensity, meteorological data also revealed that various locations in Nigeria differed in the number of hour of sunshine. Thus the effect of hour of sunshine on the growth of *C. sorokiniana* and *Euglana gracilis* were also investigated. It was observed that growth rate of *C.sorokiniana* and *Euglena g.* increased with increase in the number of hour of sunshine (Table 2). With these results, it can be inferred that *C.sorokiniana.* and *Euglena gracilis* can be cultivated at kaduna, Owerri and Enugu with long period of hour of sunshine. Richmond (2001), showed that the longer the hour of sunshine the higher the productivity.

This study has shown that inoculation volume influenced the growth rate of *C. sorokiniana* and *Euglena gracilis* with high inoculation volume having the highest growth rate (figure 2). Increase in inoculation volume enhanced the productivity of microalgae species. This implies that in locations with short hour of sunshine, example Jos and high rain fall like Benin cultivation of microalgae can be enhanced by increasing the inoculation volume.

Furthermore, the weather conditions in different geographical locations were analyzed and compared with the optimal conditions for growth of microalgae species. In all, kaduna has the highest solar intensity, hour of sunshine and temperature, probably due to the high cloud (cirrostratus) and position of kaduna from Atlantic ocean (Pulz,1992) whereas Jos has the lowest , because Jos is in the plateau and the type cloud (stratus) that is prevalent in that area (Pulz , 1992) .Benin (south) and Enugu, Owerri (East) have greater rain fall and shorter dry season because they are nearer the equator, low cloud (Nibostratus) which give rise to continuous rain (Pulz, 1998) .

The progressive increase in solar radiation in Nigeria within the period of this research may be attributed to ozone layer depletion (Torzillo *et al.,* 1991). The relatively high temperature throughout the year, high solar light intensity, and average rainfall in Nigeria are clear indications that Nigeria has suitable weather condition for cultivation of microalgae.

Conclusion

Our results showed that the productivity increased with increase in solar light intensity, hour of sunshine and inoculum volume. Nigeria has a vast potential for cultivations of microalgae; high solar light intensity, long period of sunshine, high temperature throughout the year, and low average rainfall. Thus investors both foreign and local can invest in the production of microalgae in Nigeria.

References

Cress well I.,Christi, Y.and Moo-Young, M., (1989). Bioprocess intensification through photobioreactor engineering pages 74A, 575-583. *Elsevier science Amsterdam.*

David I, D'Addario,E.Fascetti,E., and Valdiserri, M.(1995). Hydrogen production from organic wastes by continuous culture of *Rhodobacter sphaeroides* RV in hydrogen energy progress, proceedings of the 11th world hydrogen energy conference, Veziroglu , T.N. (eds), stuHgart, Germany, June 23-28, 1995, pp 2577-2282.

Dubinsky and Achituv,(2003). Microalgal biotechnology at the turn of the millenium: a personal view. *Journal Applied Biotechnology 12*: 441-451

Green E.R, Grima, E.M and Jessy, A.H (1980). Modelin of Eicosapentaenoic acid (EPA) production in tubular photobioreactors; Effects of dilution rates, tube diameter and solar irradiance**.** *Biotechnology Bioengineering; 68*: 173-188.

Larkum I. and Berret, G. (1983). The effect of growth temperature on the bioenergetics of photosynthetic algal cultures. *Biotechnology Bioengineering 7*: 555-561 .

Ogbonna, J.C., Yada, H. and Tanaka, H. (1994). Light supply, coefficient: A new engineering parameter for photo bioreactor design *Journal of Fermentation Bioengineering.* 80: 369-376.

Ogbonna, J.C. and Tanaka, H. (1998). Cyclic autotrophic/ heterotrophic cultivation of photosynthetic cells- A method of achieving continuous cell growth under light / dark cycles. *Bioresource Technology* 65:65-72.

Pulz O. (1992). Cultivation Techniques for Micoalgae in open and closed ponds. Proceedings of the 1st European workshop on microalgal biotechnology . Potsdam, p 61.

Pulz O, (1998). Photobioreactors design and performances with respect to light energy input. In: Scheper T. (ed). Bioprocess and algae reactor technology, apoptosis. (Advances in biochemical engineering/ biotechnology, vol. 59) Springer, Berlin Heidelberg New York, P. 123.

Richmond, A. (1986). Large scale microalgal culture and applications. In: pound F.E. Chapman D.J. (eds) progress in physiological research volume 7 Biopress, Bristol.

Ronald, A., S., Boussiba, A. Vonshak and R. Kopel (2003). A new tubular reactor for mass production of microalgae out doors. *Journal of Applied phycology 5*: 327- 332.

SmithJ.K(1996).Production and nutritive value of Single cell protein from *Fusarium oxysporum* grown in vinasse .*Journal of Fermentation Technology* 63:91-94.

Torzillo, G,. A. Sacchi and R. Materassi (1991) . Temperature as an important factor affecting productivity and night biomass loss in *Spiriulina platensis* grown outdoors in tubular photobioreactors . Bioresource Technology 38:95-100.