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AUTONOMIC SYSTEM FOR VITROCULTURES ILLUMINATION

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ABSTRACT. In this experiment we assembled a photovoltaic panel from recycled solar cells and have used it, with an accumulator and a timer, as power supply for a LED-based growth box for *in vitro* cultures, trying this way to eliminate the consumption of electric energy used in biotechnological vitroconservation process. In order to test the efficiency of this system, we used *Solanum tuberosum* L. inocula as biological material and, within 8 weeks, we found that this project can be adapted, improved and successfully used in plant biotechnology area. The obtained *green power* could be used to reduce the electricity expenses for vitrocultures to almost zero, especially in the conservation domain, where, for illumination, is not necessary to have a bright light.

KEYWORDS: vitroculture, LED, *Solanum tuberosum* L., *green power*, photovoltaic, recycled

INTRODUCTION

The rising of industry, of the exuberant lifestyles and economical development require an ascending energy amount, need which is fulfilled – most of it – by using fossil resources. The exploitation of these underground deposits affects irreversibly the environment and, if we do not focus on changing present economy into a bioeconomy - the integration of economy in biological systems - (Roegen, 1979; Mayumi, 2001; Bonaiuti, 2011) and an eco-economy – an economy based on environmental factors - (Brown, 2001), the heritage that we are going to leave to the next generations will be a heavy one. The idea of a sustainable economy leads to a few principles, one of them being the utilization of renewable energy sources – like wind, sun, tides, thermal waters, etc. – instead of old polluting electric fossil-based power stations. In the Roegen's view, in order to achieve this goal, the economy must decrease, but the efficiency must increase (Roegen, 1971). Also, the utilization of recycled materials reduces the global energetic consumption by eliminating of natural resources exploitation and technological processes.

Today, the technology offers the possibility to use devices that have a lower energetic consumption. As an example, LED is a lighting electronic component, whose last generation offers a high brightness. The LED is a semiconductor device made from a combination of chemically polarized semiconductors. The chemical composition is chosen to define the energy of the electrons that pass across the boundary between the two types of semiconductor. This electron energy is converted to light as electrons flow though the device. LEDs are environment friendly (do not emit UV or IR radiation) and their consumption is very low, so they could be easily supplied from a small photovoltaic source. The applications that follow this conclusion could be multiple, one of them being plant vitrocultures, especially the vitropreservation. *In vitro* cultures can be considered simplified experimental systems, which permit a sequential study of different morphogenetic programs (Toma et al, 2003). International Board for Plant Genetic Resources (IBPGR) has evaluated the vitropreservation in aseptic conditions as being realistic and efficient. They recommend living collections establishment, so to have anytime available plant germplasm (Cachiţă et al, 2005). Vitropreservation is an alternative method to preserve genetic materials, based on plant *in vitro* cultures, with rare subcultivations.

In this experiment we intended to prove that illumination produced by LED, supplied from a photovoltaic panel as *green power* source, can be used to maintain alive a vitroculture in slow growth state. The term "photovoltaic" comes from the Greek φῶς (*phōs*) meaning "light", and "voltaic", from the name of the Italian physicist Volta, after whom a unit of electro-motive force, the volt, is named. The term "photo-voltaic" has been in use in English since 1849 (Smee, 1849). Albert Einstein explained the photoelectric effect in 1905 for which he received the Nobel Prize in Physics in 1921 (http 1) and Russell Ohl patented the modern junction semiconductor solar cell in 1946 (http 2). Photovoltaic (PV) systems use solar electric panels to directly convert the sun's energy into electricity. This conversion of sunlight to electricity occurs without moving parts, is silent and pollution free in its operation.

The species we choose to experiment with was *Solanum tuberosum* L., an important plant to be preserved, always needed as food, as seedling or as primary matter. The most important varieties are already stored in living collections, in gene banks, but the preservation is costly and, by this experiment, we intended to eliminate the electricity consumption by using an alternative renewable energy source, in order to reduce the preservation costs.

MATERIALS AND METHODS

For this experiment we used growth boxes – produced by us (Pop et al,, 2007; Pop et al, 2009) – based on Jao and Fang prototype (Jao and Fang, 2003), having LEDs as light source (Fig.1), which were supplied with electricity from an accumulator, charged with a photovoltaic panel, made by us from recycled photovoltaic cells (Fig.2) taken from garden solar lamps.

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The cells were wired together parallel, respecting their polarity. Finally, the output voltage was measured and found as being 2.08 Vcc - in a cloudy day - more than enough to charge the 1.2V NiMH accumulators (2500 mA/piece), class AA.

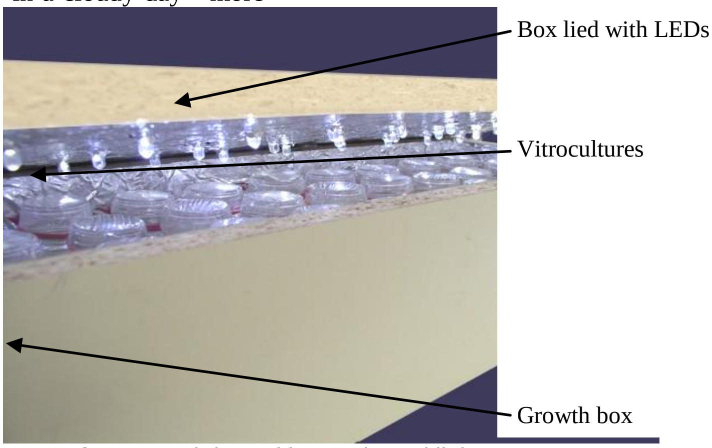

Fig.1 Growth box with LED-based light source

The montage was made manually, using common tools (Fig.2). Usually, the photovoltaic panels are quite expensive, but this was obtained very cheaply from recycled materials, and it provides enough power to supply a growth box containing 20 LEDs of 20mA each, being also, for anyone, an easy to be made system, with most common tools

Fig. 2 Stages of photovoltaic panel construction: 1-2 garden lamp; 3-6 – garden lamp disassembly; 7-8 – photovoltaic cells extraction; 9 – photovoltaic cells assemblage; 10 – wiring; 11 – voltage measuring; 12 – photovoltaic panel (the accumulators were placed on the back) mounted in a recycled scanner box.

The growth boxes were plugged to the autonomic system like in figure 3, using insulated conductors and electric sockets. The photovoltaic panel was placed outdoor and oriented to South, for the best solar exposition.

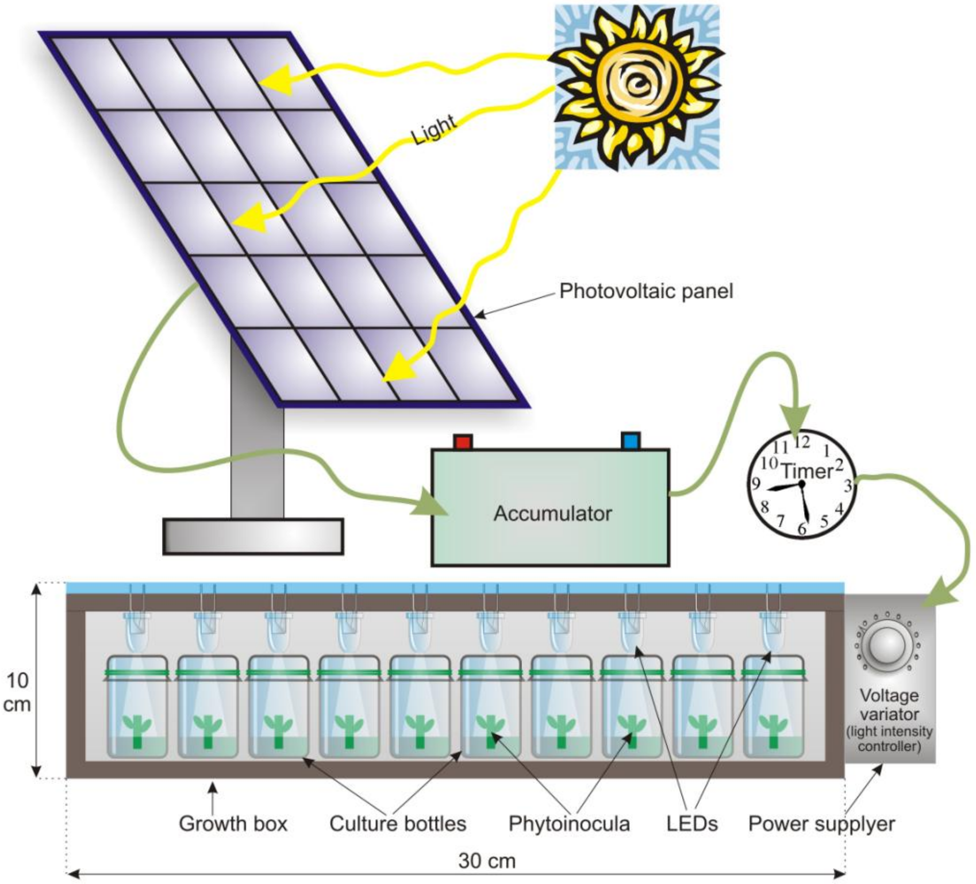

Fig.3 The photovoltaic system-growth box ensemble

The biologic material was taken from a *Solanum tuberosum* var. GARED *in vitro* culture. The inocula consisted in single node fragments of stalk (Rannali, 1997) which were placed in presterilized recipients (vol.=50 ml, height=6.5 cm; Ø=2.5 cm) containing standard Murashige and Skoog (1962) media, having Heller macroelements (Gautheret, 1959) and glycine, but without growth regulators. The pH of the media was adjusted to 5.5, before autoclaving at 121°C (249.8°F) for 30 min (Cachiţă et al, 2000).

The resulted experimental variants were as following:

V_0 – LED white light [16.2 µMoles/m^2/s (1200 lux)];

V_1 – LED white light [1.62 µMoles/m^2/s (120 lux)].

After inoculation, the bottles corresponding to V_0 were placed on shelves under CFL white light, at a proper distance in order to get a 16.2 µMoles/m^2/s light intensity (1200 lux) at their base. The others were put in growth boxes, and there was one LED above each bottle, at 1 cm distance (Fig.1). The light intensity was set to 1.62 µMoles/m^2/s (120 lux). The photoperiod was set at 16h light from 24h.

RESULTS AND DISCUSSION

The experiment lasted 8 weeks and the survival percentage is presented below (Fig.2). The survival percent was good on the most of variants, being over 98% (Fig.4), fact that show the chosen method for vitroculture illumination is a proper one.

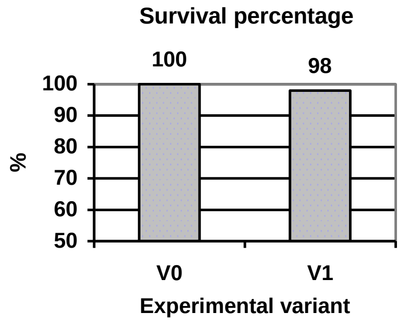

Fig.4 The survival percents of phytoinocula

The plantlets had different growth and development, according to the intensity of light used for illumination (Table 1). The statistical significance of differences was calculated by *t-test* for two tailed strings with unequal variances, using MS-Excel.

Table 1

The monitored parameters of *Solanum tuberosum* L., at 8 weeks of vitroculture.

ID	Experimental variant / Parameters (average values)	V_0 considered 100%	V_1	%
1	***Stalk length (cm)***	8.0±0.89	2.03±0.13	25.37
	Variance	0.8000	0.0200	n/a
	Statistical significance	n/a	***	
2	***Leaflet number***	19.2±1.22	3.06±0.68	15.93
	Variance	0.8062	0.4625	n/a
	Statistical significance	n/a	***	
3	***Sprout number***	2.19±0.54	1.88±0.34	85.84
	Variance	0.2958	0.1167	n/a
	Statistical significance	n/a	*	
4	***Root length (cm)***	3.41±0.20	2.86±0.20	83.87
	Variance	0.0438	0.0398	n/a
	Statistical significance	n/a	***	

Legend: V_0 – LED white light [16.2 µMoles/m^2/s (1200 lux)]; V_1 – LED white light [1.62 µMoles/m^2/s (120 lux)]; n/a- not applicable, irrelevant; ns- non significant difference (p≥0,1), *- significant (0,05≤p<0,1), **- distinctly significant difference (0,01≤p<0,05), ***- very significant difference (p<0,01).

The values of monitored parameters show statistically significant differences between V_1 and control variant (V_0). The most important for vitropreservation is the length of stalk. If the vitroplantlets grow slowly, the subcultivation interval grows. In our case, the stalk length of V_1 - where the phytoinocula were illuminated with LEDs supplied from the *green source* – had an average of 25.37 smaller than of V_0 (control variant). After the last measurements, the inocula from V_1 were placed under normal intensity light, without changing the bottles, and within 1 week a regenerative process was observed.

CONCLUSIONS

According to the observations made during this experiment, we can conclude that the autonomic illumination system is working fine and can be used successfully in vitroculture. It can be studied, improved, developed and tested on other species too. The autonomic illumination system can be produced with a low investment and the electricity consumption can be totally eliminated in the process of vitropreservation. If more solar cells would be added to the photovoltaic panel, a bigger amount of solar energy would be converted into electricity and then the vitrocultures used for micropropagation, where a brighter light is needed, could also be illuminated with this system, free of risk (low voltage), saving electricity (produced in polluting classical power stations), saving money, saving lot of space and keeping the environment cleaner.

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REFERENCES

Bonaiuti M, *From Bioeconomics to Degrowth: Georgescu-Roegen's 'New Economics' in Eight Essays*. Ed. Taylor and Francis, 2011.

Brown L, *Eco-Economy: Building an Economy for the Earth*, W. W. Norton & Co., NY, 81, 2001

Cachită CD, Halmagyi A, *Vitroconservarea resurselor vegetale*. Al XIV-lea Simpozion Naţional de Culturi de Ţesuturi şi Celule Vegetale. Editura Alma Mater-Sibiu, 1-17, 2005.

Cachită CD, Sand C, *Biotehnologie vegetală*, Vol. I. Ed. Mira Design, Sibiu, 2000.

Gautheret RJ, La culture des tissus végétaux: techniques et réalisations. Masson Edit, 1959.

Jao RC, Fang W, *An adjustable light source for photo–phyto relate research and young plant production*. Applied Engineering in Agriculture, Vol. 19(5), 601–608, 2003.

Mayumi K, *The origins of ecological economics: the bioeconomics of Georgescu-Roegen.* Routledge, 2001.

Murashige T, Skoog F, *A revised medium for rapid growth and bioassays with tobacco tissues cultures.* Physiologia Plantarum, 15, 55-159, 1962.

Pop L., Cachiţă C.D, *Preliminary research concerning the reactions of Sequoia sempervirens vitrocultures to „high brightness" LED illumination*. Analele Universităţii din Craiova, 215-219, 2007.

Pop L, Cachiţă CD, *LED application at sequoia sempervirens vitrocultures illumination,* Studia Universitatis, WUVG Arad , 313-317, 2009.

Ranalli P, *Innovative propagation methods in seed tuber multiplication programmes.* Potato Research, 40, 439-453, 1997.

Roegen GN, *The entropy law and the economic process*, Harvard University Press, 1971.

Smee A, *Elements of electro-biology,: or the voltaic mechanism of man; of electro-pathology, especially of the nervous system; and of electro-therapeutics*. London: Longman, Brown, Green, and Longmans, p. 15, 1849.

Toma C, Toma I., *Citodiferenţiere şi morfologie vegetală*. Ed. Corson, 2003.

***http://www.nobelprize.org/nobel_prizes/physics/laureates/1921/ accessed on Aug. 28th 2011.

***http://www.google.com/patents?id=HdxtAAAAEBAJ&printsec=abstract&zoom=4&source=gbs_overview_r&cad=0#v=onepage&q&f=false accessed on Aug. 28th 2011.

***IBPGR – IBPGR *Advisory Committee on in vitro Storage*, Report of the First Meeting, IBPGR, Rome, 1983.