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An Arduino Based Cost Effective and Portable Luxmeter

Arduino Tabanlı Uygun Maliyetli ve Taşınabilir Bir Lüksmetre Tasarımı

SUMMARY

Light is an important physiological effects that determine the development of vegetation. Light intensity and measurements are important for agriculture and livestock. In this study, a cost effective and portable luxmeter was developed for agricultural purposes using Arduino and GY-30 sensor module and compared with a commercial device. The regression results between 0.945 and 0.969 (very high) obtained in study were in agreement with the recent studies. It was understood that the developed system showed results compatible with commercial luxmeter devices.

Keywords: Arduino, GY-30, BH1750FVI, luxmeter, light intensity

ÖZET

Işık, bitki örtüsünün gelişimini belirleyen önemli fizyolojik etkilerdir. Işık şiddeti ve ölçümleri tarım ve hayvancılık için önemlidir. Bu çalışmada, Arduino ve GY-30 sensör devresi kullanılarak tarımsal amaçlar için uygun maliyetli ve taşınabilir bir lüksmetre geliştirilmiş ve ticari bir cihaz ile karşılaştırılmıştır. Çalışmada, elde edilen 0.945 ile 0.969 (çok yüksek) arasındaki regresyon sonuçları, son yıllarda yapılan çalışmalarla uyumlu bulunmuştur. Geliştirilen sistemin ticari lüksmetre cihazları ile uyumlu sonuçlar gösterdiği anlaşılmıştır.

Anahtar Kelimeler: Arduino, GY-30, BH1750FVI, lüxmetre, ışık şiddeti

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INTRODUCTION

Light is one of the important physiological effect that determine the development of plants and vegetation. Light is the energy source of plants and is involved in many physiological events, the most important of which is photosynthesis. It is impossible for plants to survive under a certain amount of light, but the required amount varies according to plants. Light acts by its intensity, wavelength, degree of polarization, direction and duration. Electromagnetic waves with wavelengths between 400-750 nm are called light or light energy. Wavelengths in this range are visible to the naked eye, and about 50% of solar radiation is in this range (Akman et al., 2012).

The most important energy source that warms the atmosphere and the earth is the sun. All living things and meteorological events develop directly or indirectly depending on solar energy. The ability of plants to photosynthesize, food production and all of life depend on energy from the sun. Rays from the sun are called radiation. The wavelengths entering the ionosphere layer are between 225-3200 nm. Some of these rays are visible and some are invisible rays. It is the wavelengths between 400-700 nm that plants benefit physiologically. (Karaşahin, 2022).

Light is defined as a photon or quantum, meaning the smallest particle that can be absorbed in plant growth. The energy content of photons is inversely proportional to their wavelength. The human eye can see light with wavelengths between 400-735 nm. The spectrum range used by plants in Photosynthesis is 400-700 nm, and this spectrum range is called photosynthetically active radiation or PAR (Sönmez, 2019).

Not only its effect on the physiological events of plants, light also affects the shape of the organs morphologically, the formation and flowering of flower organs biologically. Increasing light intensity causes stunting, trichome growth and the formation of color pigments such as anthocyanins in plants. Quality is as important as light for plant growth, and plants need some wavelengths of light for optimum growth. The visible medium wavelength rays of sunlight direct the basic physiological and biochemical events in plants, especially photosynthesis. Photosynthetically active radiation (PAR) is the spectrum range used by plants in photosynthesis and this range constitutes the part of visible light from 400 to 700 nm (Köse, 2014).

Factors such as stress, comfort, health status, lactation and estrus cycle in animals affect milk production. Lighting is an important environmental factor in milk production performance. Many studies have been conducted on the effect of lighting on milk yield. Although lighting is a subject that is often overlooked in Turkey, there are scientific studies on the effects of correct and efficient lighting on milk production and animal health in dairy farms in recent years (Demir et al., 2020).

In terms of energy use, one of the most important inputs in poultry farming is lighting. It is known that lighting, especially lighting intensity and day length, has positive effects on egg production. This effect, normally provided by sunlight, is achieved by using additional artificial light in commercial production (Efil and Sarıca, 1998).

The measurement of light is called photometry (Şenol, 2017). The amount of luminous flux per unit area of a surface per unit time is called the illuminance level. The unit of illuminance level is lux. Lumens per square meter (lm m^{-2}) is also the conjugate of lux (Kamberli, 2011). Luminosity and illuminance can be measured with commercially available instruments called luxmeters or luminance meters (Hänel et al., 2018).

In today's technology, various calculations, graphics, visualization and automation processes are carried out under computer control with appropriate software and hardware. Especially in automation processes, the cost and the physical size of the peripheral units used are also gaining importance. However, with the help of microcontrollers, the same operations can be performed at a more affordable price and with less volume. For this reason, various microcontroller applications have been increasing in recent years. Sensor modules are used together with microcontrollers to measure physical quantities such as pH, magnetic field, color, temperature, pressure, mass, humidity. These are generally developed with open-source codes and also have communication capabilities such as internet and USB connection. In addition, they can be used not only for data input, but also as control systems, as they are output ports(Güngör and Güngör, 2022).

Liu and Zhang (2019), designed a crop growing environment monitoring system based on the Arduino platform. DHT11 temperature and humidity sensor, GY-30 light intensity sensor and MG811 carbon dioxide concentration sensor are used to collect environmentalinformation in the system. The system is composed of sensing, transmission and application layers in order to provide intelligent control of the greenhouse environment.

Astutik et al. (2019), used the BH1750FVI sensor by connecting it to the ESP8266 microcontroller in order to measure the light intensity in their work where they designed a greenhouse remote monitoring and control system. For calibration purposes, they compared the values of a commercial luxmeter with the BH1750FVI sensor and found the R^2 value to be 0.99. They stated that the BH1750FVI sensor has high validity for measuring light intensity.

Mamur et al. (2022), implemented an embedded system application in the Internet of the Things (IoT) structure in order to make organic food production more efficient in the greenhouse. They used the BH1750FVI sensor in the system to measure the light level of the environment where the plants are located. The condition of the environment was determined with the sensors and this information was transferred to the microcontroller. By analyzing the data coming from the microcontroller, the necessary warnings were transferred to a mobile communication device via Wi-Fi, and the opportunity to control the climate.

Muhammed et al. (2022), have developed an IoT-based system for remote management of cold storage facilities. They used the BH1750FVI sensor to measure the light intensity with the system. They compared it to a commercial light intensity device to calibrate the sensor. The calibration was carried out using a LED light source with variable illumination intensity in the cooling chamber at 5°C. They determined a very high correlation (R^2 = 0.99) between the BH1750 and the commercial light intensity meter.

In this study, a cost effective and portable luxmeter was developed for agricultural purposes using Arduino and GY-30 sensor module and compared with a commercial device.

1. MATERIAL AND METHODS

Arduino UNO has ATmega328 microcontroller of Microchip company. It has 14 digital input/output ports with 6 PWM features, 6 analog channel inputs with 10-bit resolution and USB connection. Arduino UNO has a 10-bit analog-to-digital converter (Güngör and Güngör, 2022).The GY-30 is an electronic module with the BH1750FVI light intensity measurement sensor on it. Light intensity can be measured from 0 to 65535 lx. The module communicates with microcontrollers over the I2C protocol (Bilici et al., 2018). Lutron LX-1102 was used as commercial lux meter (Figure 2a). It can measure in the range of 0 to 400000 lx (±3%).

The prepared system consists of Arduino UNO microcontroller board, GY-30 light intensity measurement module, an LCD screen and a battery. The components are connected as shown in Figure 1. Then, the necessary codes were written in the Arduino IDE and uploaded to the Arduino board, so the system was made to display the values obtained from the sensor on the LCD.

Along with the developed system (Figure 2b), measurements were made with a commercial device at the same time. It is desired to make measurements for agricultural purposes.Measurements were made in greenhouse,open field andsparsely wooded field. Fifty measurements were made in each area with the devices. Regression analysis was performed between the measurement values in each field.

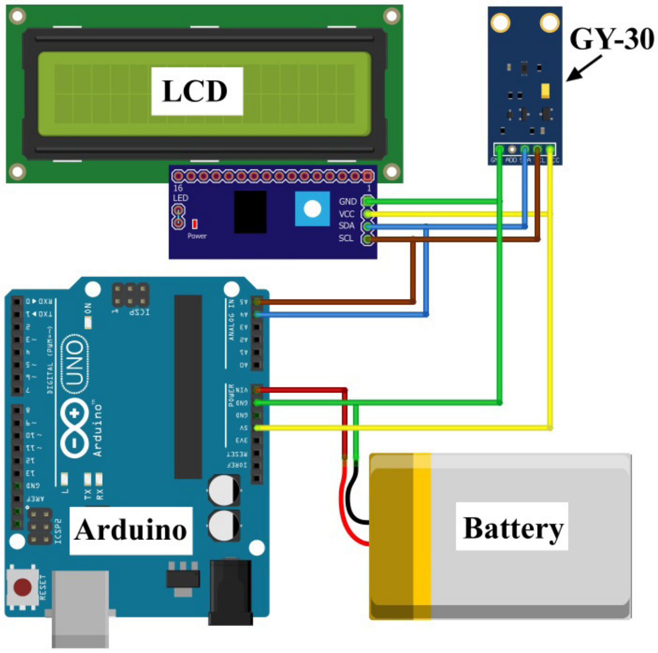

Figure 1. Schematic representation of developed luxmeter

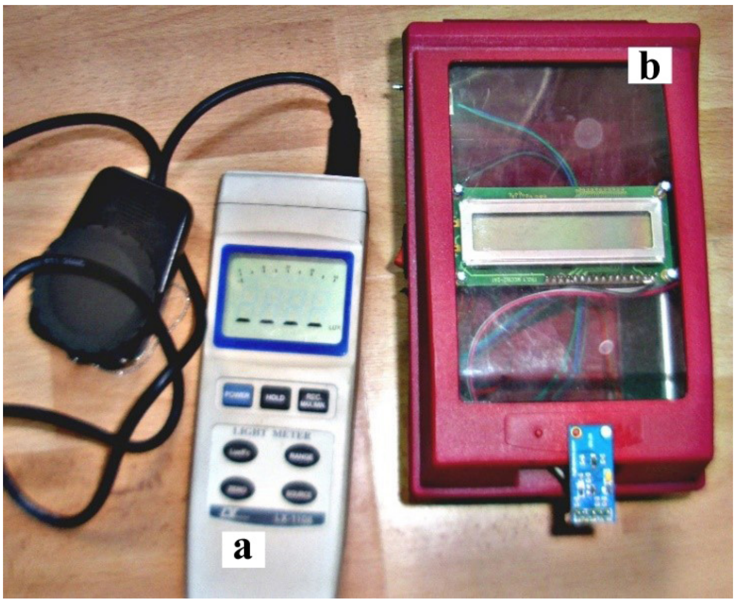

Figure 2. Developed (a) and commercial (b) luxmeter

2. RESULTS and DISCUSSION

After the regression analysis between commercial luxmeter and developed system values R-squared was found between 0.945 - 0.969. The regression relations between commercial luxmeter and developed system are given in Table 1. In Table 1, commercial luxmeter is abbreviated as LC and developed system as LA. In addition, the regression plots for greenhouse, open field and sparsely wooded field is given in Figure 3-5 respectively.

Table 1. The regression equations

Field Type	Regression Equation	R^2 (%)	Number of measurements
Greenhouse	LC = -3236 + 1.229 LA	94.5	50
Open field	LC = -1829 + 1.04 LA	96.9	50
Sparsely wooded field	LC = 662.6 + 0.8367 LA	96.2	50

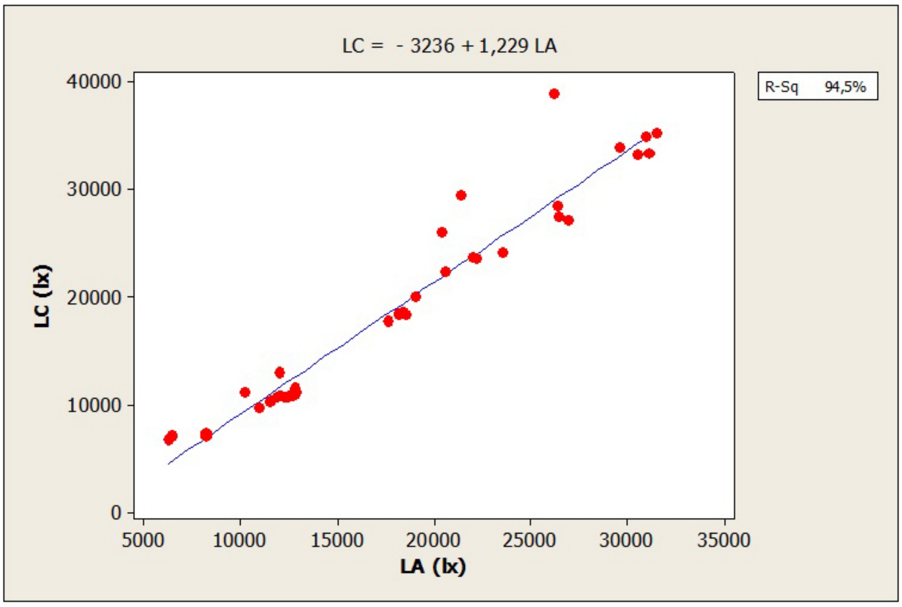

Figure 3. Regression plot of commercial and developed luxmeter for greenhouse

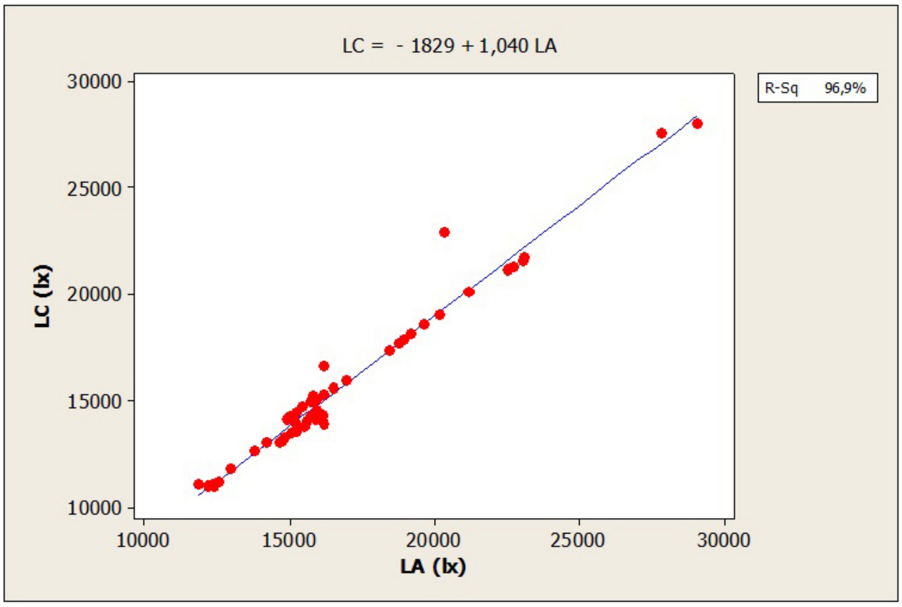

Figure 4. Regression plot of commercial and developed luxmeter for open field

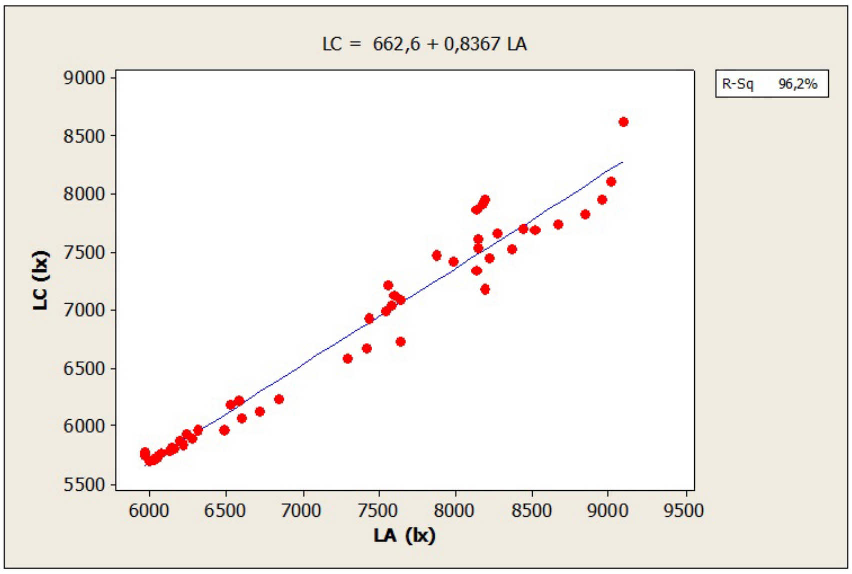

Figure 5. Regression plot of commercial and developed luxmeter for sparsely wooded field

The regression results between 0.945 and 0.969 (very high) obtained in our study were in agreement with the studies of Astutik et al. (2019) and Mohammed et al. (2022). Thus, it was understood that the developed system showed results compatible with commercial measuring devices. R^2 between commercial and developed luxmeter for greenhouse slightly different from outdor measurements. Ordinary glass filters the light in some bands and refracts the sun's rays in different directions, as well as there are different light reflections in the greenhouse. While commercial lux meters have an optical part that collects the refracted and reflected light in front of the sensor, this feature is not available in the developed system. Although the developed system is not very suitable for laboratory and scientific studies, it has been evaluated as usable in agricultural production activities that do not require very high precision.

CONCLUSION

Today, various technologies and concepts such as information and communications technologies in agriculture (ICT-agri), precision agriculture, smart agriculture, remote sensing, geographic information systems, variable rate application, product tracking, from farm to table food safety, farm management have begun to be used in agriculture. These technologies are data-intensive. To do this, a large number of sensors are required. Sensors are the easiest, cheapest, and most commonly used with microcontrollers instead of complex computer software and hardware. Thus, natural and technological limitations in front of data collection will be reduced. In addition, since microcontrollers can be used not only to obtain data but also as control systems, they will also increase the automation and mechanization capacity in agricultural processes.

Light and light intensity are important areas on which agricultural research should be done. With the widespread use of microcontroller-based light measurement devices in this field, it will contribute to the development of agricultural and animal production.

Author Contribution

MYP: conceptualization, hardware arrangements, microcontroller code design in ArduinoIDE, fieldstudy, data collection, statistical analysis, writing (original draft preparation), writing (review and editing); **AÖ:** fieldstudy, data collection, writing (original draft preparation), writing (review and editing). All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical statement

The authors declared that this article complies with research and publication ethics.

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