PERFORMANCE EVALUATION OF IRRIGATION AUTOMATION FOR CULTIVATION SYSTEM OF RICE INTENSIFICATION (SRI) COMBINED WITH JAJARLEGOWO SYSTEM: THEORIES, METHODS, AND TECHNIQUES

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Abstract

The objective of this article is to review and represent about automation irrigations that have been gained in irrigation system performance evaluation for cultivation System of Rice Intensification (SRI) combined with Jajarlegowo System. This paper is based on the literature that is concerned with concepts, techniques, and methodologies applied to the automation irrigation and their performance in Indonesia. The development of automation irrigation for paddy field in Indonesia was presented and it was discussed. Several studies of automatic irrigation systems have been conducted in Indonesia. The results showed that the use of irrigation automation system combined with a system of rice intensification (SRI) and combined with jajarlegowo can increase rice productivity. This method is effective because the rice plants are watered according to their needs so that the growth becomes good. The method of irrigation automation is carried out using a water level control system adapted to the age of the rice plant. Water level sensors, irrigation actuators, and drainage actuators are installed in paddy fields to support the irrigation automation. In the application directly in the paddy fields owned by Indonesian farmers, this has not been done thoroughly. The main obstacle from the observation result of the research shows that automatic irrigation system technology has not shown any real difference compared to conventional irrigation. In addition, this automatic irrigation system should also be accompanied by human resources trained in its use and maintenance.

Keywords: irrigation; drainage; automation: jajarlegowo

1   Introduction

Irrigation on agricultural land is very important because it becomes one of the factors of success in agricultural cultivation. FAO (2017) said that agricultural irrigation has become a major problem in many countries in the world because it concerns about the effectiveness of the use of water resources and land. Many studies were conducted to evaluate the performance assessment and diagnosis in irrigation technology from developing countries (Gorantiwar & Smout, 2005; Kuscu, Boluktepe, & Demir, 2009; Molden, Sakthivadivel, Perry, & De Fraiture, 1998; Murray-Rust & Snellen, 1993). These studies cover several irrigation technology for cultivation system of rice intensification (SRI) combined with Jajarlegowo System in Indonesia.

The study using the system of rice intensification (SRI) method shows that the productivity of rice crops may increase (Budi I Setiawan et al., 2014). The theory of this system is to provide water in accordance with the needs of rice crops. Appropriate water supply in accordance with the needs of rice crops will only be achieved by applying technology. The technology applied is by control system or irrigation automation system. The irrigation system will be embedded in a program in which the water level will be adjusted according to the age of the rice plant.

Another growing system is the jajarlegowo planting system. This system adopts the method of removing one of the rows of plants and closely tying the other row of plants. That way, it is as if all the rows of plants are on the marginal row of a paddy field. According to research results, researchers (Srihartono & Budiarti, 2013) indicate that plants in the marginal row have better productivity compared to other rows. The planting system that can be applied to palawija plants is jajarlegowo 2: 1 (every two rows of plants there is one row emptied).

Because planting systems and technologies that support them have great potentials developed, it is necessary to evaluate their performance from the last few years of their application. So that, the objective of this article is to review and represent about automation irrigations that have been gained in irrigation system performance evaluation for cultivation System of Rice Intensification (SRI) combined with jajarlegowo system.

2   Methodology

A comprehensive review was carried out of empirical literature on the theories and methodologies applied to irrigation performance evaluation (up to 2018). Many studies were identified for the literature review that mainly based on published researches including manuscripts from academic journals, in addition to some researches presented in books, Ph.D. thesis, and international agencies reports. These studies were categorized into three groups (Table 1). The first one focus on the concepts and theories related to irrigation performance evaluation. The second group is mainly concentrated on the framework and evaluation process. The last group is related to the methods, tools, and techniques applied by different researchers.

3   Historical Review

3.1   *System of Rice Intensification and Water Management*

The System of Rice Intensification, or SRI, is a set of alternative agricultural practices to increase rice production by changing the management of plants, soil, water and nutrients. In water management, SRI recommends intermittent irrigation (as opposed to permanent flooding in a conventionally managed production system). SRI for improving rice production has been attracting worldwide attention for its relatively high yield and greater water productivity (Hasanah et al., 2017; Budi I Setiawan et al., 2014). This is based on the results of research conducted in the Nusantara Organic SRI Center (NOSC), Sukabumi Regency of West Java Province of Indonesia. The experimental plot area is 16 m^2 with 4 experimental plots. The results of this study indicate that the productivity of rice plants in the range of 5.71 - 8.61 t·ha^{-1}. This method is also claimed to minimize water usage and the minimum of greenhouse gases.

Water management becomes very important process of rice cultivation. In the field itself as reported by researchers (Arif, Mizoguchi, & Setiawan, 2013), Water management for rice plants has been tested through Intermittent Irrigation treatment and continuous flooding treatment. This research conducted in village of Karang Sari, district of Cikarang Timur, Bekasi, West Java, Indonesia during the

first rice season of 2007/2008. Furthermore, in order to monitor water levels, researchers (Chusnul et al., 2012) have conducted estimation of water content for rice in paddy fields using ANN method. This will be used as program system input to be embedded in an automatic irrigation system. Characteristic of each water management treat in detail as follows:

1. Treatment Intermittent Irrigation. The soil was kept moist but with no standing water during the vegetative stage (initial and crop development stages), then shallow standing water with depth ranging from - 5 to 2 cm was applied during the reproductive stage, and finally water was drained to maintain saturated soil until harvesting day. Seedling by young seedlings (10 day after sowing). Transplanting by single transplanting (one seedling per hill) spaced at 30 cm × 30 cm. Weeding: four times with an interval of 10 day and starting from 10 day after transplanting (DAT). Fertilizer: an organic fertilizer applied at 7 t/hm^2.

2. Treatment Continuous flooding. The field was maintained by ponding water with the interval of 2–5 cm water depth during planting period, then at the late stage, water was drained to maintain saturated soil until harvesting day. Seedling: old seedlings (30 day after sowing). Transplanting: 5–10 seedlings per hill spaced at 20 cm × 20 cm. Weeding: every two times during early vegetative stage. Fertilizer: chemical fertilizers based on the guideline of agricultural officer.

Normally the water supply in the cultivation of rice fields aims to meet the needs of water plants to grow optimally. The water requirement of rice plants will vary for each variety during the cultivation. Each phase of rice growth also requires different water. The growth phase of paddy consists of the initial phase, vegetative phase, generative phase, grain-feeding phase and grain maturation phase. The results of Researchers (Budi Indra Setiawan, Arif, & Widodo, 2015) states that the treatment of wetland water can be implemented in three forms, namely treatment intermittent irrigation, treatment continuous flooding and dry treatment. Each treatment will require a water level that varies according to the day after planting as in Figure 1.
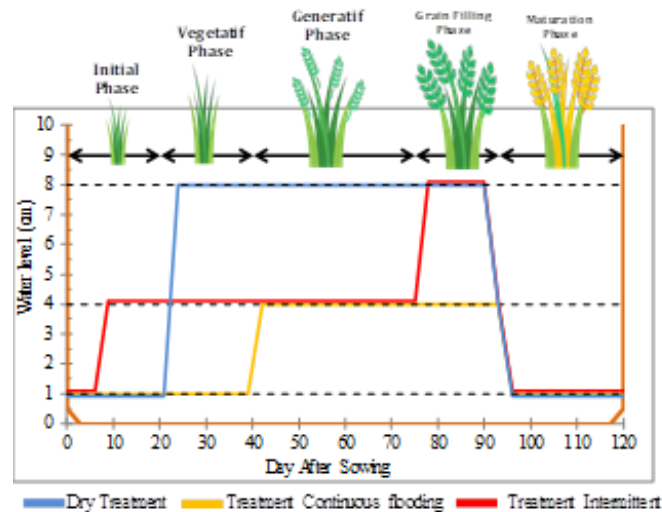
Figure 1. Treatment of water supply in rice plants

3.2 System of Jajarlegowo Cultivations

Efforts to increase the productivity of rice one of them is by applying jajarlegowo planting system. The jajarlegowo planting system is a cropping system that takes into account the cultivation of plants and is intermittent cropping between two or more rows of rice plants and one empty row (Figure 2). The goal is that the population of plants per unit area can be maintained even can be improved (Suriapermana & Syamsiah, 2012). This system is considered to increase productivity because the population can be higher and the orientation of the crop is also better in the utilization of solar radiation. Added by researchers (Sohel, Siddique, Asaduzzaman, Alam, & Karim, 2009), the optimum spacing will provide growth of the top of the plant and the growth of the root part is good so it can take advantage of more sunlight and take advantage of more nutrients. For the rice plants themselves can use jajarlegowo spacing 4:1 (25-50) cm × 12.5 cm (Ikhwani, Pratiwi, Paturrohman, & Makarim, 2019).
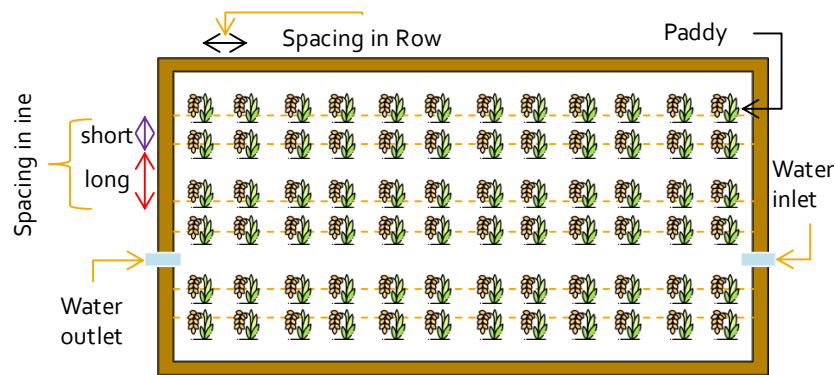
Figure 2. System of rice plant spacing jajarlegowo method

3.3 Methods Automation Irrigations

Many irrigation automation methods have been developed. One of them is reported by researchers (Pfitscher et al., 2012) for rice crops. The developed system has been using the internet network in monitoring the condition of the water level in the field. The reported schematic diagram of the proposed automation system is presented in Figure 3. From the schematic, it can be seen that the workings of the method developed using water level sensor technology to measure the height of the water surface. The water level height will be accepted by the microcontroller to be forwarded to the pump. The results of this study also said that there can be a critical condition in some ways the application of this technology. Critical situations such as malfunction of some equipment, adverse weather conditions and unacceptable levels of controlled variables can be quickly identified and addressed through the features of the alarm screen of the developed system.
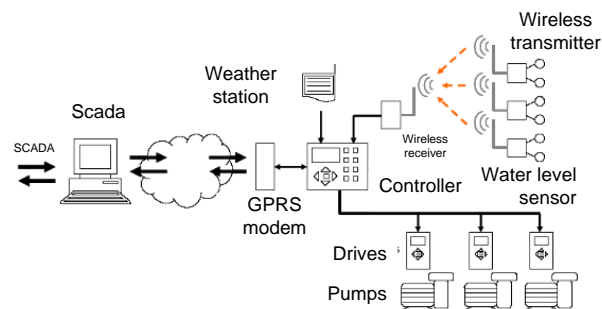

Figure 3. Schematic diagram of the automation system

In Indonesia, this automation system has been reported by researchers (Sirait, Saptomo, & Purwanto, 2015). Irrigation equipped by an automatic control system can keep the water level in the soil at a certain level according to the needs of plants. Automatic control system was constructed by utilizing digital technology, microcontroller and sensor networks. Microcontroller was used as an automatic controller to operate electrical valve based on soil moisture conditions and water level in paddy fields. Water level of the field was set at a range of 0 to 5 cm. The result shown that the automatic irrigation system can keep the water level in paddy fields between the desired setpoint range. However, in this study, no reported yield was obtained during the study. The schematic of the automatic irrigation system used is presented in Figure 4.
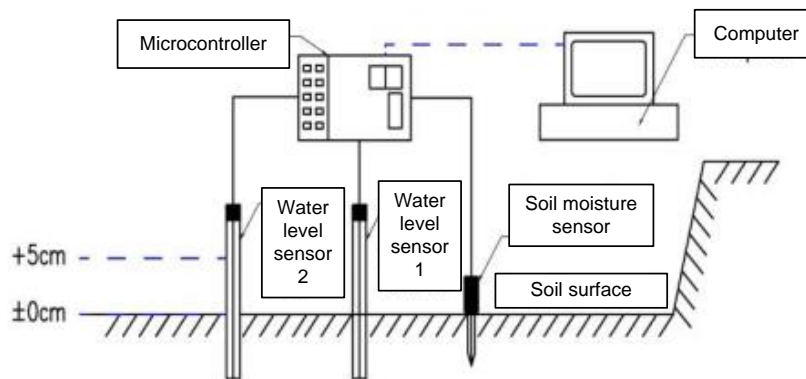

Figure 4. Sensor layout in paddy field

3.4 Analysis of Rainfall Factor

One of the most important factors to consider in irrigation is rainfall. Rainfall will affect the equilibrium of water in a region. For that, the measurement data of the last 10 years rainfall in Cisaat District, Sukabumi District (6 ° 54'4.46 "S - 106 ° 53'58.81" T) was collected.

From the data obtained it is known that in the last 10 years maximum rainfall intensity, rainfall intensity, and the number of rainfall days are 80.3 mm, 2610.2 mm and 186 days/year, respectively. The annual distribution of these parameters is shown in Figure 5.
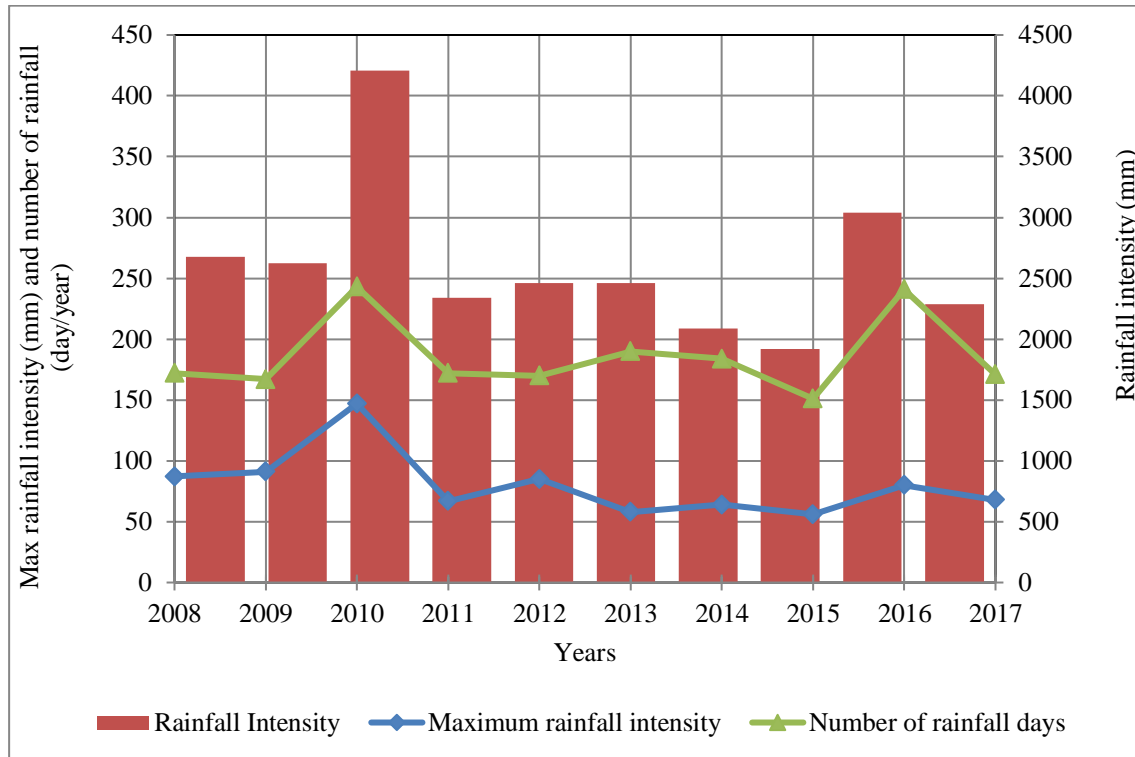
Figure 5. Annual distribution rainfall

4   Conclusion

Availability of fresh water is one of the elementary conditions for life on Earth. Agriculture is one of the major water-consuming sectors. Irrigated agriculture is of major importance in many countries allover the world. The automated irrigation system has an important role in controlling the use of electricity and water to ensure the quality of grain, to improve irrigation efficiency and increase the productivity.

5   Recommendation for Future Work

From the results of this literature review can be seen that the extent to which the development of technology irrigation system automation applied in Indonesia. Based on that, then, there are some very important research topics followed up on the next research. The first research topic is to focus on improving the performance of a simpler automated irrigation system that is used and does not

require complicated maintenance. The second research topic is to focus on the development of water-giving technology in paddy fields to be evenly distributed throughout the surface of rice fields. This becomes a challenge because of the uneven surface of wetland soil. The third research topic is, focusing on developing irrigation automation based on mobile technologies such as Android to control the development of high levels of wetland water and get the information of the rice plants themselves. These topics are generally necessary for developing more effective automation irrigation in Indonesia.

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