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Application of Cultivation Technology for Rice (*Oryza sativa* L.) in Three Sectors of Rain Patterns in South Sulawesi

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ABSTRACT

This study carried out to determine the effect of each component of cultivation technology application on the production of rice (Oryza Sativa L.) in South Sulawesi. A research was carried out in three rain-type sectors within South Sulawesi Province, i.e: Maros regency for the West Sector, Bone regency for the East Sector and North Luwu regency for the Transitional sector. A study was conducted from December 2019 to January 2020 in the form of a survey (study literature, observation, and interviews), with the selection of samples carried out purposively to 30 respondents on each location. Observation data in this study consisted of plant spacing, rice variety, dose of fertilizer, watering system, harvest time, and plant yields. Data analysis employed multiple linear regressions with SPSS software 22 version. The results showed that the average rice production in Maros, Bone and North Luwu regencies, South Sulawesi, was still relatively low, Maros Regency was 7.032 kg ha^{-1}, Bone was 5.020 kg ha^{-1} and North Luwu was 6.497 kg ha^{-1}. The multiple regression equation for rice production in Maros, Bone and North Luwu Regencies, South Sulawesi is Y = 3,354.185 -17.751 plant spacing –4.044 watering system +36.839 fertilizer doses. The fertilizer dose was the most significant effect on rice production in all locations.

Keywords:
Multiple regression; rain type; rice

1. Introduction

Rice is an important food crop as it is a staple food for Indonesian people. The development of rice has strategic role in Indonesia since the 270 million of Indonesian population need an estimation of 34.93 million tons of rice for their consumption (Central Bureau of Statistics (BPS), 2020). According to the statistic, at the national level the rice production fluctuated in recent years. Production in 2018 was 59.20 million tons, in 2019 was 54.60 million tons, and in 2020 was 54.64 million tons. Therefore, the increase in rice production constantly needs to meet the supply and demand of rice.

South Sulawesi is an Indonesian province with three rain-type sectors, namely the West Sector consists of Maros Regency, the Eastern Sector consists of Bone Regency and the Transition consists of North Luwu Regency. These three areas have potential for rice cultivation. Bone Regency has land use area for rice fields of around 118,564 ha with potential production of around 225,632 tons. Maros with an area for rice fields around 26,205 ha with a potential production of around 291,723 tons. North Luwu has an area for rice fields around 28,970 ha with a potential production around 122,000 tons (BPS, 2020). These indicate the rice development in three locations could be the prototype for other regencies in South Sulawesi.

Two approaches for rice development efforts are cultivation process and rice genetics. These approaches have the specific advantage of increasing the rice productivity. Based on cultivation process, there are some efforts to increase rice production, such as plant spacing, watering system, and fertilizer doses (Subagyono et al., 2019; Padjung et al., 2020). As for based on genetic approach, the selected variety kind and its nature like harvest time are two good objects in genetic approach (Abduh et al., 2021). The right combination of rice cultivation technology affects the increase in rice production (Harjadi, 2017; Abduh et al., 2021). The method of integrated plant management technology is an approach to synergize technology components to solve problems and increase the efficiency of farm inputs (Anggraini et al., 2013; Asmoro, 2015). Therefore, it is important to identify the technology components that could increase production for the three sectors of the rainfall pattern in South Sulawesi. This study aimed to determine the effect of each component of cultivation technology application on the production of rice (*Oryza Sativa* L.) in South Sulawesi.

2. Materials and Methods

A series of survey was carried out in Maros, Bone and North Luwu Regency of South Sulawesi Province, from December 2019 to January 2020. The purposive location determination was due to the three types of rain sectors for area with potential rice crops. Hence, we designated Maros Regency for the West Sector, Bone Regency for the East Sector, and North Luwu Regency for the Transitional sector. The research consisted of field observations and interviews of 30 respondents for each district make a total of 90 farmer respondents.

2.1 Research Data and Data Collection Methods

2.1.1 Research Data

The data in this study consists of primary and secondary data:

a) Primary data were obtained through interviews with farmer respondent related to the application of rice cultivation technology in three regencies (Maros, Bone and North Luwu Regency), the process includes questioning with questionnaires and photo documentation (Faisal, 2021).

b) Secondary data is collected through research and review of relevant literatures, scientific publications, books, journals, etc. Secondary data were also obtained from results of previous studies which were relevant with this study. In addition, secondary data were also obtained from relevant agencies. Among important secondary data such as climatic data in the three regencies (Maros, Bone and North Luwu) obtained from the office of Maros Climatology Station and data on the area of planting and rice production obtained from the Central Statistics Agency for Maros, Bone, and North Luwu.

2.1.2 Research Data Collection Method

Methods for collecting data both primary and secondary in this research were

a) Primary data collection

1. The main method for data and information collection regarding the application of rice cultivation technology by farmer respondents in the study locations was a series of survey. A survey is a method that could use a questionnaire as the main instrument to collect data (Irawan, 2007). The Field Survey started by determining the location points to be visited, then the data collection related to the list of questions in the questionnaire was performed.

2. Interviews were conducted on respondents (farmers, extension workers, and various stakeholders) to obtain the desired data and information. According to Prabowo (1996) interview is a method of collecting data by asking something to a respondent, the method is to have a face-to-face conversation.

3. Observations or direct observations were focused on the condition of the fields and as cross-check measure on rice farmers' cultivation techniques as well as other relevant important things. It can provide more data and information in addition to the results of the interviews.

b) Secondary data were obtained through literature study, and most significantly through the assistance of local government agencies such as from agriculture office regarding rice production data, and climatic data from the meteorological office in the regency (Maros, Bone and North Luwu).

2.2 Data Analysis Method

This research focused on the application of rice cultivation technology which included several factors (plant spacing, variety, dose of fertilizer, watering system, harvest time, and plant yields) that affect rice production. Data were obtained by field surveys and interviews with rice farmers in the three regencies (Maros, Bone and Luwu Utara).

a) Analysis of Primary and Secondary Data

Primary data and secondary data were analyzed using multiple linear regression data analysis (Gomez and Gomez, 1995) executed with SPSS software. This analysis enabled to see the relationship between the applications of rice cultivation technology that affects production. The multiple regression formula for this purpose was:

$$Y = a + bX1 + cX2 + dX3 + eX4 + fX5$$

Notes:
Y = Plant Yields (output quantity)
X1 = Plant spacing
X2 = Variety
X3 = Dose of fertilizer
X4 = Watering system

X5 = Harvest time
a = Intercept
b = Plant spacing coefficient
c = Variety coefficient
d = Dose of fertilizer coefficient
e = Watering system coefficient
f = Harvest time coefficient

Contribution value of each factor to the production of rice plants was seen from the determinant value (R2). The observed variables were weighted before being analyzed. The purpose of weighting was to express how much influence the observed variables have on rice production. The weighting method was in a form of ranking method. The ranking method is a simple method of giving weight, where in the preparation of the weights are made in certain levels. Criteria and weights are made based on the consideration of the researcher.

b) Determination of Scoring Application of Rice Cultivation Technology

The data obtained from the field were generally qualitative and quantitative, prior to the multiple linear regression analysis through the SPSS software 22 version. The scoring was carried out on the application of rice cultivation technology. The scores given to each rice cultivation technology were based on the results of interviews, literature studies and observations (Faisal, 2021).

3. Results and Discussion

3.1 Results

The results of the study on the rice plant spacing application can be seen in Figure 1. It shows that farmers used the largest spacing of 20 x 20 cm were 28 people each in the regency of Maros and Bone. On the other hand, respondents in North Luwu Regency used 25 x 25 cm spacing. Meanwhile, the spacing of 30 x 30 cm was found to be used by 1 respondent from Bone Regency.

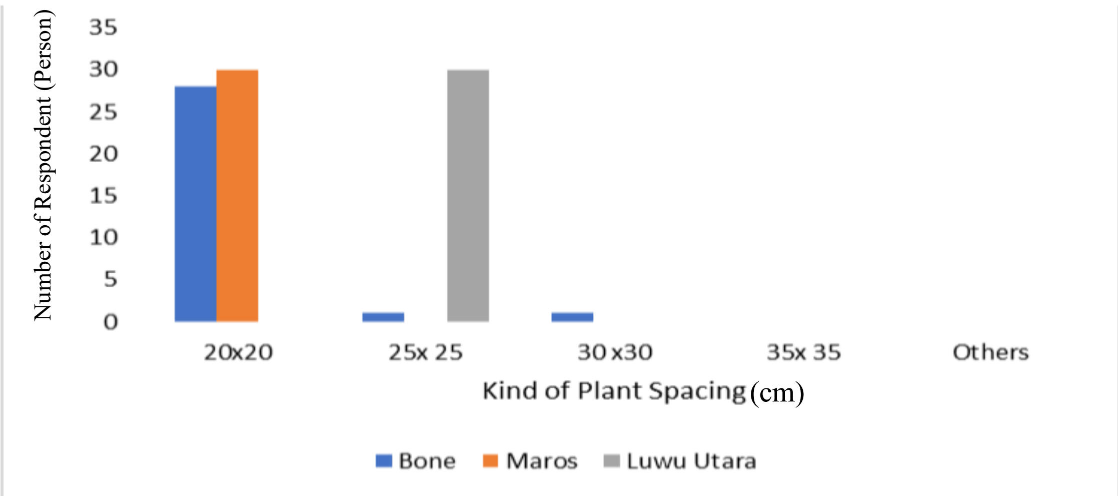

Figure 1. Relationship between the plant spacing implemented by farmers and the number of respondents in the three regencies (Maros, Bone and Luwu Utara)

The results on varietal use are shown in Figure 2. It is seen that Inpari is the dominant variety used in North Luwu, Maros and Bone Regencies. However, some respondents in

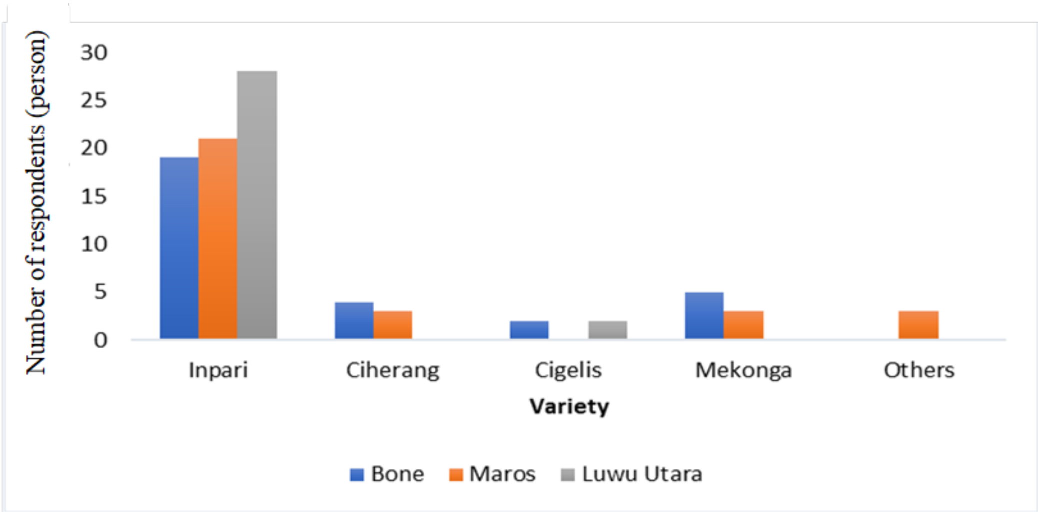

Figure 2. Relationship of varieties used by farmers with the number of respondents in three regencyRegency (Maros, Bone and North Luwu)

The results of the study on fertilizer doses are shown in Figure 3. The highest application of urea was in the range of 100-200 kg ha^{-1}. SP-36 fertilizer with the highest rate at more than 75 kg ha^{-1}. Meanwhile, KCl with the highest range of 100-250 kg ha^{-1}. At the research location, there were no farmers who applied organic fertilizers.

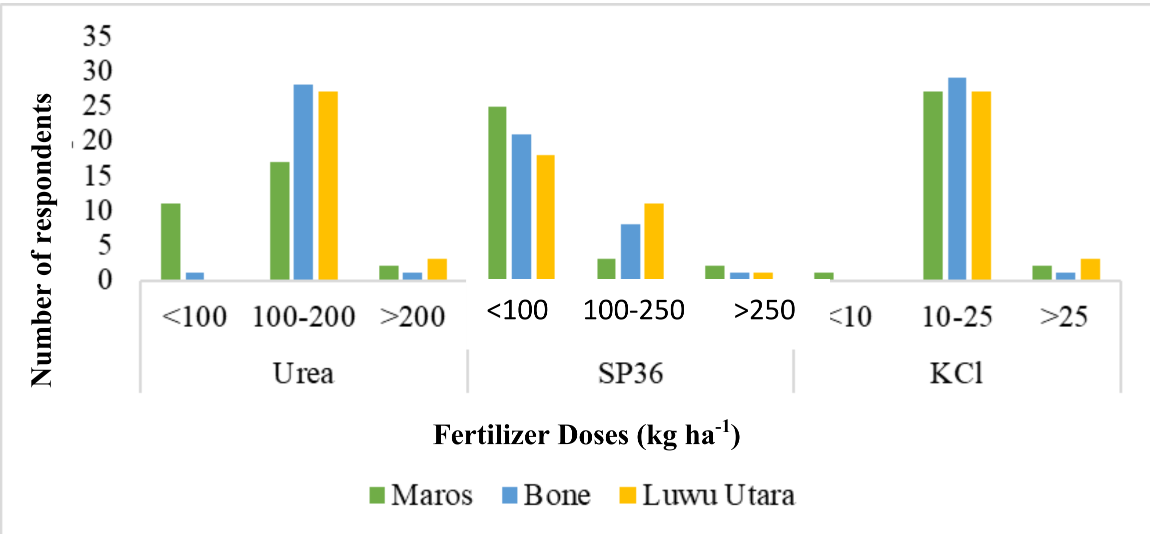

Figure 3. Relationship between the dose of fertilizer used by farmers and the number of respondents in the three regencies studied (Maros, Bone and Luwu Utara).

The use of rice irrigation system is shown in Figure 4. Based on this figure most farmers use irrigation systems, namely 27 respondents in Bone, 16 respondents in Maros Regency, slightly more than rain-fed (14 respondents). Whereas, there were 21 respondents used rain-fed system in North Luwu Regency, which became the dominant irrigation system in the district.

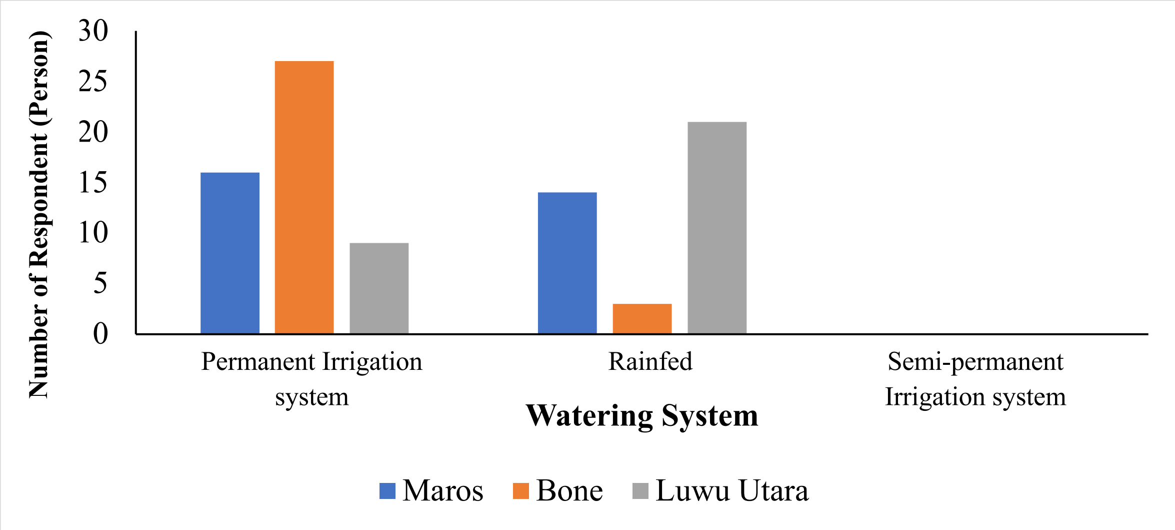

Figure 4. Graph of the relationship between the rice watering system used by farmers and the number of respondents in three regencies (Maros, Bone and Luwu Utara).

The results of the average productivity in each regencies are shown in Table 1. The highest average productivity was in Maros Regency with a range of 6.70 ± 3.03 tons ha^{-1}. On the other hand, Bone Regency has the lowest productivity with a range of 5.09 ± 1.27 tons ha^{-1}.

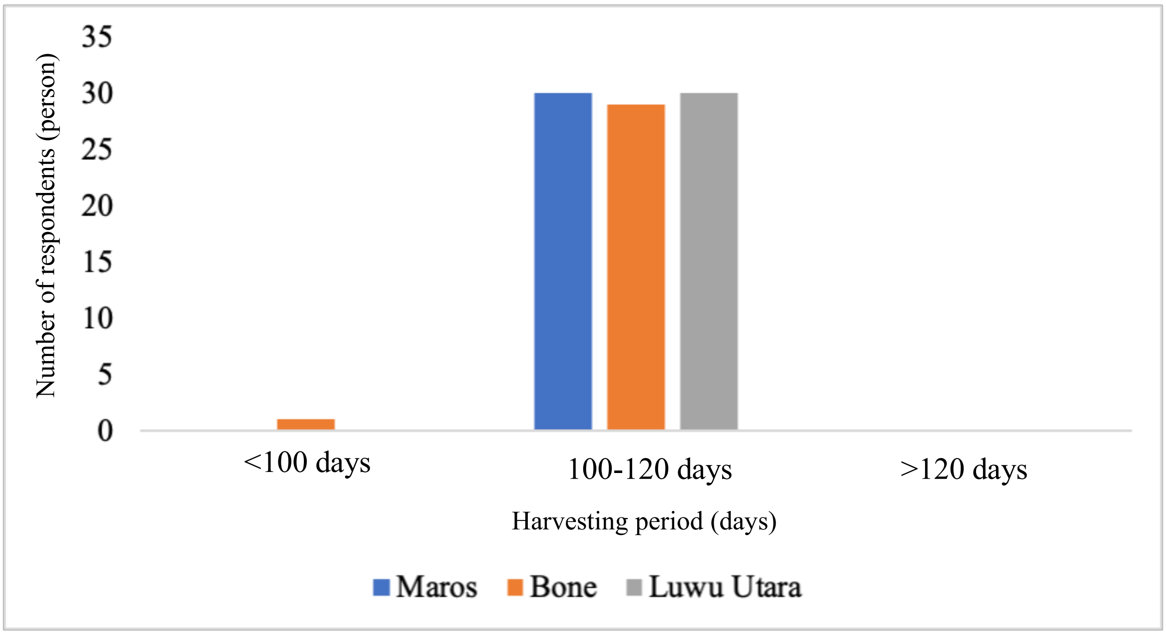

Figure 5. Relationship between harvest time used by farmers and the number of respondents in the three regencies (Maros, Bone and Luwu Utara)

The results of multiple regression analysis are shown in Table 2 and 3. Table 2 shows that the regression coefficients and probabilities of each factor. Based on Table 2, plant spacing, irrigation system and fertilizer doses were factors that have a significant effect on multiple regression analysis. This is also supported by Table 3, where the multiple regressions have a significant effect on the analysis of variance. Both tables indicate that the resulting multiple regression is valid for interpretation.

Table 1. Rice productivity of respondents in the three regencies of studying South Sulawesi

Total Production	**Productivity (ton ha^{-1})**		
	Bone	**Maros**	**Luwu**
Average	5.09 ± 1.27	6.70 ± 3.03	6.50 ± 1.19
Maximum	10.00	13.00	8.40
Minimum	4.00	1.50	4.70

Table 2. Results of multiple linear regression analysis of cropping patterns of water availability in rice plants in the three regencies (Maros, Bone, North Luwu)

Regression Model	**Regression coefficient**	**Probalility**	**Remarks**
Constant	3354.185	0.025	
Planting System	-17.751	0.002	Significant
Irrigation System	-4.044	0.038	Significant
Fertilizer Dose	36.839	0.000	Significant
Variety	-0.455	0.855	Not significant
Harvest Time	-2.113	0.870	Not significant

Source: Primary data after processing, 2021.

3.2 Discussion

Multiple regressions are a regression analysis that combines several characters in one formula to predict a dependent variable. The effectiveness of the estimation variables is strongly influenced by the significance of the regression coefficients on each variable and the overall effect of the combined variables in estimating productivity (Triyanto et al., 2019). In this research, both requirements met, especially in the character of plant spacing, irrigation system and fertilizer doses. It indicates the three characters are the main factors affecting productivity in the three regencies. On the other hand, the variety and harvest time had no effect on predicting productivity. The not significant effect of the two characters was due to fact that the respondents in the three regencies are relatively overconfident with the Inpari variety for their rice cultivation. This similarity will correlate with the harvest time of the three varieties. According to Akbar et al. (2022), the harvest time of Inpari, especially Inpari 32, is around 100-120 days. Therefore, the difference in varieties between respondents was not influenced by the variety factor and harvest time. Meanwhile, the character of plant spacing, irrigation system and fertilizer doses determined the diversity of respondents' productivity from the three regencies.

Table 3. Results of F-test on the effect of cropping system, irrigation system, fertilizer dose, varietal rotation, and harvest time that affect rice production.

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	57 753 674.478	5	11 550 734.896	28.537	0.000[b]
Residual	34 000 214.411	84	404 764.457		
Total	91 753 888.889	89			

The three main factors have different directions of diversity in predicting productivity diversity. The fertilizer dose is the only factor that has a positive variance in influencing productivity. On the other hand, the plant spacing and irrigation system have a negative variance direction. Based on this research, the most widely used spacing was 20 x 20 cm, except in North Luwu Regency with 25 x 25 cm spacing. The 20 x 20 cm spacing had a higher score than the 25 x 25 cm spacing according to questionnaire responses. It is an indication that 25 x 25 cm spacing can optimize potential productivity compared to a spacing of 20 x 20 cm. In general, optimum spacing will provide space for plants to grow well, without experiencing much competition for water, nutrients, and sunlight (Indriaty, 2018). The optimum spacing facilitates the process of plant metabolism, especially in the process of photosynthesis (Gusmiatun et al., 2022). On the other hand, close spacing could result in competition between plants for water and nutrients (Ezward, et al., 2017), resulting in stunted growth reduced crop yields. Therefore, the use 20 x 20 cm spacing relatively had increasing competition between plants compared to a spacing of 25 x 25 cm. Hence, the spacing of 25 x 25 cm has a more potential for optimum productivity.

The multiple regressions for irrigation system also show a negative variance value, yet, the coefficient value is not as high as the coefficient of spacing. It is because this research found only two dominant irrigation systems, namely rainfed with the highest questionnaire score and the technical irrigation system. In addition, the two irrigation systems have relatively similar number of respondents. However, irrigation systems are more widely used than rainfed systems, except in North Luwu Regency. Based on the results, irrigation systems will be more effective to optimize productivity as opposed to rain-fed systems. In general, the purpose of an irrigation system is to provide additional water for plants in sufficient quantities and when needed. In addition, according to Subagyono et al. (2019), irrigation is also useful for facilitating soil processing, regulating soil temperature, cleaning or washing soil from high acidity, cleaning up waste dirt in waterways, and flooding the soil to eradicate nuisance plants (weeds), pests and diseases. On the other hand, the rain-fed system has a mechanism that is very dependent on nature, so that the pattern of regulating water entering the planting area is unpredictable (Thamrin et al., 2019). This can trigger floods and droughts in crops, so that rice cannot produce stably. This instability would reduce the productivity and index of rice cropping. Therefore, the technical irrigation system becomes an indispensable watering system in the three sectors of the rain pattern in supporting the productivity of rice plants.

Fertilizer dose is the factor with the highest coefficient and a positive direction in predicting the potential for rice productivity. It indicates that this factor is the most dominant factor determining productivity. In this study, the highest score synergized with the range of the highest fertilizer dose group, so the higher the category, the higher the productivity. However, the concept of this research is categorical, so that deeper research on the concept of fertilization needs to be carried out systematically. In general, the application of chemical fertilizers will have a significant effect on increasing crop productivity (Soplanit et al., 2018). However, excessive doses of fertilizer will poison plants, damage soil quality and induce the explosion of plant-disturbing organisms (Nuryani et al., 2019). Therefore, fertilization requires the right or balanced dose. Fertilization with appropriate doses can increase soil fertility, fulfill plant needs and ultimately maximum productivity could be achieved. In addition, the application of the right fertilizer will have an impact on stability in increasing crop production, plant resistance to disease attacks and adaptation to unfavorable climate change (Taisa et al., 2021). According to Asrul (2013), the provision of chemical fertilizers need to ensure the availability of elements of plant's requirements, hence they can determine the required amount of fertilizer. Based on this, it can be concluded that the main factor in increasing rice productivity in the three regencies is the optimization of chemical fertilizer doses. However, this fertilization dose needs to be systematically deepened and combined with the use of organic fertilizers. The application of organic fertilizers can stabilize the potential for land productivity (Siregar, 2018). This has been reported by several studies (Hartatik et al., 2015). Therefore, this research needs to progress with the concept of optimizing the dose of chemical fertilizers and organic fertilizers with a quantitative concept. This can optimize information in making policies on cropping patterns in the three sectors of rainfall patterns in South Sulawesi. Moreover, the existing productivity data in the three regencies are still considered not optimal. Although this productivity has exceeded the national average productivity of 5.226 tons ha^{-1} (Katadata, 2022).

4. Conclusion

The main factors that affect productivity in this research were plant spacing, watering system and fertilizer doses. Fertilizer doses factor was the only factor that has a positive diversity direction in predicting productivity with a very high coefficient value. The multiple regression formulation in this research was Y = 3,354.185 -17.751 plant spacing --4.044 watering system +36.839 fertilizer doses. The productivity of the three regencies from the results of this study needed improvement to reach 8-9 tons ha^{-1}. Therefore, future researches development is necessary by taking the concept of optimizing the dose of chemical fertilizers and organic fertilizers with a quantitative concept.

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