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Relationship Between Compliance Level of Good Agriculture Practices with Increased Production of Sugar Cane (*Saccharum officinarum* L)

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Abstract— *The increase in sugar cane yields is influenced by many factors, one of which is farmer compliance in implementing good agriculture practices (GAP). The implementation of various cultivation methods and technologies cannot be carried out partially and must be integrated into a technology package. This technology package then becomes effective and efficient in producing high sugar yields. We conducted this research to determine to what extent the implementation of GAP by farmers affects production, including % Yield, % Brix, and % Pol sugarcane. We conducted research at the sugar cane production centre in Malang Regency. The stages of this research were carried out by a) a survey of 20 farmers and locations by looking at the compliance of the GAP with a total area of approximately 10 Ha. This sampling is Purpose Random Sampling with a modified Likert scale technique. b) Carrying out Yield Analysis and Correlation with Rank-Spearman Correlation is carried out to see the relationship between the application of GAP to the yield of sugarcane. The results show the compliance of GAP, which are based on the five main indicators of successful sugarcane cultivation, including land cultivation, fertilization, pest and disease control, defoliation, the process of sending the row material to the factory and all of them has a positive correlation to the yield of sugarcane with farmer compliance to implement GAP reaching 70 %. Then farmers' compliance with GAP in cultivation shows a positive correlation in increasing the results of %Yield, % Brix, and % Pol.*

Keywords— ***Yield, good agricultural practices (GAP), Farmer compliance, Sugar Factory***

I. BACKGROUND

Sugar is a commodity that has strategic value in the Indonesian economy because it is a staple material used directly by the community and industry (Supriyati, 2011, Syahnaz et al., 2022). National sugar consumption in 2021 will reach 7.3 million tons consisting of 3.2 million tons of consumption sugar and 4.1 million tons of industrial sugar. The sugar industry in Indonesia currently uses sugar cane as a raw material of 2.36 million tons in 2021. This number has increased by 2.58% from last year's 2.13 million tons (Puspitasari et al., 2021). Two main factors determine sugar production in Indonesia: farm or cultivation carried out by farmers and off-farm or sugarcane processing in sugar factories (Sudiarso & Prigandarini, 2022). These two factors must work together to achieve high sugar production. From the on-farm side, implementing Good Agriculture Practices (GAP) greatly determines the weight or productivity of sugarcane and its yield value. While off-farm, namely processing sugar cane into sugar, is determined by factory conditions and calculation of sugar yield (Hariadi, 2015; Yunitasari, 2015; Maghfiroh et al., 2017).

In the on-farm aspect, to ensure the success of sugarcane cultivation, the government regulates Good Agriculture

Practices for sugarcane commodities through regulations on Guidelines for Good Milled Sugar Cane Cultivation by a) variety arrangement, b) determination of planting period, c) land determination, d) soil preparation e) seed preparation f) planting g) maintenance h) harvesting (cutting, loading and transport) i) worker/labour health. In this study, we then determined GAP activities which refer to selecting seeds/seedlings, land preparation, determining varieties, planting, maintenance, pest control and harvesting (cutting, loading and transport) to be the main factors for successful cultivation. Compliance with GAP by farmers becomes absolute. Several research results evaluating the implementation of GAP in the production of several types of plants showed positive results. Shofi et al. (2019) state that applying organic SOP GAP positively correlates with organic red rice production. Mahyuda et al. (2018) state that applying GAP for Gayo arabica coffee cultivation has an impact on improving quality and production yields.

The application of GAP is a matter of serious study that needs to be carried out, considering that farmers need to pay more attention to the quality and quantity of their sugarcane production through exemplary GAP implementation. On the other hand, farmers' motivation in implementing GAP is influenced by the purchase price, which is based on determining the yield obtained (Santosa, 2021). Determination of the yield is still under the sugar factory's authority as the buyer of the farmers' crops, which determines the yield value partially carried out unilaterally. The case study found the yield was the same, namely around 7% for all sugarcane in one milling period. Thus, the yield determination results do not reflect differences in the type and quality of sugarcane. This condition decreased the quality of sugarcane because farmers were reluctant to improve the quality of the sugarcane they produced. This is because the yield value will impact farmers' income. The lower the yield value, the lower the income earned, and it is not proportional to the production inputs provided (Amir, 2010). Lukman et al. (2008) explained that the income factor is the main objective of farmers in practising sugarcane farming. So the guarantee of income is the motivation to maintain continuity and increase the quantity and quality of sugarcane production.

The polemic about yield determination for sugarcane farmers seems to be a classic problem that traps farmers and sugar mills in an ambivalent situation, Istiawati, (2006). According to Cahyani (2017) that mutual distrust arises. On the one hand, there is distrust of farmers in the Sugar Factory due to the determination of yield yields and the incentives obtained. On the other hand, the Sugar Factory knows that farmers are no longer implementing GAP properly, so the yield is determined unilaterally. Ultimately, farmers choose to convert sugarcane land into land for other crops or convert the land into non-agricultural use because all factors are within their control (Hariadi, 2015). Then, the Sugar Factory finally obtained raw materials that were rudimentary. Because farmers who apply GAP do not get good yields, they only cultivate without regard to GAP. If conditions like this are allowed to continue, it will threaten food security at the national level. The production of white crystal sugar will decrease due to the absence of raw materials, and the import of gross sugar for refined sugar materials will be higher.

The purpose of this research is to determine the appropriateness of farmers in implementing GAP and to see how far the implementation affects the sugarcane yield. Ultimately, the Sugarcane mill's trust in farmers reappeared, and vice versa, leading to a more transparent sugar yield calculation policy that satisfies the people's sugar cane farmers and benefits sugarcane mills.

II. METHOD

Selection of location and time of research

Research locations were selected purposively in sugarcane production centres in Malang Regency consisting of Gondanglegi District and Pagelaran District. The research was carried out in October-November 2021.

Methods of Data Collection and Sample Selection

1. Level of Adoption of Good Agriculture Practices

Data collection was carried out through direct interviews with 20 sugarcane farmers using a closed-method questionnaire, where the possible answer choices were predetermined, and respondents were not given alternative answers. The respondents were selected using a purposive random sampling technique with the criteria of farmers who are partners of the Gondanglegi Village Unit Cooperative and the Krebet Sugar Factory. Respondents were given a questionnaire in which each described the implementation of the GAP, including land cultivation and fertilization, such as the type of fertilizer, the amount of fertilizer, sugarcane treatment, and others that affected the yield value of sugarcane. 5% of the prominent farmers sampled with an even distribution.

2. Sugarcane Yield Results

Sugarcane samples for yield calculations were taken from sugarcane planted by 20 interviewees. A sampling of sugarcane was carried out at 5 points using the diagonal sampling method; at each point, two ovals were taken. For analysis, the calculation of the yield value was carried out at the Pasuruan Indonesian Sugar Plantation Research Center. Sugarcane samples were taken from the

same type to reduce the bias in yield measurement. The number of samples was taken according to the standard operating procedure for the sample and immediately sent to Pasuruan Indonesian Sugar Plantation Research Center to measure the yield, Brix % and Pol %. The yield value of the measurement results will be matched with the sample farmer management system and compared with the measurement of the yield value by the sugar factory.

Varieties Arrangement Sampling

The arrangement of varieties also influences the basis for returning sampling. The variety arrangement is carried out by farmers by determining the superior varieties to be planted according to the typology of the land, determining the maturity composition, suitability of the superior varieties with the cutting plan and planting period, as well as the availability of healthy, pure and timely planting materials when needed. Planting of sugarcane is carried out based on the composition of ripeness (early ripe, medium early, medium and slow middle) which is adjusted to the raw material needs of each sugar factory. The varieties used are superior by technical standards and are certified. The varieties used and the samples for this research were BL and Late Ripe (Table 5).

Table 5. Sampling-based on varieties, various criteria and types of seeds

Variety	Criteria for maturity	Type of seedling	Number
PR	Early Ripe	New Plant cane	1
BL	Late Ripe	New Plant cane	6
BL	Late Ripe	Ratoon cane	13

Data analysis

Qualitative data from the interviews were converted into quantitative using a scoring test technique using a modified Likert scale for each variable indicator of the GAP component. This study uses an ordinal scale. According to Sugiyono (2018), an ordinal scale is a measurement scale that states categories and the rank of the construct being measured. The scoring index obtained is used to determine the percentage of GAP adherence using the following formula (Apriani, 2019):

% GAP adoption rate = (Actual score)/(Maximum score) x 100%

The percentage value of applying GAP to each component obtained is analyzed about the obtained yield value of the test results. To find out the relationship between the level of application of GAP and the yield obtained using a non-parametric statistical approach with the Rank-Spearman correlation method and we used the Kruskal Wallis Test ($P<0.05$) to see a comparison between the yields produced on the new planting species and ratoons.

III. RESULTS AND DISCUSSION

Results

GAP compliance by farmers

In this study, it is examined to what extent GAP affects yields. To know the determining factors for the success of sugarcane farmers in improving their welfare. The efficiency of the use of production inputs will also be considered in this study. Determining yields by sugar factories will not burden farmers and will become a vicious circle in their partnership between farmers and sugar factories. The results of the study are shown in Figure 1. The graph shows the compliance of Good Agriculture Practices by Farmers where it is known that the new planting cane or plant cane and ratoons are trending similarly in fulfilling their GAP. Even ratoon cane tends to be more intensive in fulfilling its GAP.

Soil tillage is carried out to create a suitable growing environment for sugarcane plants from the beginning of growth to harvest so that optimal land is obtained for sugarcane growth. Soil preparation can be done through the Manual System, the Semi-Mechanized System, or the Mechanized System.

Based on the Good Agriculture Practice (GAP) compliance scoring analysis, it is known that GAP processing sugarcane land is only carried out by 64.8% of farmers. At the same time, the rest are not by the GAP, including the absence of drainage channels, such as the unfortunate gutter. This will directly affect sustainability in cultivation, especially during the rainy season. It is bearing in mind that sugarcane plants are not resistant to anaerobic conditions. Good land cultivation with crop management during ratoon increases sugarcane production and yields (Salamah, 2016; Simamora et al., 2015).

Maintenance of sugarcane plants consists of several stages, including irrigation, replanting, fertilizing, tilling the soil and mounds, cloves, drainage arrangements, and pest and disease control. Maintenance can be done with 2 (two) systems, namely the manual and mechanical systems.

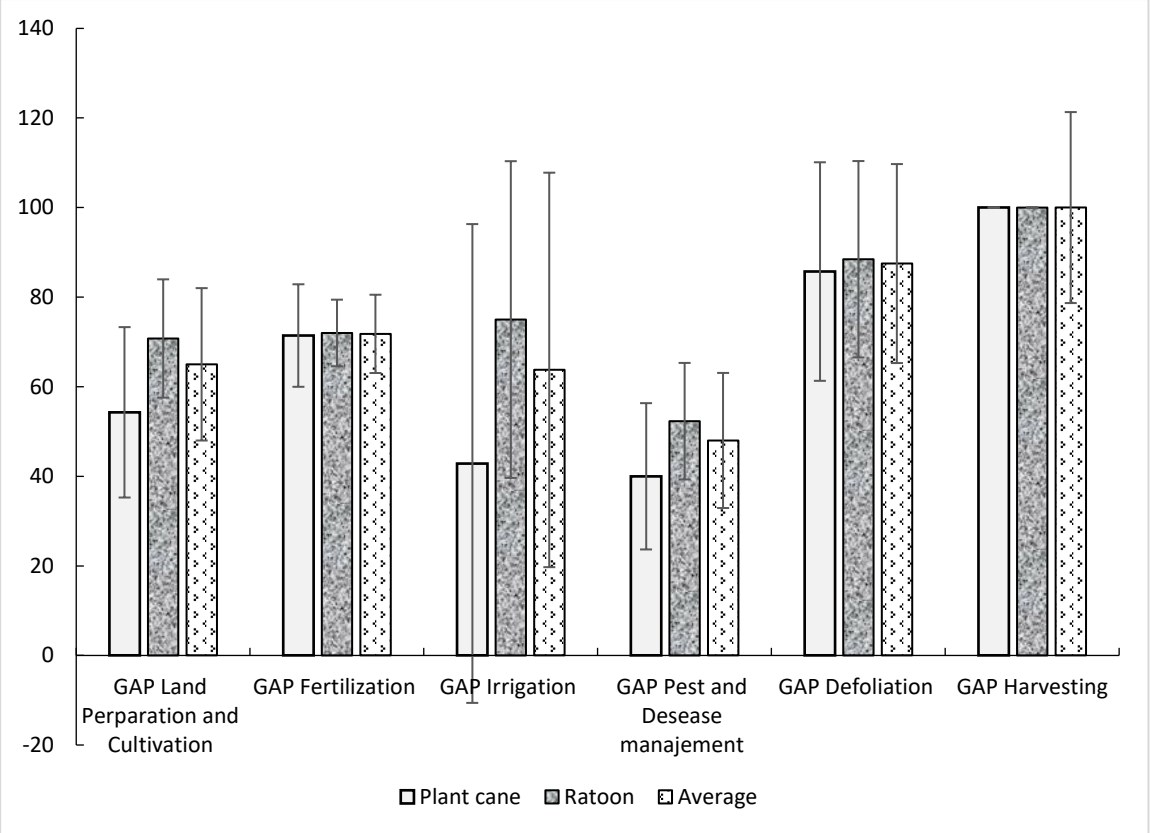


Fig.1. Graph of Fulfillment of Good Agriculture Practices by Farmers

Furthermore, in compliance with the GAP criteria for fertilization, 28% of the area still needs to meet the GAP. The GAP sugarcane fertilization is only done on 71.8% of farmers. The GAP irrigating sugarcane was only carried out in 63.8% of the sugarcane land. The rest was rainfed land that needed to be washed. In the GAP indicator, Pest and disease and weed control were carried out at 0.48% of farmers. The smallest number of the overall results is because pests and diseases have never been controlled, so the GAP is not fulfilled. Then 82% of the sugar cane area was carried out by Defoliation, where most farmers understood the benefits of Defoliation for plant quality and easier harvesting. As well as in practice, Defoliation is done two or more times, while 18% of the area is only done one time.

Slashing, loading, and transport of milled sugarcane are carried out to maximize the potential weight of sugarcane and the yield that has been formed in the plantation to become the raw material for sugar production and to fulfill the planned daily supply of quality raw materials by the milling pattern coordinated by the mill. For the success of Slashing, loading, and transport activities, it is necessary to establish proper management from planning to implementation. The results of this study indicate that 100% of the harvested area can be shipped the same day within 1 x 24 hours.

4.3 Compliance of Good Agriculture Practice with Components of Sugar Cane Products

Based on the research conducted in Figure 2, it shows that even though it comes from ratoons, if the GAP compliance is done correctly, there will not be a significant difference between the average yield % Yield (A), % Brix (B) and % Pol (C) for new sugar cane Plant cane and Ratoon.

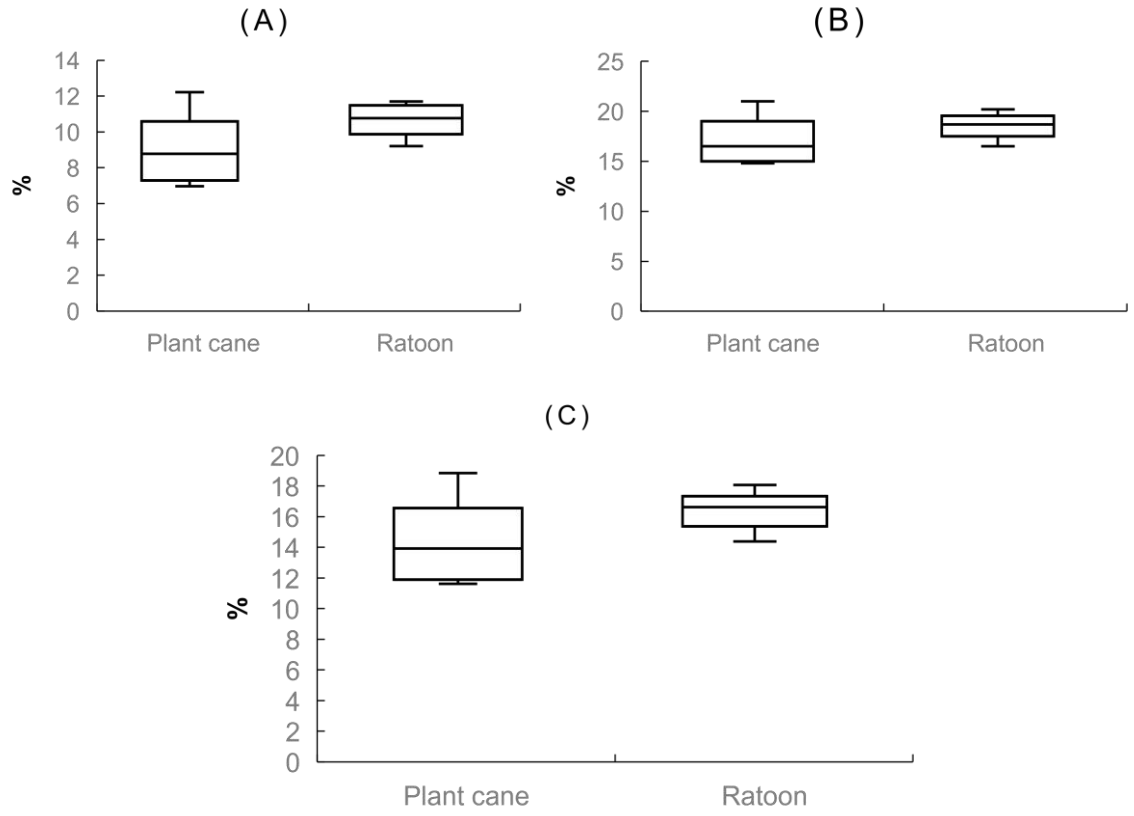
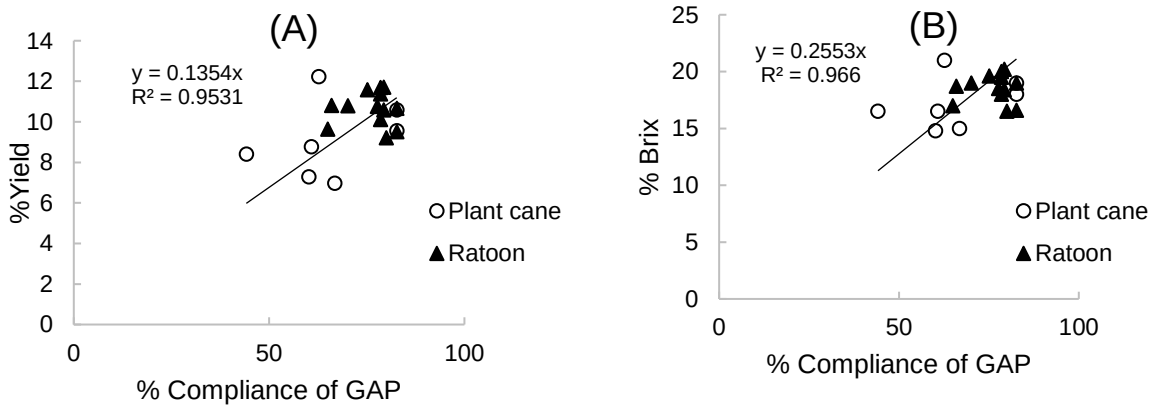


Fig.2. The average % yield (A), % Brix (B), and % Pol (C) for new sugarcane plants and ratoons, the results showed no significant difference between new sugarcane plantings and ratoons based on the Kruskal Wallis Test (P> 0.05)

We also observe whether there is a positive correlation between the average farmer compliance with GAP and the results % Yield (A), % Brix (B), and % Pol (C) for Cane and Ratoon Plants Figure 3. Both cane and ratoon plants show a positive correlation relationship between adherence to implementing GAP with % Yield, % Brix and % Pol.



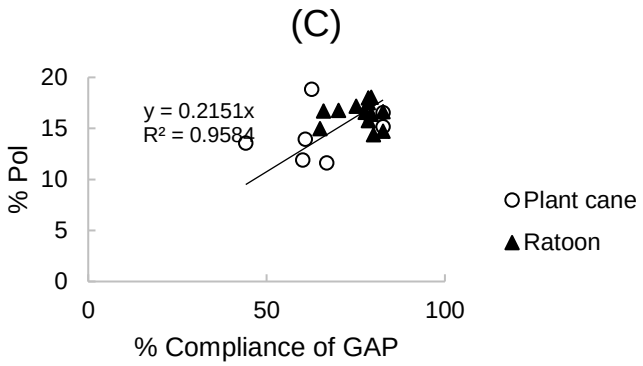
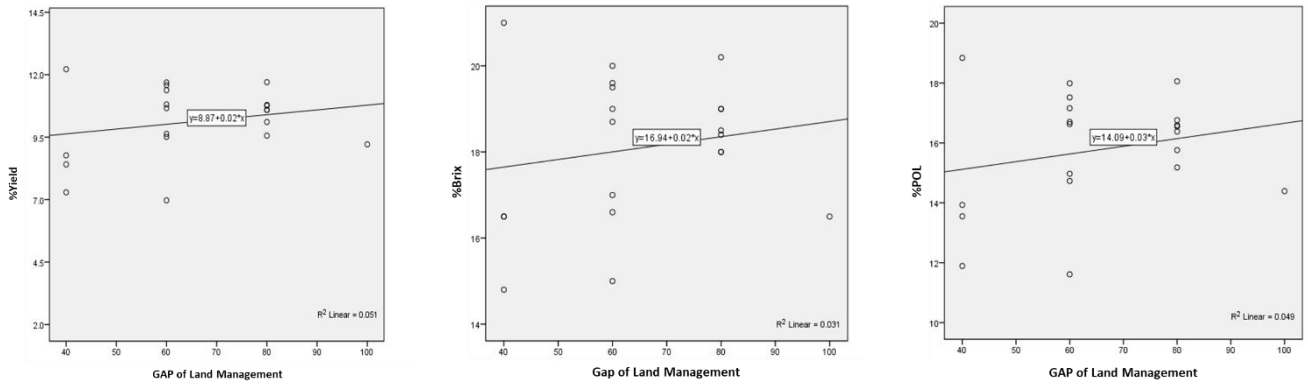


Fig.3. Regression correlation between average farmer compliance with GAP with % Yield (A), % Brix (B), and % Pol (C) for cane and ratoon plants

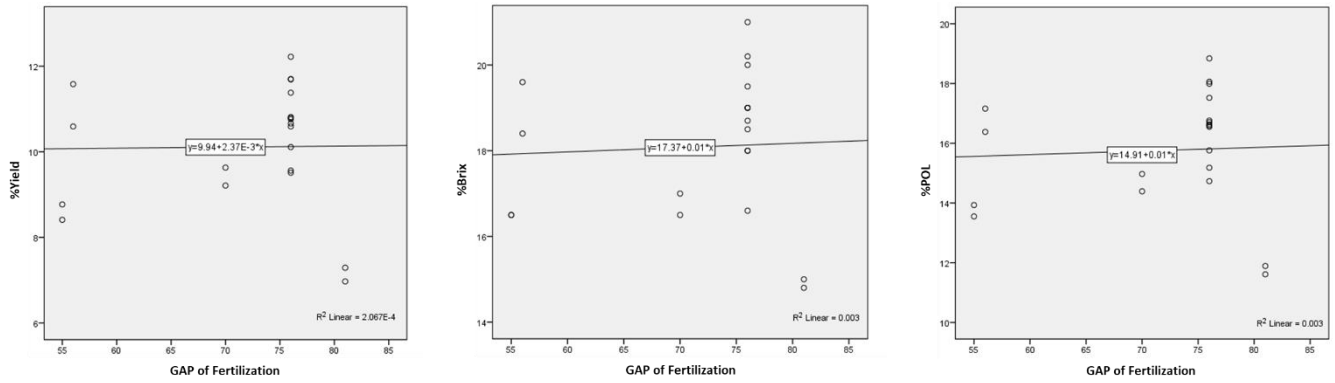
When broken down for each GAP with Spearman correlation analysis, the results show that the GAP of land cultivation with the sugar cane yield component in Figure 4. has a correlation coefficient to % yield of 0.137 and % brix of 0.143 and % pol of 0.149. As for the significance of the correlation, the results obtained between the GAP of land processing with a yield component of 0.564 for % yield, 0.546 for % brix and 0.530 for % pol. Based on these results, it can be seen that the application of GAP in land management carried out by farmers positively correlates with the components of the sugarcane yield obtained.



(A) (B) (C)

Fig.4. Graph of Correlation GAP of Land Processing with Yield Components; A). %Yield, B). %Brix, C). %Pol

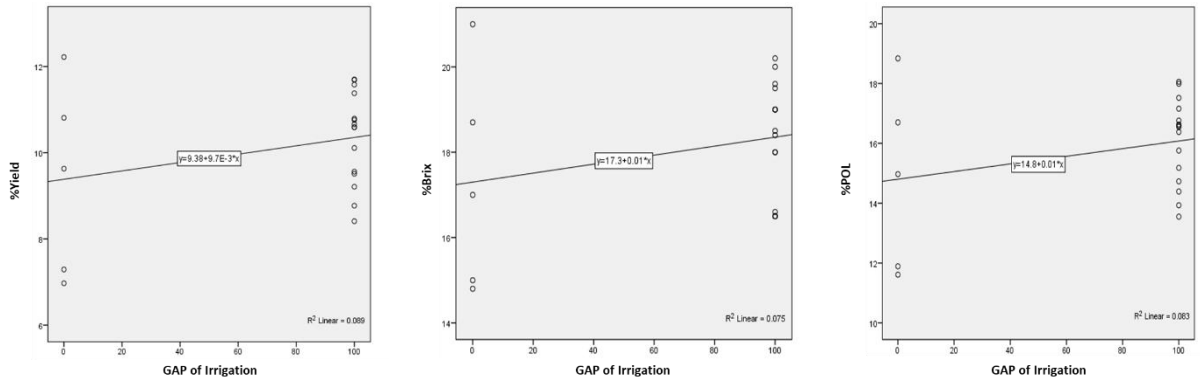
The results of the Spearman correlation analysis show that the fertilization GAP with the sugarcane yield component in Figure 5 has a correlation coefficient on the % yield of 0.043, a %brix of 0.056, and a % pol of 0.078. As for the significance of the correlation, the results obtained between GAP Fertilization with a yield component of 0.856 for % yield, 0.814 for %brix and 0.743 for % pol. Based on these results, it can be seen that the application of fertilization applied by farmers has a positive correlation with the components of the sugar cane yield obtained.



(A) (B) (C)

Fig.5. Graph of Correlation of GAP Fertilization with Yield Components; A). %Yield, B). %Brix, C). %Pol

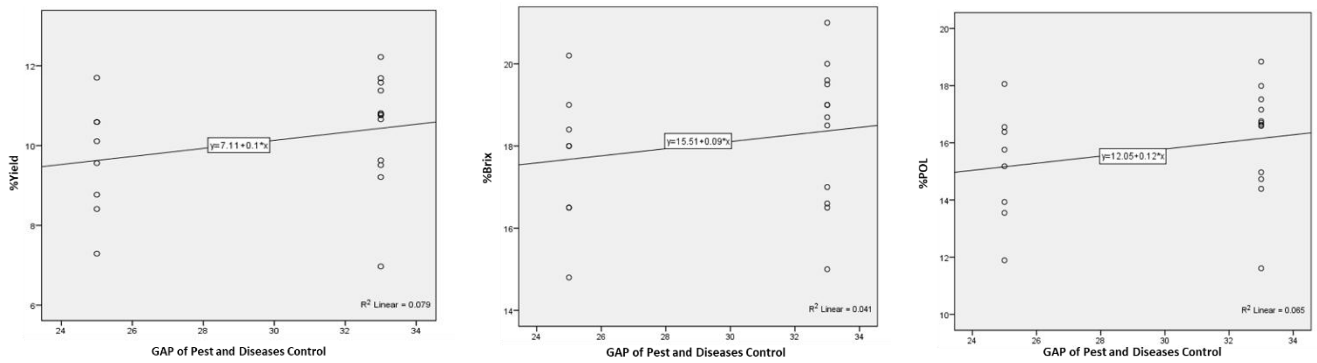
The results of Spearman's correlation analysis showed that GAP Irrigation with components of sugarcane yields had a correlation coefficient for the % yield, % brix and % pol were 0.130, 0.211, and 0.170, respectively. As for the significance of the correlation, the results obtained between GAP Irrigation with a yield component for % yield, % brix and % pol were 0.584, 0.372, and 0.473, respectively. Based on these results, it can be seen that the application of GAP in land irrigation carried out by farmers positively correlates with the components of the sugarcane yield obtained.



(A) (B) (C)

Fig.6. Graph of Correlation of Irrigation GAP with Yield Components; A). %Yield, B). %Brix, C). %Pol

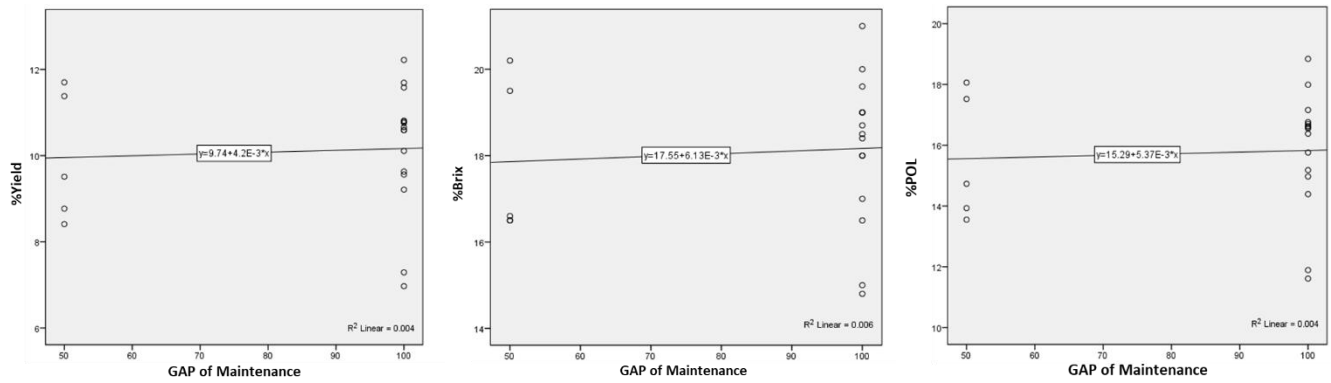
The results of Spearman's correlation analysis show that the GAP of pest control with the sugarcane yield component in Figure 7. has a correlation coefficient to % yield, % brix, and % pol ware 0.336, 0.266, and 0.319, respectively. As for the significance of the correlation, the results obtained between the GAP of pest control and the yield component such as % yield, % brix and % pol were 0.147, 0.256, and 0.171, respectively. Based on these results, it can be seen that the application of GAP in pest control carried out by farmers has a positive correlation with the components of the sugarcane yield obtained.



(A) (B) (C)

Fig.7. Graph of pest and diseases control GAP Correlation with Yield Components; A). %Yield, B). % Brix, C). %Pol

The results of Spearman's correlation analysis show that the maintenance GAP with the sugar cane yield component in Figure 8 has a correlation coefficient to % yield of 0.090 and % brix of 0.070, and % pol of 0.070. As for the significance of the correlation, the results obtained between GAP Maintenance with a yield component of 0.705 for % yield, 0.768 for % brix and 0.769 for % pol. Based on these results, it can be seen that the application of GAP in maintenance carried out by farmers positively correlates with the components of the sugarcane yield obtained.



(A) (B) (C)

Fig.8. Graph of Maintenance GAP Correlation with Yield Components; A). % Yield, B). % Brix, C). % Pol

IV. DISCUSSION

The results of our research show the importance of GAP land management as one of the critical activities in successful cultivation. Land processing is one of the land preparation techniques for planting. This aims to provide seeds and seeds with an optimal place to grow for their growth. In a study by Lubis et al. (2015) and Awe et al. (2020), it was shown that tillage and soil drainage affected increasing plant height, stem diameter and the number of age segments. The highest production estimation was obtained in good drainage treatment with deep knife processing. Deep knife processing produces higher production estimates than shallow knife processing under excellent or poor drainage conditions. This shows how vital the GAP of land management is in sugarcane cultivation.

Applying fertiliser can increase crop yields supported by the correct dosage. In a study conducted by Djajadi et al. (2016), sugarcane production and profit increased with the application of Si fertiliser, a concentration of 30% Si produced cane with the highest weight and yield and sugar rock crystal, which respectively 184.16 tons/ha and 8.36% and 15.37 tons/ha. In addition, according to Magandi (2019), Nitrogen fertilisation through Za fertiliser has a positive correlation with increasing sugarcane production and yield, so the results of this study also provide an accurate picture of the application of GAP to fertilisation, which can increase sugarcane % yield, % brix and % pol.

In fulfilling the GAP for proper irrigation, applying GAP in fertilisation can increase the % yield, % Brix and %pol of sugarcane. In line with Ardiansyah (2015), Yusara et al. (2019) state that providing water can also increase production and product at the proper needs and with the correct administration. Provision of water

according to the needs and growth phase of the plant as well as the harvest or milling period of the sugar factory.

Defoliation is an activity we then include in one of the GAPs for sugarcane cultivation. Defoliation aims to reduce pest and disease attacks. Apart from that, to improve air circulation in the garden and make it easier for sunlight to enter, C4 plants need good circulation to increase their production. Another benefit of Klentek is to prevent roots from coming out of the segments, which can disrupt plant growth and increase the number of tillers of sugarcane. (Arceneaux et al., 1980; Sales et al., 2021), Then according to Islam et al. (2016), yields and yield quality are obtained when defoliation is carried out by 40% of the number of leaves.

Integrated pest and disease control is also a GAP criterion for increasing sugarcane production. Research by Muliasari & Trilaksono (2020); Wicaksono (2012) shows that pest and disease control directly increases sugarcane production. So pest and disease control causes a decrease in sugarcane production by up to 10%, according to Subiyakto (2016). This study illustrates that the right farmers' low compliance with the GAP for pest and disease control can increase sugarcane production.

The GAP harvest and delivery time also determines the quality of the yield. According to Sriwana & Djatna (2012); Yusrina (2016), The obstacle in the distribution of sugarcane is that if the sugarcane is processed after 36 hours from the time of cutting, the yield of sugarcane will decrease (a good work of sugarcane ranges from 8% to 10%). If there are more than 36 hours of accumulation, the sugar cane yield will decrease by 1% to 2% so that productivity can decrease. So it is essential to ensure that the cane is sent immediately after cutting in less than 24 hours. In line with the implementation of this survey and research, which shows that the increase in production and yield of sugarcane is strongly influenced by farmer compliance with GAP from start to finish, including timely delivery.

V. CONCLUSION

The implementation of GAP in sugarcane cultivation determines the success of sugarcane cultivation in Indonesia. From the research results, all indicators of Good Agriculture Practices positively correlate with the sugar yield. This means that better land management by sugar cane farmers significantly increases sugar cane harvest. There is no significant difference between the newly planted cane and ratoons when farmers compliance the GAP. This illustrates how crop production can grow along with improving good cultivation management by GAP. The average yield obtained was 10.11% with % Brix 18.09% and 15.76% Pol while the average GAP compliance by farmers was 72%. This shows that the sugar cane produced by farmers in the sampling is higher than the average national yield of 7%.

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