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Intercropping of potato within sugarcane plants in a double row planting system under wet climate

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Abstract

Growing sugarcane in a double row planting system is one way to increase the productivity and sugar cane yield. Intercropping within sugarcane crops can increase the growth and productivity of sugarcane. This study aims to increase the productivity of sugarcane by adding value to potato cropping. The study used Randomized Block Design, where the treatments ae as follows: sugar cane as a planting system (A), double castor planting system (PtoP 210/50 cm) with cuttings of sugarcane stem + potato's (B); double distance planting system (PtoP 185/50 cm) with cuttings stem sugarcane + potato's (C); double distance planting system (PtoP 160/50 cm) with cuttings sugarcane stem + potato's (D); double distance wedge system (PtoP 135/50 cm) with cuttings of sugarcane stem + potato. The planting system (PtoP 110/50 cm) with cuttings of sugarcane stem without planting potato was considered as control (E). All planting systems were repeated four times. The results of the study showed that the agronomic growth of sugar cane crops in some planting systems is not different, but in C and D planting systems, the number of leaves and the number of tillers were higher compared to others. Potatoes crop production in planting systems C reached 11,880 tons ha^{-1}, which is higher than the production of planting systems A (8,640 tons ha^{-1}.) and planting systems B (8,400 tons ha^{-1}). After combining the determining factors of sugar cane production, the C planting systems is recommended for development of sugarcane crops because is better than other planting systems. The population of sugar cane plants in the C planting systems reached 18,000 clumps of plants per hectare.

Keywords: Double distance, planting system, growth, intercropping, potatos, **s**ugarcane.

Introduction

Sugar cane plants are essential foodstuffs and include nine basic food needs. Sugar cane is also an essential energy-producing plant and biomass energy, containing sugar in its stem. The sugar residues are used to produce biofuels or other bio-products after sugar extraction (Awe et al., 2020). Domestic sugarcane production is insufficient in Indonesia. The national needs reach more than 3.25 million tons per year, while the production is about 2 million tons. The shortage of more than 1.25 million tons per year still relies on imported supplies. In Indonesia, domestic production has tended to decrease over time, resulting to import at least 2.2 million tons/year (Susilowati and Tinaprilla, 2012).
In Brazil, the sugarcane plant (*Saccharum officinarum* L.) is very prominent. It is one of Brazil's primary and oldest agroindustry plants, making the country the largest producer, exporter of sugar and ethanol (Pelloso et al., 2020). Brazil is the world's largest sugar cane and sugar producer, also recorded the second in ethanol production (Carneiro et al., 2020). In 2019, Brazil's ethanol production reached 36 billion liters (both anhydrous and hydrated ethanol), which was 11% higher than the previous year's production (Aguiar et al., 2021). In Brazil, significant progress in the last four decades has placed Brazil as a world reference in technology for sugar cane production and processing (Bernardo et al., 2019). Brazil is the largest sugarcane producer (*Saccharum officinarum* L.) in the world, with the production of about 304 million tons in 1995 and increased to 759 million tons in 2017 (Figueira and Rolim, 2020). The area of sugarcane crops has reached 26 million hectares worldwide (Otto et al., 2020). Ethiopia produces sugar and ethanol from sugar cane as an integrated business (Semie et al., 2019). Sugarcane is considered an essential crop in some countries because it is the raw material for producing sugar and ethanol (Estrada-Bonilla et al., 2021). Sugar cane crops as a producer of sugar and biofuel sources, are widely grown in tropical areas and subtropics (Luo et al., 2016).
In general, the problems faced by the sugar industry occur in on-farm and off-farm activities. On the on-farm side of the problem the low level of sugar cane productivity as a sugar producer stands out, which currently only reaches a range of 6 tons/ha. Thus, the mission carried out by the Government of Indonesia, following strategies and policies, is an effort to improve productivity and efficiency in management. The productivity of sugarcane crops (*Saccharum officinarum* L.) depends on climatic and economic conditions (Figueira and Rolim, 2020). Sugarcane crops have been classified as an intensive agricultural system with high nutrient fulfillment.

Therefore, tropical dry forests target these crops (Medorio-García et al., 2020). Sugarcane plants are an important economic resource for many tropical countries and seriously optimize plantation crops with economic and environmental benefits (Luna and Lobo, 2016). In Indonesia, sugar production problems include the decline of sugar cane fields, agricultural inefficiencies, lack of suitable varieties, low productivity, and inefficient and aging sugar mills (Sulaiman et al., 2019). The success of a type of crop is determined by the seed and the quality of production, the environment in which it grows, where it is cultivated, and the management carried out by farmers. Local sugar cane in Kerinci Regency, West Kayu Aro District, is a sugar cane crop that has been around since Dutch times. More than 90% of the Sungai Asam village people depend on sugar cane plants processed to brown sugar. The sugar cane plant (*Saccharum officinarum* L.) is essential globally, not only for sugar production but also as a bioenergy plant (Wang et al., 2020). Cultivation was carried out by farmers with roughing technology, especially in the processing of brown sugar. A cultivation system with optimal technology can support increased productivity. Competition of plant nutrients available with the intercropping system can also be balanced through facilitation, a phenomenon that occurs when intercropping plants have a mutually beneficial effect on each other (Gitari et al., 2020). Waste from the harvest of sugarcane crops, which are made into compost, can be applied to increase sugar cane and plants' productivity easier to harvest (Aguiar et al., 2021).

The double wedge planting system's technology and intercropping with potatoes plants can increase sugarcane plants' productivity. Intercropping helps to diversify crop production to meet farmers' diverse needs (Geetha et al., 2018). Intercropping system with potato crops is also a means of balancing nitrogen maintained in biomass and soil, thus offering a mechanism to optimize soil N balance in potato cropping systems (Nyawade et al., 2020). Intercropping system can increase principal crops and interplant crops, additional income, and long crop resources such as sugar cane (Kaur et al., 2016).

Intercropping system creates environmental conditions suitable for intercropping plant growth. Intercropping systems are a way to improve land-use efficiency as they enable higher productivity, higher profitability, and lower overall environmental risk (Huang et al., 2020). Controlling grass using herbicides can provide advantages compared to cleaning the grass directly by hand. Thus, herbicides can reduce human labor use in managing sugarcane plants (Banerjee et al., 2018). The yield of potato interplantted within sugar cane crops is a plus obtained by farmers per hectare, compared to if sugarcane crops are planted monocultures (Nankar, 1990). Legumes' potential to be superimposed with sugarcane plants in Australia reminds that species selection is an important consideration in optimizing land use (Tian et al., 2020). The application of intercropping systems can increase yield with higher quality than monocultures. It improves soil nutrition, change the microclimate, increase biodiversity, and control pests and diseases (Wen et al., 2020). Residues such as sugarcane filter cake have consolidated reuse processes, contributing to an increase in the sustainability of the production chain. In Java, Intercropping helps to diversify crop production to meet the diverse needs of people's sugar cane farmers and plantation companies who are used to use double wedge planting systems. The double wedge planting system application can increase the number of rods and production per unit area, stem weight, stem diameter, productivityand harvest index. The difference in results is likely caused by the distance between the lines used differently. Sugar cane plants as raw material for making sugar are also plants that can serve as a medicine. Sugarcane plants need suitable land for their growth. With the increasing cost of processing land and farmers' reduced income, farmers seek to practice intercropping with sugar cane to increase overall crop productivity and increase their income (Imam et al., 1990). Sugarcane plants can grow in hot and humid climates. Suitable humidity for plant is >70%. Temperatures range from 28-34 °C. The best planting media is fertile soil and enough water but not stagnant. Obstacles in farmers' sugarcane cultivation are identified and then used as a reference to assemble appropriate cultivation technology (Cholid and Machfud, 2020). With the appropriate land, sugarcane plants can thrive with proper and optimal production. Planting sugarcane in the middle of rice fields make the irrigation easy to manage. However, if it is grown in dry areas/soil, raindrop planting should be done in some seasons. The ideal and suitable altitude for sugarcane growth is 5 to 500 m above sea level. Sugarcane crop with a wide planting distance with a space between 120-140 cm is very conducive to intercropping and mutual benefit for the two plants (Li et al., 2012).

Management of sugarcane farming determines the success of both growth and the number of tillers, promoting productivity of milled sugar cane and sugar content. The climate suitability of sugarcane crops involves the suitability of climate resources and the negative influences caused by meteorological disasters in certain regions (Liang et al., 2020). The application of new technologies in sugarcane cultivation will increase sugar cane yields, improve sugar production, and farmers' income and welfare (Shukla et al., 2019). The sugarcane cropping has occupied the lands with low fertility, clearing by burning, which exacerbate land problems primarily through organic carbon reduction (De Oliveira et al., 2016). Therefore, the use of superior quality seeds is an absolute production factor that must be met. The lack of quality and inefficient seeds in the management of sugarcane crops is one of the causes of low sugarcane productivity in Indonesia (Suwandari et al., 2020). The government feels the need to regulate seed circulation supervision through certification, which provides seed certificates after examining, testing, and controlling for requirements distributed and circulated. The lack of high-quality seeds and inefficient farms are among the primary challenges of Indonesian sugarcane farming that caused low sugarcane productivity. The release of superior local varieties into nationally selected local varieties under the name "POJ 2878 Agribun Kerinci" is a profitable and prospective opportunity to develop sugarcane crops in Jambi Province.

Results and discussions

Growth of sugarcane plants

Plant height

The analysis of sugarcane growth showed that the plant's height, the circumference of the stem, the number of leaves, and the number of weeds is very influential between planting system (Tables 1-4). The height of plants in the C and D planting systems differs noticeably compared to other planting systems. The lowest plant height was observed in A planting system (Table 1) when the high observation of

Table 1. Effect of planting system treatment on high sugarcane plants.

Planting systems	Height of plants (cm)
A (PtoP 210/50)	137.013 a
B (PtoP 185/50)	153.250 c
C (PtoP 160/50)	163.236 d
D (PtoP 135/50)	163.013 d
E (PtoP 110/50)	145.000 b

The numbers followed by the same letter do not differ markedly at the rate of 5%.

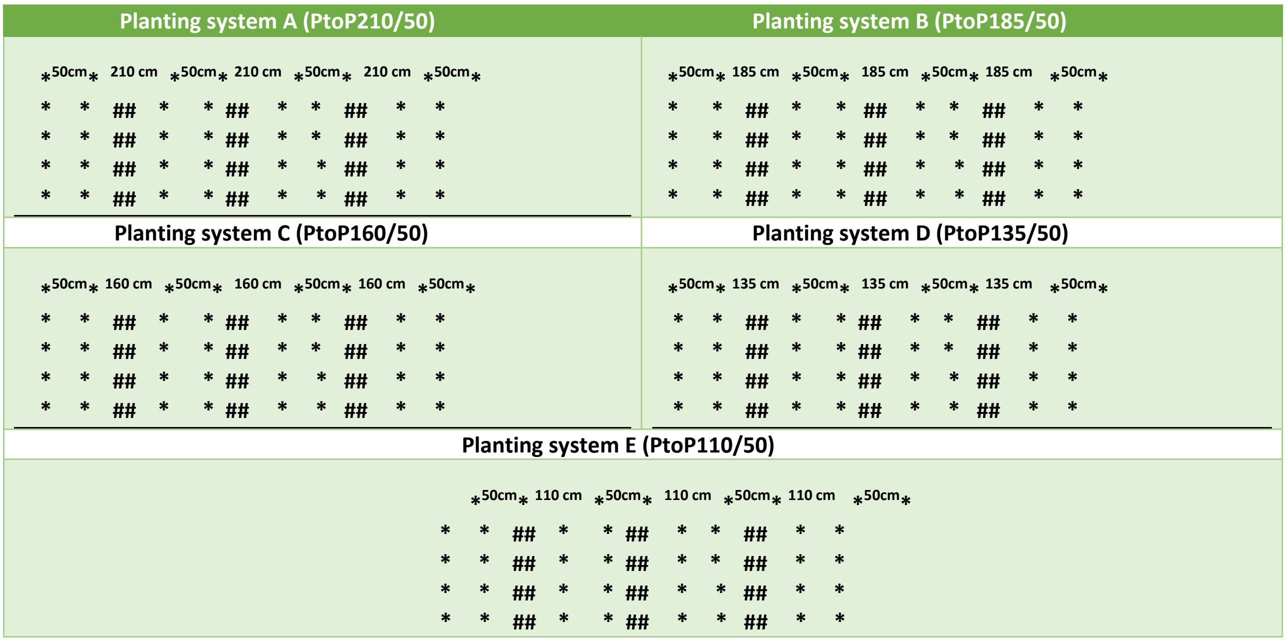

Figure 1. Schematic image of the planting system configuration. PtoP: Distance between row of sugarcane crops for potato planting. *: Sugarcane plants. ##: Potatoes plants

Table 2. The effect of planting system on sugar cane stem circumference.

Planting systems	Stem circumference (cm)
A (PtoP 210/50)	10.375 ab
B (PtoP 185/50)	11.180 b
C (PtoP 160/50)	13.111 c
D (PtoP 135/50)	14.125 c
E (PtoP 110/50)	9.527 a

The numbers followed by the same letter do not differ markedly at the rate of 5%

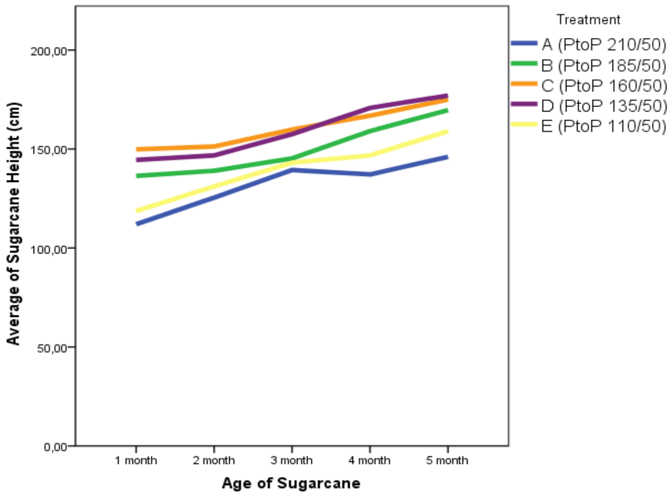

Figure 2. The high development of sugarcane plants in each planting ~~systems~~ (age 1-5 months).

Table 3. The effect of planting system on the number of sugar cane leaves/stem.

Planting systems	Number of leaves/stems
A (PtoP 210/50)	9.361 a
B (PtoP 185/50)	9.875 ab
C (PtoP 160/50)	10.263 bc
D (PtoP 135/50)	10.597 c
E (PtoP 110/50)	10.083 bc

The numbers followed by the same letter do not differ markedly at the rate of 5%.

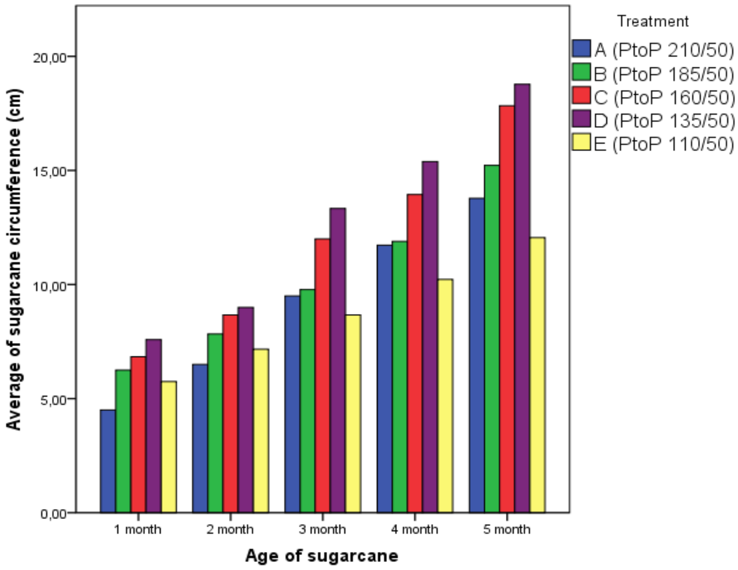

Figure 3. Development of sugar cane stem circumference in each planting systems (age 1-5 months).

Table 4. The planting systems effect of the on the number of sugarcane tillers.

Planting systems	Number of tillers/stem
A (PtoP 210/50)	7.444 a
B (PtoP 185/50)	8.375 ab
C (PtoP 160/50)	9.944 b
D (PtoP 135/50)	9. 625 b
E (PtoP 110/50)	8.111 ab

The numbers followed by the same letter do not differ markedly at the rate of 5%.

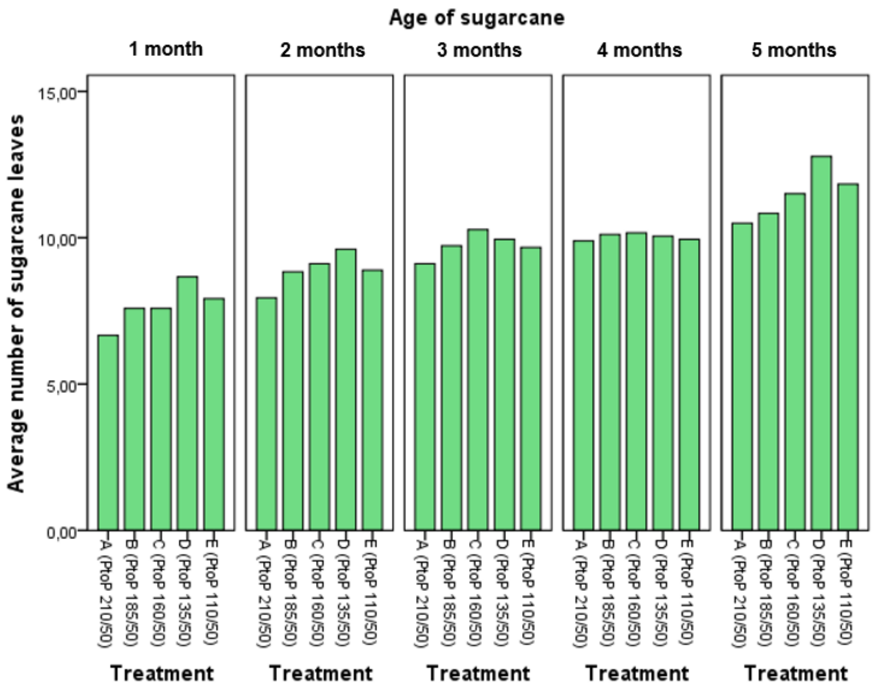

Figure 4. The development of the number of sugarcane leaves in each planting systems.

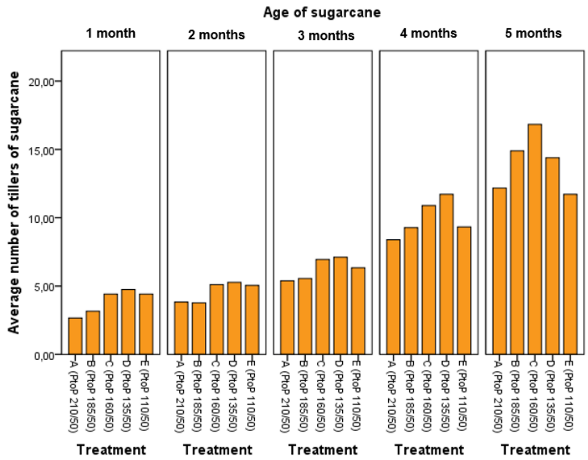

Figure 5. Development of sugarcane tillers in each planting systems (age 1-5 months).

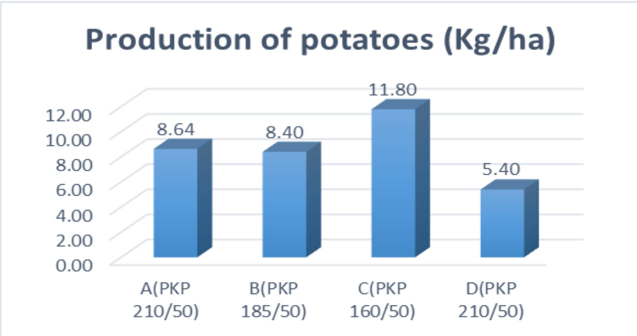

Figure 6. Production of potatoes crops as intercropping at each planting systems.

sugarcane, where plants are still in growth (aged five months), based on the description of the sugarcane plants at harvest age (12-14 months), the plant's height can reach 3 meters.

The C and D planting systems have shown higher growth than other planting systems since the beginning of development (Figure 2).

Stem diameter

The analysis of stem diameter showed that the C and D planting systems was noticeably higher than other planting systems. The lowest stem diameter was in E planting system (Table 2). According to description of POJ 2878 Agribun Kerinci cultivar, the larger the rim of the cane stem will produce more sugar cane juice.

The C and D planting systems already show higher stem diameter growth than other planting systems since the beginning of development (Figure 3).

Number of leaves

The observation of leaf count observations showed that C, D, and E planting systems did not significantly differ but differed noticeably from A and B's planting systems (Table 3). The number of leaves plays a role in photosynthesis to increase the sugar content of sugar cane. The C, D, and E planting systems already showed more growth in the number of leaves than in other planting systems in the 5th month after planting (Figure 4).

Number of tillers

Observations of the number of leaves showed that B, C, D, and E planting systems did not differ significantly, but C and D planting systems differed from A planting system (Table 4). The number of tillers at harvest age (age 12-14 months) can reach 20-25 tillers. The application of intercropping can increase the number of cane tillers, increasing the productivity of sugar cane. The B, C, and D planting systems showed more growth in the number of tillers than in the 5th month after planting (Figure 5)

Production of potato crops

Production of Granola G4 potato planted between sugarcane in planting system C showed significantly higher (11.880 kg ha^{-}1) compared to others (Figure 6). In C planting system (PtoP 160/50 cm) two rows of potato crops were planted among sugarcane plants. The second production was achieved at system A (PtoP 210/50 cm) (10.368 kgha^{-1}). Production at B planting system (PtoP 185/50 cm) is 9,450 kg ha^{-1}. The production at D planting system (PtoP 135/50 cm) was 7.245 kgha^{-1}. The yields showed the advantages of potato crops, including legume crops with intercropping systems, which can be attributed to minimal interaction competition (Gitari et al., 2020).

In C planting system (with two lines of potato crops between sugar cane crops) we found potato production is better and higher than A planting system (3 lines of potato crops). This condition is likely caused because the growth of potato crops in A planting system is less optimal due to the distance between row potatoes that are too close. It looks that in C planting system, the distance between the row of the potatoes is rather loose and gets more sunlight. The E planting system (PtoP 110/50) considered as control with no potato plants cultivated within or between sugarcane plantations.

Materials and Methods

This study was held in 2019 in Sei Asam Village, Kayu Aro Barat District, Kerinci Regency, Jambi Province, Indonesia. Sugarcane seeds were obtained from the Basic Seed Garden (KBD) of the Department of Plantation and Livestock Kerinci Regency. A Random Block Design, with five planting systems of sugar cane planting system was adopted as following: (A) Double distance planting system (PtoP[1]) 210/50 cm) with cutting of sugarcane stem + potato crops. (B) Double distance planting system (PtoP 185/50 cm) with cutting of sugarcane stem + potato crops. (C) Double distance planting system (PtoP 160/50 cm) with cutting of sugarcane stem + potato crops. (D) Double distance planting system (PtoP 135/50 cm) with cutting of sugarcane stem + potato crops and (E) a planting system (PtoP 110/50 cm) with sugarcane stem without potato plant as control. All planting systems were replicated four times. Schematic image of the planting system configuration is shown in Figure 1. The activity was carried out on farmer's land by involving four cooperative farmers as a replication. The land area of each farmer was 0.5 hectares. Agronomic observation data were analyzed with covariance and Duncan's advanced tests.

Conclusion

The agronomic growth of sugar cane crops did not differ significantly at 5-month stage. However, but in the C and D planting systems, the growth of plants is better, showing the number of leaves and the number of tillers/stem more than other planting systems. Potato crop production in planting system C reached 11,880 tons ha^{-1}, higher than the production of planting system A (8,640 tons ha^{-1}) and planting system B (8,400 tons/ha^{-1}). After combining the determining factors of sugarcane production, the C planting system is recommended for developing sugarcane plants, as it showed better than other planting systems, producing higher potato yields. The population of sugar cane plants in planting system C reaches 18,000 clumps of plants per hectare.

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