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Study of Upland Rice Cultivation as an Intercrop Between Rows of Barangan Banana Plants (*Musa acuminata* Linn.) in Deli Serdang District

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ABSTRACT

Utilizing the potential of dry land under annual crops in the development of intercropped upland rice is one of the efforts to overcome the reduction of strategic land for upland rice. The problem of intercropping upland rice with annual crops is the shading caused by the canopy of the main crop. Therefore, upland rice varieties that can adapt to the conditions of shaded drylands are needed. This study aimed to examine the ability of upland rice genotypes as intercrops to adapt to dry and shaded land, through an appropriate planting system. The research was conducted on ± 4-5 months old banana plants with a spacing of 3 m between rows and 2 m within rows, covering an area of ± 4000 m^2. This study was in a factorial form using a Split Plot Design, with the main plot of the planting system treatment consisting of two levels: Tegel system and Jajar Legowo 2:1. The sub-plots were two genotypes of upland rice from Deli Serdang, North Sumatra, namely Silayur and Sirabut, as a comparison, the shade-tolerant variety Rindang 2 and the drought-tolerant variety Inpago 11 were used. The observed variables included plant height, number of tillers, number of productive tillers, grain weight per clump and per plot, and weight of 1000 grains. Local upland rice cultivars Silayur and Sirabut are more adaptable to dryland and shaded conditions, as intercrops between banana rows. Silayur planted with the 2:1 jajar legowo system produced higher productive tillers (6.19 stems) when compared to the tegel system (5.73 stems). Silayur with tegel system showed the highest average grain yield per plot at 2.01 tons/ha, followed by Sirabut at 1.65 tons/ha. The production of these two genotypes was higher when compared to the varieties Rindang 2 and Inpago 11 at 1.15 tons/ha.

Keywords : *Banana, Deli Serdang, jajar legowo, tegel system, upland rice*

1. INTRODUCTION

Efforts that can be made in overcoming the reduction of strategic land for rice cultivation, due to the high conversion of paddy fields to non-agricultural sectors is to utilize the potential of dry lands under annual crop stands as intercrops, in the development of upland rice cultivation.

Banana Barangan is one of the horticultural commodities, which is most widely cultivated on dry lands in Deli Serdang Regency. It was recorded in 2020 that 18 out of 22 sub- districts in Deli Serdang utilized garden and yard land for the cultivation of Barangan banana plants, with a production of 205,793 tons (Dinas Pertanian Kabupaten Deli Serdang, 2021). Between the rows of banana plants there are empty spaces that can be utilized in developing upland rice cultivation. In several villages in the Upper Sinembah Tanjung Muda (STM) District of Deli Serdang

Regency, it was found that some people utilize the empty space between banana rows for upland rice cultivation as an intercrop. However, the cultivation has not used the right planting system, so the productivity is still relatively very low (<2 tons/ha) (Chaniago, Suliansyah, et al., 2022b).

The problem of upland rice cultivation as an intercrop between annual crops is the shading caused by the main plant canopy, as a result the intensity of sunlight that can be received and utilized by rice plants for the photosynthesis process is lower. Therefore, upland rice varieties that are able to adapt to the conditions of shaded dry lands are needed. In 2017, the Ministry of Agriculture's Balitbangtan through BB Padi released two new superior varieties of upland rice that are both shade and drought resistant, namely Rindang 1 Agritan and Rindang 2 Agritan, which are suitable for planting as intercrops under annual standing crops (Hamdani, Kiki & Susanto, 2020).

The results of drought test research on 24 local upland rice genotypes from Deli Serdang using Polyethylene Glycol (PEG) 6000 (Chaniago et al., 2021) and continued with water stress tests below field capacity (Chaniago, Rammadhan, et al., 2022; Chaniago et al., 2023), with the same time also conducted a test of tolerance to shade (Chaniago, Suliansyah, et al., 2022b) Local upland rice genotypes from Deli Serdang Regency that are resistant to both drought and shade were found, namely Silayur and Sirabut.

The cultivation of upland rice as an intercrop between stands of oil palm, rubber or coconut has often been studied. In cultivating upland rice as an intercrop between stands of annual plants, what must be considered is planting time and planting density, with the aim of minimizing competition for nutrients, water and sunlight intensity, both between species and between individuals within species.

Studies on upland rice cultivation between banana rows have never been conducted. Based on the results of the author's survey during the exploration of local rice diversity in several villages and subdistricts in Deli Serdang Regency, it was found that several communities in Durian Tinggung Village, STM Hulu District, which is the center of Barangan banana cultivation, use the land between the rows of banana plants to grow local upland rice as an intercrop. However, they do not use proper spacing or planting systems, so production is still very low. For this reason, the intercropping system of upland rice needs attention so that it can be widely developed.

In line with the above problems, it is necessary to study the cultivation of local upland rice as an intercrop between rows of barangan banana plants, by comparing two planting systems, namely conventional (tegel) and 2:1 jajar legowo system.

In addition to the use of drought- and

shade-adapted varieties, one intensification measure that should be considered in upland rice cultivation as an intercrop between rows of banana plants is the regulation of plant density. According to Rasool et al. (2012), plants can produce optimum yields in an environment if the density of plant population per unit area of land is taken into account. Jajar legowo planting system is an engineering arrangement of planting distance between rows of plants to be wider and narrowing the planting distance in the row so that there is an increase in the number of clumps of rice in the row, thus increasing the number of plant population per unit area of land (Erythrina & Zaini, 2014; Sahara & Kushartanti, 2019).

The tegel (conventional) planting system is rice planting with the same distance between rows and within rows (20 cm x 20 cm or 25 cm x 25 cm) and no rows are left empty. The jajar legowo planting system is a rice planting system by adjusting the planting distance between clumps and between rows so that there is a compaction of rice clumps within rows and widening the distance between rows. This system can increase the plant population per unit area (Sihombing et al., 2020).

There are several types of jajar legowo planting systems that are often applied by farmers, namely jajar legowo 2:1, 3:1, and 4:1. Based on the results of the research, it is known that the type of jajar legowo 2:1 can be applied to obtain quality grain to increase rice productivity by 14.15% (Suhendrata, 2015). The results of other studies showed that two-row jajar legowo system planting with spacing of 20 cm x 10 cm x 40 cm can increase production between 560 - 1,550 kg/ha compared to garden tegel system with spacing of 20 cm x 20 cm (Suhendrata, 2010). Abidin et al. (2013) found that the Jajar Legowo planting system can increase rice productivity by 20.9% through transplanting and 20.3% through direct seed planting.

This study aimed to examine the ability of upland rice genotypes as intercrops to adapt to dry and shaded land, through an appropriate planting system.

2. MATERIALS AND METHODS

This research was carried out in a farmer's banana field, with an area of ± 4000 m^2 (10 rante), located in Bandar Dolok Village, Pagar Merbau District, Deli Serdang Regency, North Sumatra Province, with an altitude of ± 35 m above sea level and coordinate point 3˚34 6ˈ" N 98˚54 47 " E. This land has been planted with bananas aged ± 4-5 months with a spacing of 3 m between rows and 2 m within rows, where the number of plants per clump is maintained so that there is one mother and one sapling that is maintained (Figure 1).

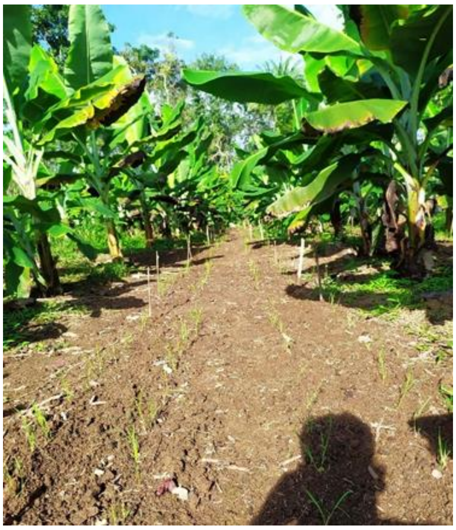

Figure 1. The banana plantation is ± 4-5 months old with a planting distance of 3 meters between rows and 2 meters within rows.

The materials used in this study included four genotypes of upland rice: two local upland rice genotypes selected from drought and shade resistance test were Silayur and Sirabut, two shade tolerant and drought tolerant varieties were Rindang 2 and Inpago 11, Urea fertilizer at a dose of 200 kg/ha (20 g/m^2), SP_{36} 100 kg/ha (10 g/m^2) and KCl 100 kg/ha (10 g/m^2), insecticide active

Deltametrin 25g/l (Decis 50 EC), fungicide active Propineb 70% plus Zinc as a complement (Antracol 70 WP), fungicide active Mankozeb 80% (Dithane M-45 80 WP). The tools used include were Lux meter LX 1330B, anymeter TH 603, soil survey instrument, electric scale, knapsack sprayer, hoe, machete, tugal, plastic rope, stationery and documentation tools.

This study is a factorial experiment that was arranged using a Split Plot Design (SPD) model and was repeated four times, with the planting system as the main plot consisting of 2 levels, namely: the tegel system with a spacing of 25 cm x 25 cm a population of 45 plants/plot (J1) and the 2:1 jajar legowo system with a spacing of 25 cm x 12.5 cm x 50 cm, a population of 64 plants/plot (J2). The subplot treatments were rice genotypes consisting of 4 levels, namely two local upland rice genotypes selected from drought and shade tests, namely: Silayur (G1), Sirabut (G2), as a comparison, the shade-tolerant variety Rindang 2 (G3) and the drought-tolerant variety Inpago 11 (G4) were used.

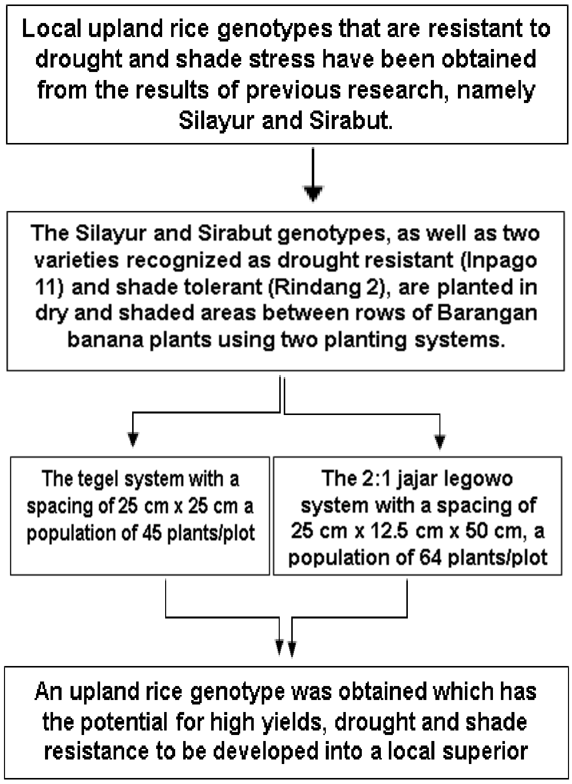

Figure 2. Research flow chart

Observed variables for agronomic characters included plant height growth (cm), the number of tillers and productive tillers (stems), the weight of grain per clump (g) and per plot (g), weight of 1000 grains (g).

The data obtained were then subjected to analysis of variance (Anova) at the 5% level, and if the effect was significant, it was followed by Duncan Multiple Range Test (DMRT) mean difference test at the 5% level.

Microenvironmental measurements include: light intensity measured by Lux meter LX 1330B (Figure 3), air temperature and air humidity measured by Anymetre TH 603 (Figure 4). Soil temperature and soil pH were measured with a soil survey instrument (Figure 5). Soil moisture was measured using a soil moisture sensor (Figure 6). Measurements were taken from planting to the end of the study at one-month intervals.

Figure 3. Lux meter LX 1330B measuring light intensity

Figure 4. Anymetre TH 603 for measuring air temperature and air humidity

Figure 5. Soil survey instrument for measuring soil temperature and pH

Figure 6. Soil Moisture Sensor to measure soil moisture

3. RESULTS AND DISCUSSION

The summary of analysis of variance on the treatment of planting system (J), upland rice genotype (G) and JxG interaction, on plant height (TT), number of tillers (JA), number of productive tillers (AP), grain weight per clump (WC), grain weight per plot (WP) and 1000 grain weight (WG), can be seen in Table 1.

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Table 1. Summary of analysis of variance on the plant height (PH), number of tillers (NT) and productive tillers (PT), grain weight per clump (WC) and per plot (WP) and 1000 grain weight (WG) in the treatment of planting system (J), rice genotype (G) and the interaction of the two treatments (JxG).

Source of Diversity	PH	NT	PT	WC	WP	WG
Cropping System (J)	2.35tn	2.00tn	0.12tn	0.11tn	19,50*	0.99tn
Upland rice genotypes (G)	0.44tn	46,93*	86,56*	10,57*	7,72*	0.77tn
JxG interaction	0.49tn	2.91tn	3,69*	0.27tn	0.36tn	0.06tn
CV a (%)	4,27	2,99	3,08	21,09	26,02	13,21
CV b (%)	5,72	7,68	4,69	25,77	29,47	8,39

Description: * (significant effect); tn (not significant effect); CV = Coefficient of Variance

The interaction of four upland rice genotypes (Silayur, Sirabut, Rindang 1 and Inpago 11) with two planting systems (tegel system and jajar legowo 2:1), had no significant effect on all observed variables, except for productive tillers which showed a significant effect (Tabel 1).

The planting system on all observed variables had no significant effect, except for the weight of grain per plot which showed a significant effect. Different genotypes of upland rice showed a significant effect on all observed variables, except for the weight of 1000 grains not significantly different (Tabel 1).

Plant height

The growth rate of TT d from the age of 2, 4, 6, 8, 10, 12, 14 and 16 weeks after planting, of four genotypes of upland rice with tegel and jajar legowo 2:1 (Figure 5a, 5b), planting systems showed responses that were not significantly different.

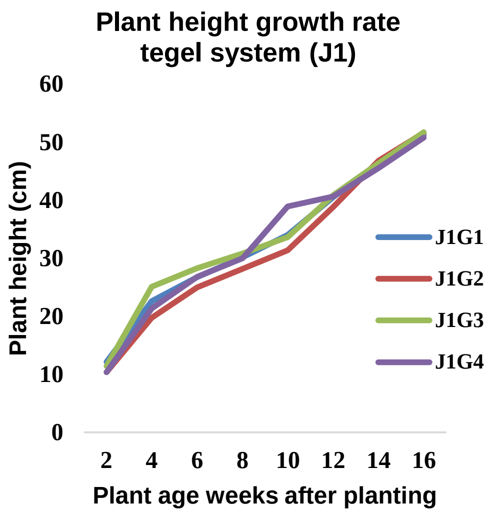

Figure 5a. Plant height growth rate at 2, 4, 6, 8, 10, 12 and 16 weeks of age of four upland rice genotypes with tegel systems (J1)

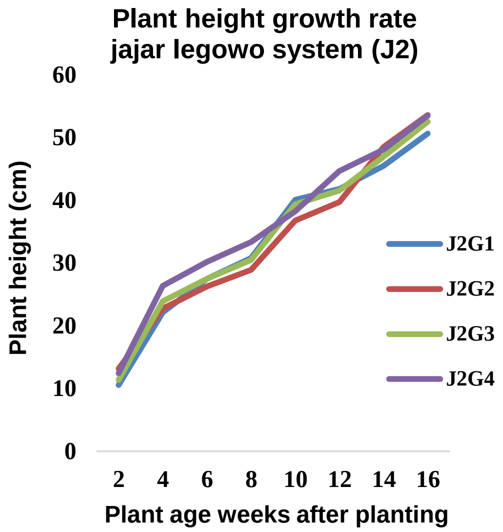

Figure 5b. Plant height growth rate at 2, 4, 6, 8, 10, 12 and 16 weeks of age of four upland rice genotypes with jajar legowo systems (J2)

The effect of planting system of tegel and jajar legowo 2:1, was not significantly different on the growth of plant height, this was thought to be due to unfavorable growing environment factors. It is known that planting rice between rows of banana plants is a big challenge, because there is high competition between banana plants and rice plants for water and nutrients in the soil. In addition, the light intensity received by the rice plants is lower due to shading from the banana canopy.

However, there is a tendency that the jajar legowo planting system provides better plant height growth than the tegel planting system. In principle, the jajar legowo system allows the rows of rice plants to be on the periphery, which has a good effect on plant growth. The use of jajar legowo planting system will provide an advantage where all rows are on the periphery, making it easier in the process of plant maintenance both in fertilization and control of plant disturbing organisms such as pests, diseases and weeds.

The results of research by Megasari et al. (2020) showed that the 2:1 jajar legowo system gave the best plant height growth in the local upland rice variety Ponelo. Planting with jajar legowo system allows all plants to absorb maximum sunlight and good air circulation, obtain nutrients evenly, and facilitate plant maintenance (Darmawan, 2016).

Number of tillers and productive tillers

Similar to plant height, all rice genotypes tested with tegel and jajar legowo 2:1 planting systems had no significant effect on the number of tillers (Table 2). In contrast to productive tillers, all rice genotypes gave significantly different responses between tegel and jajar legowo 2:1 systems (Table 3).

Duncan's test on four genotypes of upland rice (Silayur, Sirabut, Rindang 1 and Inpago 11) with two planting systems (tegel system and jajar legowo 2:1), showed that the genotype of Silayur upland rice planted with tegel planting system was significantly different from the jajar legowo planting system, where jajar legowo 2:1 produced more productive tillers than tegel (Table 3).

Table 2. DMRT test of four upland rice genotypes in the treatment of tegel and jajar legowo planting systems on number of tillers (stems)

Genotypes of upland rice (G)	Planting System (J)		Average (G)
	Tegel (J1)	Jajar Legowo (J2)	
Silayur (G1)	6,04	6,50	6,27 b
Sirabut (G2)	6,36	6,14	6,25 b
Rindang 2 (G3)	4,68	4,61	4,64 a
Inpago 11 (G4)	4,64	4,46	4,55 a
Average (J)	5,43	5,42	

Description: The mean values in the same column by the same lowercase letter are not significantly different at 5% DMRT. CV a = 2,99% dan CV b =7,68%

Table 3. DMRT test of four upland rice genotypes in the treatment of tegel and jajar legowo planting systems on number of productive tillers (stems)

Genotypes of upland rice (G)	Planting System (J)		Average (G)
	Tegel (J1)	Jajar Legowo (J2)	
Silayur (G1)	5,73 c	6,19 d	5,96 c
Sirabut (G2)	5,18 b	4,99 b	5,09 b
Rindang 2 (G3)	3,74 a	3,68 a	3,71 a
Inpago 11 (G4)	3,86 a	3,73 a	3,80 a
Average (J)	4,63	4,65	

Description: The mean values in the same column and row followed by the same lowercase letter are not significantly different at 5% DMRT. CV a = 3,08% dan CV b = 4,69%

Grain Weight per Clump, per plot and 1000 grains

The effect of planting system and jajar legowo 2:1, on all rice genotypes tested had no significant effect on grain weight per clump (WC), grain weight per plot (WP) and 1000 grain weight (WG), this can be seen in Tables 4, 5 and 6.

The response of these four rice genotypes to WC, WP and WG was not affected by the 2:1 tegel and jajar legowo planting systems. The ability of a plant to produce high productivity is highly dependent on genetic and environmental factors as well as the cropping system. Even if the genetics of the plant are good, if it is not supported by an optimal growing environment such as availability of water, nutrients and sufficient sunlight, it will not produce high productivity.

All rice genotypes planted with tegel system or jajar legowo 2:1 had no significant effect (Table 4,5,6), but there was a tendency that Silayur and Sirabut planted with tegel system produced higher grain weight per plot when compared with jajar legowo 2:1 system. Silayur produced grain weight per plot of 401.86 g/plot (2.1 tons/ha) and Sirabut 329.12 g/plot (1.7 tons/ha). When compared with the varieties Rindang 2 and Inpago 11, both genotypes of upland rice of this origin are still higher.

Table 4. DMRT test of four upland rice genotypes in the treatment of tegel and jajar legowo planting systems on grain weight per clump (g)

Genotypes of upland rice (G)	Planting System (J)		Average (G)
	Tegel (J1)	Jajar Legowo (J2)	
Silayur (G1)	6,52	6,45	6,49 b
Sirabut (G2)	5,25	6,04	5,65 b
Rindang 2 (G3)	3,64	3,39	3,51 a
Inpago 11 (G4)	3,79	3,79	3,79 a
Average (J)	4,80	4,92	

Description: The mean values in the same column followed by the same lowercase letter are not significantly different at 5% DMRT. CV a = 21,09% dan CV b =25,77%

Table 5. DMRT test of four upland rice genotypes in the treatment of tegel and jajar legowo planting systems on grain weight per plot (g)

Genotypes of upland rice (G)	Planting System (J)		Average (G)
	Tegel (J1)	Jajar Legowo (J2)	
Silayur (G1)	401,86	256,09	328,97 c
Sirabut (G2)	329,12	241,62	285,37 b
Rindang 2 (G3)	229,54	137,53	183,53 a
Inpago 11 (G4)	229,10	152,70	190,90 a
Average (J)	297,41 b	196,99 a	

Description: The mean values in the same column and row followed by the same lowercase letter are not significantly different at 5% DMRT. CV a = 26,02% dan CV b =29,47%

Table 6. DMRT test of four upland rice genotypes in the treatment of tegel and jajar legowo planting systems on 1000 grain weight (g)

Genotypes of upland rice (G)	Planting System (J)		Average (G)
	Tegel (J1)	Jajar Legowo (J2)	
Silayur (G1)	19,04	19,81	19,42
Sirabut (G2)	20,43	19,34	19,88
Rindang 2 (G3)	19,08	18,17	18,62
Inpago 11 (G4)	19,03	20,71	19,87
Average (J)	77,25	73,75	

Description: The mean values in the same column and row followed by the same lowercase letter are not significantly different at 5% DMRT. CV a = 13,21% dan CV b = 8,39%

The effect of planting system of tegel or jajar legowo 2:1 on upland rice Silayur, Sirabut, Rindang 2 and Inpago 11 on 1000 grain weight had no significant effect. Based on the existing description, these four rice genotypes have different 1000 grain weights, such as Rindang 2 has a 1000 grain weight of ±31.3g and Inpago 11 ±25g (BB Padi, 2019). The results of characterization of grain samples obtained during the exploration, a 1000 grain weight of Silayur field rice ±24.76g and Sirabut ±29.24g (Chaniago, et al., 2022a). Although genetically, these four genotypes have different characters in the grain, but during the vegetative growth phase until reproduction, the plants experience the dry season, so it is likely that the response of the four rice genotypes tested, both with the planting system tegel and jajar legowo 2:1, has the same mechanism to defend itself in the face of drought stress, this is indicated by the grain weight produced is not significantly different.

Genetically, the four upland rice genotypes have diverse characters, but during the vegetative to reproductive growth phase, the plants experience the dry season, so it is likely that the response of the four rice genotypes tested, both with the tegel and jajar legowo 2:1

planting systems, has the same mechanism to maintain themselves in the face of drought stress. The two local upland rice genotypes planted between banana rows with the two planting systems showed more adaptability to low light intensity and dry soil conditions when compared to the varieties Rindang 2 and Inpago 11.

Silayur and Sirabut are upland rice genotypes originating from STM Hulu District, Deli Serdang Regency, North Sumatra, located at elevations of 633-753 m above sea level, cultivated in hilly areas, which are accustomed to drought conditions. Silayur has white rice while Sirabut has red rice.

The different genetic makeup of the four rice genotypes tested is one of the factors causing the diversity of plant appearance, in this case including the number of tillers and productive tillers. In line with the results of research by Anhar et al., (2016), stated that the formation of the number of tillers and productive tillers is different because each variety has diverse gene traits. Herawati et al. (2019) stated that the number of productive tillers is one of the important agronomic characteristics and is a determinant of genotype identity. According to Hadi et al. (2020) in addition to genetic and environmental factors, the cultivation system also greatly affects plant growth and development. The difference in the number of tillers of each genotype is thought to be due to the influence of these factors

The response of these four rice genotypes to production (WC, WP and WG) was not affected by the 2:1 tegel and jajar legowo planting systems. The ability of a plant to produce high production is highly dependent on genetic and environmental factors, as well as the cultivation system. Although the genetics of the plant is good but if it is not supported by an optimal growing environment such as the availability of water, nutrients and sufficient sunlight, it will not produce high production.

The production of the four rice genotypes tested, showed that Silayur and Sirabut upland rice, had a higher ability to adapt to drought and shade stress environmental conditions, than the varieties Rindang 2 and Inpago 11. It is known that at the time of the research there was a long dry season of approximately 4.3 months.

According to the records of the Climatology station in Sampali, it is known that from February to May 2021, rainfall in Pagar Merbau District, Deli Serdang Regency, from the beginning of rice plant growth to production, rainfall is very low ranging from 14-63 mm with rainy days ranging from 1-5 days.

This is supported by environmental data in the plantation area recorded during the study, obtained the average air temperature from the beginning of growth until entering the grain maturation phase, 31°C, soil temperature 46°C, air humidity 32% and sunlight intensity entering the plantation area ± 19300 Lux (ranging from 30-35%). Silayur and Sirabut are field rice that is accustomed to growing and developing in local environmental conditions, with very low rainfall during the dry season.

4. CONCLUSION

Local upland rice cultivars Silayur and Sirabut are more adaptable to dryland and shaded conditions, as intercrops between banana rows. Silayur planted with the 2:1 jajar legowo system produced higher productive tillers (6.19 stems) when compared to the tegel system (5.73 stems). Silayur with tegel system showed the highest average grain yield per plot at 2.01 tons/ha, followed by Sirabut at 1.65 tons/ha. The production of these two genotypes was higher when compared to the varieties Rindang 2 at 1.15 tons/ha and Inpago 11 at 1.15 tons/ha.

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