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Rainfall Distribution as the Base for Determining Cotton Planting Time in Rice Fields after Rice in Kampar, Riau, Indonesia

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ABSTRACT

One important factor in cotton plants is rainfall. Rainfall is a determining factor for cotton cultivation in both paddy fields and dry land. Rainfall distribution analysis was conducted based on a series of long-term rainfall data to determine the chance of rainfall in various amounts of rainfall in Kampar District (Gunung Sahilan sub-district) as one indicator of the success of cotton development in Riau. By knowing the distribution of rain during the planting season, additional requirements for irrigation water can be determined. Rainfall during the rainy season is distributed from November to April and has a chance of falling (60%) between 200-250 mm/month. From May to October (dry season) the average amount of rain is less than 50 mm/month with a 60% chance of rain. Planting cotton and soybeans should be done as soon as possible, no later than a week after rice is harvested or early March. Rice planting is carried out at the beginning of the rainy season, November or December. If the total rainfall during the cotton growing season is more than 500 mm, the additional need for irrigation water in cotton plants is around 100 mm which can be given twice as irrigation. Additional irrigation water can be done by direct watering, the source of which comes from shallow wells that are scattered in several locations. The need for water will increase if cotton and soybean planting time is increasingly retreating. The use of shallow and embung (shallow water in the form of puddles) wells is highly recommended to meet water needs in the dry season, and management of plants, among others, by regulating plant density and mulching is also recommended to suppress evaporation.

Keywords: Cotton, *Gossypium hirsutum*, Distribution of rain, Rain, Planting time, Riau

INTRODUCTION

Cotton plants need certain requirements to grow and develop well. One of the factors affecting the success of cotton plants in Indonesia is rainfall. Not only does the amount of rainfall affect cotton production, but more importantly is its distribution during growth. Cotton plants require adequate water availability requirements, especially for germination and growth as well as dry conditions at harvest [1].

Rainfall and its distribution during the growing season have a significant effect on cotton production. Cotton is developed by intercropping with secondary crops so there is a very complex interaction between two or more plants in the use of water, light, and nutrients. If all three of these factors can be managed properly, the two plants will complement each other in resource use.

Kampar Regency is one of the centers of cotton development in Riau which is often an indicator of the success of cotton in Indonesia in general and Riau in particular. About 67% of the cotton area in Riau is in Kampar Regency and accounts for 81% of the yield of seed cotton. The average productivity of cotton produced can reach 1.1-1.4 tons/ha [2]. The rainfed rice fields available in Kampar Regency are quite extensive but their utilization is less than 10%. The cotton area in Kampar in 2005 was 1,097 ha [2]. Thus the development opportunities are quite extensive and with the support of available cultivation technology, the development of cotton in paddy fields has the opportunity to increase the area and national cotton production.

In the intercropping system, cotton yield loss due to competition with soybeans reaches 20-40% [3]. To reduce

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the level of competition for planting arrangements, it is necessary to provide better growth space. With cotton plant density regulation (33,000 plants/ha) and soybeans (198,000 plants/ha) arranged in 1 row of cotton (1 plant/hole) and 3 rows of soybeans, cotton production reaches 1,252 kg/ha and soybean 866 kg/ha [4]; Likewise, arranging cotton planting systems (32,566 plants/ha) and corn (38,000 plants/ha) arranged in 3 rows of cotton and 2 rows of corn cotton production reached 1,564 kg/ha and corn 3,841 kg/ha [5].

The results of land suitability assessment for cotton plants in Riau paddy fields indicate that 22,265 ha of land is very suitable (S1) where 12,020 ha of land is located in Kampar District [6]. The definition of land is a very suitable island that does not have or a few limiting factors for its use. Soils that have the potential to develop cotton in Kampar belong to Vertisols with very high clay content (>30%) and have fractures and close periodically. Such properties of the soil are also found in the districts of Ngawi, Madiun, Bojonegoro and Gresik [7].

With the existing rainfall pattern that runs from November to April, the determination of planting both rice and cotton afterward must be adjusted. The habit of local farmers maintaining cotton after the soybeans are harvested so that the age of cotton increases in length and the time of harvesting of cotton is getting longer. With the growing age of cotton plants, the certainty of water availability is very important. As the second crop after rice or secondary crops causes' cotton planting time to retreat frequently, as a result, it is often faced with drought conditions which cause production to decline due to increased pest attacks.

Rainfall after harvesting soybeans is still needed because at that time the cotton is still in the flowering phase or the beginning of fruit formation, although physiologically the plant is 90 days old after planting. Branch formation and development is hampered because the spacing between cotton and soybeans is very tight. After the soybeans are harvested the branches of the new cotton plant can develop well. With a relatively short distribution of rain from November to April, cotton planting time needs to be regulated, especially should be adjusted to the pattern of water requirements and local rainfall patterns. The withdrawal of cotton planting time is usually associated with a decline in rice planting time and land preparation for cotton plants after rice is harvested.

This paper presents information on the distribution of rainfall throughout the year as a basis for consideration for the timing of planting cotton in paddy fields after paddy in Kampar, as well as the additional need for irrigation water for cotton in relation to the time of planting cotton.

IN COTTON DEVELOPMENT

Kampar district

Cotton plants in Kampar are jointly developed or inserted between soybean plants in rainfed lowland fields. Planting the two plants was carried out after the rice plants were harvested. Cotton plants need intensive maintenance after the soybeans are harvested because in that period they have entered the dry season so that the fulfillment of water needs for cotton is very limited.

The pattern of planting in rainfed lowland is paddy – secondary crops I– secondary crops II. In areas where limited rainfall of secondary crops often does not provide good yields, cotton can, therefore, be planted together with soybeans in the intercropping system, so that the cropping pattern becomes rice-soybean+cotton. The opportunity to develop cotton in Kampar Regency is very high because it can be planted with soybeans in rainfed rice fields after rice. The area of soybeans that can be utilized is still very widely available because the newly developed ones only reach 3-6%. The available soybean area and can be used together with cotton ranges from 21,649-25,956 ha [8]. Most cotton production in Riau comes from Kampar Regency **(Table 1)**. **Table 1** shows that an increase in the production area is not always followed by a significant increase in production. In conditions where the El-Nino phenomenon occurred in 1997 which was marked by decreasing rainfall, the area and cotton production decreased.

Table 1. Areas and cotton production in Kampar and Riau districts.

Year	Area (Ha)		Production (kg)	
	Riau	Kampar	Riau	Kampar
2014	920	588	810.082	726.516
2015	1.448	858	1.264.432	1.192.381
2016	1.184	938	1.142.461	707.239
2017	1.939	1.307	1.445.199	1.191.797
2018	1.977	1.342	1.881.435	1.494.949
Total	926.548	2386.649	810.082	1433.755
Average	185.3096	477.3298	810.082	716.8775

Source: Kampar District Agriculture and Forestry Service [8]

Based on the above reasons, support from all stakeholders is needed to continue to increase the production and production of cotton in Kampar through intensification and extensification. One way is to use soybean land with intercropping with cotton and arrange the planting time so that the remaining rainfall at the end of the rainy season can still be utilized.

As in other regions, the success of cotton plants in Kampar Regency is also strongly influenced by climate factors, especially rainfall after soybeans are harvested. This is closely related to the need for water for cotton that is still large, while the availability of water begins to decrease due to entering the dry season.

RAINFALL DISTRIBUTION AS BASIC FOR DETERMINING COTTON PLANT TIME IN KAMPAR

The climate type in Kampar Regency is dominated by D (moderate) according to Schmith and Ferguson, such as climate types in Mojokerto, Pasuruan, Probolinggo and parts of Banyuwangi [9]. Opportunities to obtain rainfall in various outpourings are presented in **Figure 1**. The opportunity for rain is calculated based on the average monthly rainfall observation data for the last 20 years or the frequency of occurrences from 20 years of observation in the Gunung Sahilan District, Kampar.

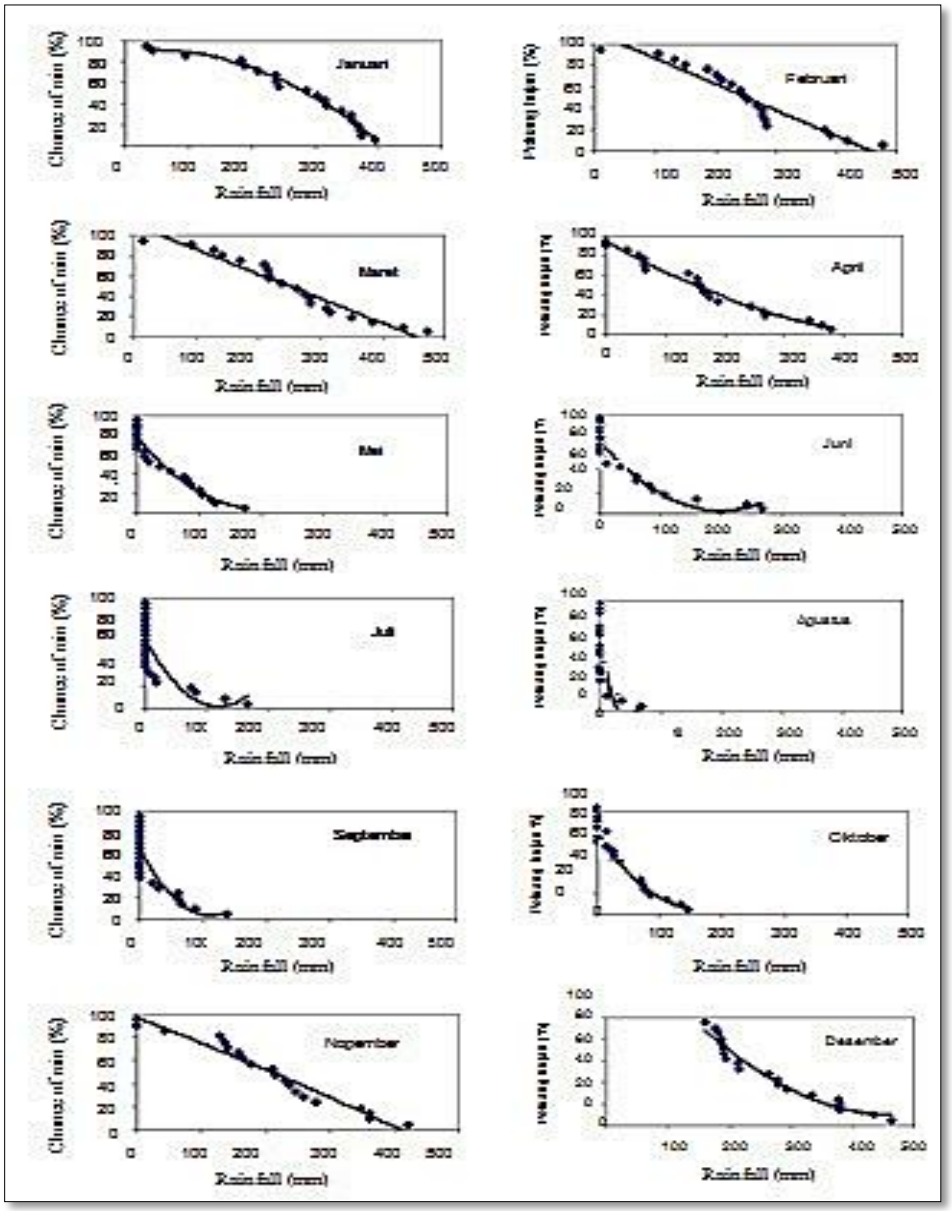

Figure 1. Distribution of rain from January to December in Kampar (Gunung Sahilan sub-district).
Source: Riajaya et al. [10]

Opportunities for 60% to get rain above 100 mm/month only occur during the November to April period, this indicates that during this period the rainy season occurred. At the beginning of the rainy season, which is November, 80% of the observation data shows rainfall between 100-300 mm/month, and in December the rain has a chance to fall between 200-300 mm/month and can even reach 450 mm/month. Even though during the rainy season rainfall can reach above 400 mm/month but the chance of occurrence is very small at 10%. To get rainfall >300 mm/month the chance is only 30-40%. Thus during the rainy season on average (50%), the rainfall per month is between 200-250 mm.

In the dry season, which is characterized by collecting observational data (60% chance) on rainfall, less than 100 mm/month occurs from May to October. Although rain can reach more than 100 mm/month at the beginning of the dry season (May) but the chance is less than 10%, as an indication of the transition into the dry season. During this period the average rainfall ranges from 0-50 mm/month. The practice of new farmers planting cotton in April or May or planting in the dry season is the availability of water has started to decrease. This fact causes a decrease in the availability of water in the soil because of the decreasing outpouring of rain. In May or June, rainfall reaches 250 mm but the frequency of occurrence is below 10%.

By considering the length of the rainy and dry season, the need for cotton water, and the rice-soybean+cotton cropping pattern, to avoid water shortages in the next crop after rice, at the beginning of the rainy season (November/December) farmers must have planted rice and at the latest a week after rice is harvested, soybeans and cotton must be planted. The presence of drought-resistant cotton varieties or early maturing varieties is expected to anticipate climate change or shift in planting time, which is currently still in the stage of adaptation testing in several development locations.

Setting the planting time is highly recommended for areas that are very dependent on rainfall as a success factor. Hearn and Fitt [1] also report that late cotton planting can reduce cotton production. Therefore planting time is determined so that the length of the planting season is in accordance with the needs of the plant. Furthermore, delaying planting time can increase pest populations.

Soybean and cotton planting immediately after the rice harvest is highly recommended so that cotton is still getting enough rain, especially in early March so that by the end of May soybeans can be harvested, while cotton at that time was still in the period of fruit formation and development. The dryness that occurs during this period can reduce fiber length so that it is easily broken during spinning. To stimulate cotton growth, additional water and nutrients need to be added because in April/May rainfall has begun to decrease. Additional water and nutrients are needed to perfect the formation of cotton in the middle and upper branches that are expected to be harvested. This has something to do with the effect of intercropping with soybean planting systems which can inhibit the formation of vegetative branches and lower generative branches.

Besides soil and plant factors, the availability of water for cotton plants after soybeans are harvested is needed so that nutrient uptake by plants can run well. Nutrient uptake of N, P and K by the most cotton plants in the flower bud formation phase until fertilization, i.e., 30-40% N, 31-35% P and 23-53% K [7]. Thus in these phases, the availability of water is absolutely necessary so that cotton productivity increases.

The opportunity for rain can also be seen in **Figure 2**, where the chance of rain >60% occurs from November to March. In April there is a transition from the rainy season to the dry season. The intended rain opportunity is to get rain >20 mm/week. In **Figure 2**, it can be seen that in the dry months the chance of rain ranges from 20%, and when compared with **Figure 1** it can be seen that rainfall accumulates in the range of 0-50 mm/month, this indicates that in May-October the dry season has entered.

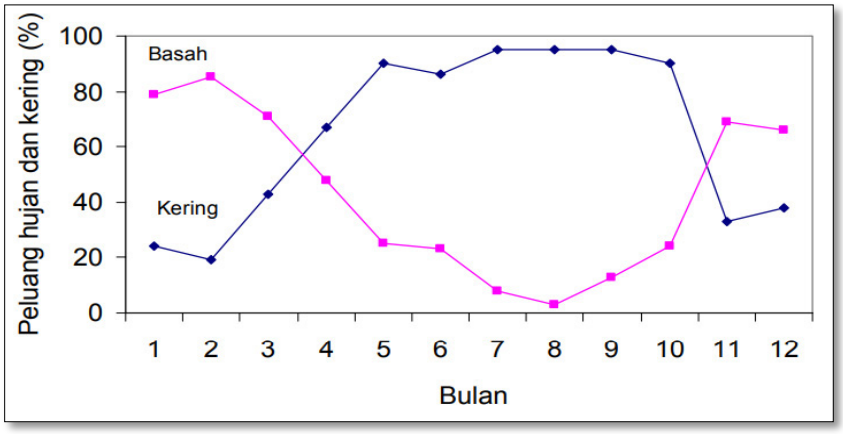

Figure 2. Opportunities for rain and dryness in the district Gunung Sahilan, Kab. Kampar.
Source: Riajaya et al. [10]

The cotton plant is the second plant after rice so that when rice planting retreats from December to January, cotton cultivation will retreat until May. At the beginning of the dry season the condition of the land is still relatively wet and generally on Vertisols (mostly Kampar) land has the ability to store water longer so that the first additional irrigation water needs to be done in late May or early June. The delay in planting time in secondary crops also results in a decrease in water availability for plants, efficient use of water and spurred biotic and abiotic stresses [11]. Thus the development of cotton in paddy fields after rice cannot be separated (interrelated) or must be integrated with the management of previous crops, namely rice in order to utilize the availability of rainwater.

IRRIGATION ADDITIONAL NEEDS

In cotton

The addition of irrigation water is intended to meet the water needs of cotton plants, because when soybeans are harvested cotton still needs a lot of water. Water requirements at various phases and the level of productivity to be achieved can be seen in **Table 2**. The higher the level of productivity to be achieved, the more water needs. To get a cotton productivity level of 500 kg/ha, a minimum of 500-790 mm of water is needed and to achieve a higher level of cotton productivity of 2,000-2,500 kg/ha, it takes 690-1,078 mm of water for 140 days from planting to completion.

Table 2. Daily water requirements at two levels of cotton productivity.

Stadia cotton growth (days)	Age (days)	Level of seed cotton yield (kg/ha)	
Budding flower	0-35	400-500	2000-2500
Flower buds first interest	35-60	1.5-2.0	1.5-2.0
First interest first fruit break up	60-105	2.5-3.0	3.0-3.5
First fruit break up	105-140	7.0-12.0	9.0-15.0
All fruits are broken		2.0-3.0	4.5-7.0

The highest water requirements occur when the first flower emerges until the first fruit bursts, ages 60-105 days after planting, reaching 7-15 mm/day **(Table 2)**. In this phase, the cotton plants need the highest nutrients so that the water needs also increase. If the water and nutrient factors can be fulfilled in the amount and the right time will increase production. Thus in this period, the water needs of plants must be fulfilled. The need for cotton in paddy fields is met by rainfall and irrigation water. Water requirements in intercropping plants continue to increase, especially in the period 8-13 weeks after planting [12], so that the condition of water in the soil during that period must be optimum.

Riajaya [13] calculated that the average evapotranspiration of cotton and soybean intercropping was 550 mm during its growth, assuming irrigation efficiency of 70% (average for furrow irrigation), the total water requirement needed to be 7.9 ml/ha which could be fulfilled from irrigation (50%), rainfall (30%) and water stored in the soil (20%).

Approximately 95% of fiber production comes from fruits formed in the 8th-12th week after planting [14]. During this period cotton is very vulnerable to water shortages. Actually, cotton still needs water before harvest but does not require rain, meaning that water must be sufficiently available in the soil. Therefore the choices of soil type and water conservation techniques need to be considered. Excessive irrigation water supply will cause [15]. Therefore delaying planting time does not only reduce the groundwater condition quickly but also increases the frequency and total irrigation needed and irrigation costs. The decrease in water availability will ultimately reduce the productivity and income of farmers.

Wet groundwater conditions at the beginning of the cotton and soybean growing season or in the second cropping period which is supported by adequate rainfall will greatly help meet the water needs of plants until approximately one month after planting, besides also depending on the distribution of rainfall and planting time. Therefore planting cotton intercropping with soybeans should be done as soon as possible after rice is harvested; especially to utilize the remaining groundwater and rainfall so that the first irrigation can be delayed until it reaches 50 mm cumulative evapotranspiration on clay and 40 mm on clay [16]. Some also get high cotton yield by accelerating planting in paddy fields after rice which is done without tillage needed depends on the availability of existing land, usually utilizing low basin or land areas which are not effective land for agriculture. In addition, crop management by regulating the density of plants to reduce evaporation, adjusting the planting season with rain patterns and using plant remnants as mulch to reduce evaporation is highly recommended [17,18]. These techniques are intended to improve the efficiency of water use by suppressing water loss through evaporation. In the intercropping system, it has actually implemented a method of planting closely, starting at the age of 30 days after planting the canopy, the two intercropped plants overlap so that the evaporation will decrease. In such conditions weed growth will decrease.

In principle, rainwater conservation techniques consist of in-situ conservation, namely maximizing the use of rainwater

on land and harvesting run-offs so that plants can be reused [19]. To be able to apply the water conservation techniques appropriately, the available climate factors, soil and water resources need to be considered [20,21].

CONCLUSION

Rainfall in the rainy season is distributed from November to April and has a chance of falling (60%) by 200-250 mm/month. From May to October (dry season) the average amount of rain is less than 50 mm/month with a 60% chance of rain. With limited distribution and amount of rain, planting cotton and soybeans is done simultaneously as soon as possible at the latest one week after rice is harvested or early March, especially to utilize the remaining groundwater and rainfall at the beginning of the season. Rice planting should be done at the beginning of the rainy season in November or December [22-24].

In addition, to meet the needs of cotton water in the dry season the making of shallow wells on adjacent land or embung is highly recommended, and the application of crop management includes regulating plant density, adjusting the planting season with rain patterns, and using plant remnants as mulch.

CONFLICT OF INTEREST

There is no internal conflict with any party and any institution.

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