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Determination Of Effective Planting Season Based On Optimum Soil Water Content In Lolong Guba Area, Buru Island

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Abstract - One agro-climatic aspect that needs to be considered in plant cultivation is the planting season. The study aimed to describe the land's water balance and determine a productive planting season in the Lolong Guba area. This research uses data from the Lolong Guba region, consisting of data: climate for the 1994-2023 period, soil texture, and support. Data analysis was carried out in stages: calculating 75% probability rainfall using the ranking order method; calculation of land water balance using the modified Thorthwaite-Mather bookkeeping system; and determining the effective planting season based on soil water content conditions from the results of land water balance calculations. The research results show that the soil water deficit in the Lolong Guba area is very small during the period May to July, namely less than 5 mm/month and in December there is no water deficit. The optimal soil water content period lasts for 7 months, namely January to July. Thus, the Lolong Guba area has a planting season of 8 months starting in December and ending in July.

Keywords - Planting season, soil water content, Lolong Guba

INTRODUCTION

Determining the appropriate planting season is a key factor in agriculture to increase productivity sustainably. Soil water content is a major factor affecting plant growth. Optimal soil water content not only supports plant physiological processes but also plays a role in efficient water resource management. In many areas, planting seasons are often determined based on rainfall patterns, but increasingly uncertain climate change makes these patterns difficult to predict.

The only water supply for dryland agriculture is rainfall. Therefore, when using rainfall information/data for different agroclimate studies in a region, it is necessary to consider rainfall characteristics. In reality, only certain climate patterns are usually provided by agroclimate studies that apply monthly average rainfall estimates. Although this data cannot reveal rainfall diversity, it can help in identifying homogeneous agroclimate zones. Rainfall is not only highly variable but also often unpredictable and irregular. Predicting the timing and zone of rainfall is difficult because of the very high monthly rainfall variation from year to year. In this regard, Bey & Las (1991) stated that to prevent the risk of drought due to overestimation or wasting time and water resources due to underestimation, it is very important to use the probability value when estimating rainfall.

In relation to the availability of soil water available to plants, there is variation in different types of soil and plants, which makes the general approach less effective. Therefore, a more focused approach, such as determining the planting season based on the ideal soil moisture level, can be a more accurate and efficient solution. One approach to determine the soil water content at optimum conditions is through the calculation of the land water balance.

Various research results in the Maluku region to determine the planting season based on the optimum soil water content

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include those conducted on Ambon Island by Laimeheriwa et al. (2019), in the Saumlaki Area of Yamdena Island by Uspessy et al. (2020), and Laimeheriwa et al. (2022) in the Aru Islands.

Observing the research background that has been mentioned, the study conducted aims to describe the land water balance, as well as determine the productive planting season in the Lolong Guba area. The results of the study are expected to provide a better understanding of the correlation between plant growth time and soil water content. Determining the planting season based on soil water content can help farmers plan their agricultural activities, reduce the risk of crop failure, and improve food security.

MATERIALS AND METHODS

This study uses data from the Lolong Guba Area of Buru Island, in the form of: (1) climate data, (2) soil data, and (3) regional position data, as well as other supporting data. Lolong Guba is a sub-district in Buru Regency, Maluku Province. The astronomical position of this area, which covers an area of 457.02 km^2, is around 03º21'56" South Latitude and 126º56'14" East Longitude (Figure 1).

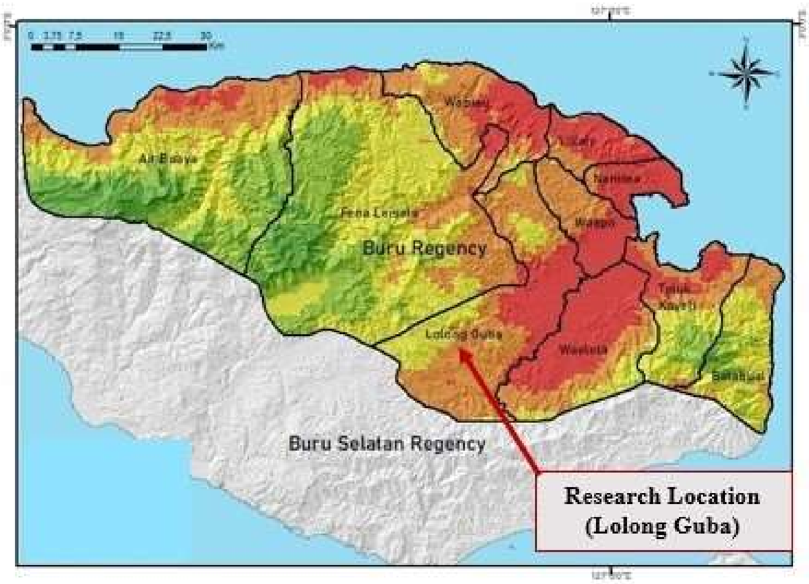

Figure 1. Research location

Data Collection

(1) The climate data sources are the results of observations from the Namlea Meteorological Station and generation data from the Climate Data and Information Laboratory of the Faculty of Agriculture, Pattimura University. The data include: (i) monthly rainfall for the period 1994-2023, and (ii) air temperature, relative humidity, duration of sunshine, and wind speed for the period 2009-2023.

(2) Data on dominant soil types in the Lolong Guba area based on field survey results.

(3) Elevation, latitude and longitude data and other supporting data were obtained from field survey results and various relevant references.

Data Analysis

Data analysis in this study includes: (1) determining rainfall with a 75 percent chance of being exceeded, (2) calculating land water balance, and (3) determining planting seasons.

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Determination of rainfall with a 75% chance of being exceeded (R75)

Based on the idea that when rainfall in the Lolong Guba area is distributed normally, the hierarchical sequence method is used to calculate the rainfall value with a 75% chance (ranking order method; Biloro et al., 2021; Sitorus et al., 2023), the equation is:

$$Fa = 100m / (N + 1)$$

Explanation:

Fa = probability level (%)

m = serial number (rank) from the highest to the lowest rainfall in the rainfall time series data period

N = Number of data (years)

Land water balance calculation

With some adjustments, the Thornthwaite & Mather (1957) bookkeeping system is used to calculate the monthly land water balance in the Lolong Guba area. Specifically, the Penman-Monteith Method packaged in the Cropwat 8.0 Program is used to determine the amount of potential evapotranspiration. In the calculation, review depth: 1 m; soil texture: loam; field capacity: 335 mm; permanent wilting point: 155 mm; and water holding capacity: 180 mm; optimum soil water content: 245 mm

Determination of planting season

Planting season in Lolong Guba area is determined from the calculation of land water balance in conditions of 75% chance rainfall (R75) using categories, namely: the time period where the soil moisture level is ideal or at optimum condition for growth; where SWCopt = SWC > PWP + 0.5 x WHC (Las, 1992; Nangimah et al., 2018). SWCopt is optimum soil water content; PWP is permanent wilting point, and WHC is water holding capacity.

RESULTS AND DISCUSSION

Land water balance

In tropical areas such as Indonesia, the potential for water availability is strongly characterized by rainfall. The potential for plant water needs can be determined by potential evapotranspiration, while the ability of the soil to store water is mainly influenced by the physical properties of the soil. Sometimes due to the distribution according to time that is difficult to monitor, the problem of water availability and needs can be a limiting factor for agricultural activities, both in dry and wet areas. Therefore, agricultural activities in the region must always pay attention to and adjust to the distribution pattern of rainfall and potential evapotranspiration, including the dynamics/fluctuations in soil water content (Pramudia & Santosa, 1992).

One way or approach that connects rainfall, potential evapotranspiration and fluctuations in soil water content is through the calculation of the land water balance. From the results of the water balance calculation, it can be seen when there is a deficit (lack) of water and when there is a surplus (excess) of water in the soil. In addition, the water balance also provides information on how the soil water content fluctuates periodically, so that better crop management actions can be taken such as determining the right planting time and pattern, and when to provide water if there is a shortage, and other actions.

The water balance in each region will be affected differently by various location-specific climate variables. Because of the different climates, it is important to calculate the soil water balance in each region or location to determine the soil water conditions periodically (at least monthly). One of the advantages is that it helps planners to consider the local climate when developing the best agricultural management plan. On the other hand, by taking into account the optimal soil moisture level, dry period, and crop water needs at various growth stages, the findings from the water balance assessment can provide a general picture of the growing season of an area.

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Rainfall is the only water supply for agricultural land in dryland agriculture. Therefore, when using rainfall information/data for different agroclimate studies in a region, it is necessary to consider the characteristics of rainfall. The fact shows that only certain climate patterns can be described by agroclimate studies that apply monthly average rainfall estimates. Although these data cannot reveal the variability of rainfall, they can help in identifying homogeneous agroclimatic zones. The nature of rainfall is not only highly variable but also often unpredictable and irregular. Predicting the time and zone of rainfall is difficult because of the high variation in monthly rainfall from year to year. In this regard, Bey & Las (1991) stated that to prevent the risk of drought due to overestimation or wasting time and water resources due to underestimation, it is very important to use probability values when estimating rainfall.

Rainfall values that have a 75% probability of being exceeded are usually used in agriculture. A 75% probability indicates that there will be at least three years with a certain amount of rainfall in four years. The probability of occurrence is often less than 50% if we use the average rainfall value; this means that there is a higher probability of not having a certain amount of rainfall. Therefore, the rainfall value with a probability of 75% calculated using the Wilbull Formula (ranking order method) is used in calculating the land water balance of the study location with the Thornthwaite & Mather (1957) bookkeeping system. Meanwhile, the Penman-Monteith equation from the CROPWAT 8.0 software package is used to determine the potential evapotranspiration value. The results of the land water balance calculation at the study location are as shown in Table 1.

Table 1. Calculation of land water balance in the Lolong Guba area

Month	R75	PE	R75-PE	APWL	SWC	dSWC	EA	D	S
January	235	144	91		309	91	144	0	0
February	233	137	96		335	26	137	0	70
March	168	140	28		335	0	140	0	28
April	144	143	1		335	0	143	0	1
May	118	142	-24	-24	312	-23	141	1	0
June	116	137	-21	-45	295	-17	133	4	0
July	115	129	-14	-59	284	-11	126	3	0
August	37	130	-93	-152	232	-52	89	41	0
September	10	139	-129	-281	192	-40	50	89	0
October	18	143	-125	-406	173	-19	37	106	0
November	44	149	-105	-511	165	-8	52	97	0
December	199	146	53		218	53	146	0	0
Annual	1437	1679				0	1338	341	99

Description: R75=75% chance rainfall (mm); PE=potential evapotranspiration (mm); APWL=potential accumulation of water loss (mm); SWC=soil water content (mm); dSWC=change in soil water content (mm); EA=actual evapotranspiration (mm); D=water deficit (mm); S=water surplus (mm).

Due to low rainfall, the potential evapotranspiration score exceeded the actual value, resulting in a water deficit at the study site. On the other hand, the difference between rainfall and potential evapotranspiration, as well as monthly variations in soil water content, greatly affect the excess water that occurs throughout the rainy season (Madubun et al., 2024; Lesilolo et al., 2024). The water deficit at the study site continued for 7 months (May to November), in the range of 1-106 mm/month; a total of 341 mm/year (Table 1). In May, June, and July, the amount of water deficit was very small, which was only in the range of 1 to 4 mm/month. This indicates that in these months it is still possible for plants to grow and develop with a low risk of water shortage. There was an annual water surplus of 99 mm for 3 months, namely in February, March, and April, with monthly surpluses of 70 mm, 28 mm, and 1 mm, respectively. Figure 2 shows the soil water shortage and excess in the study area.

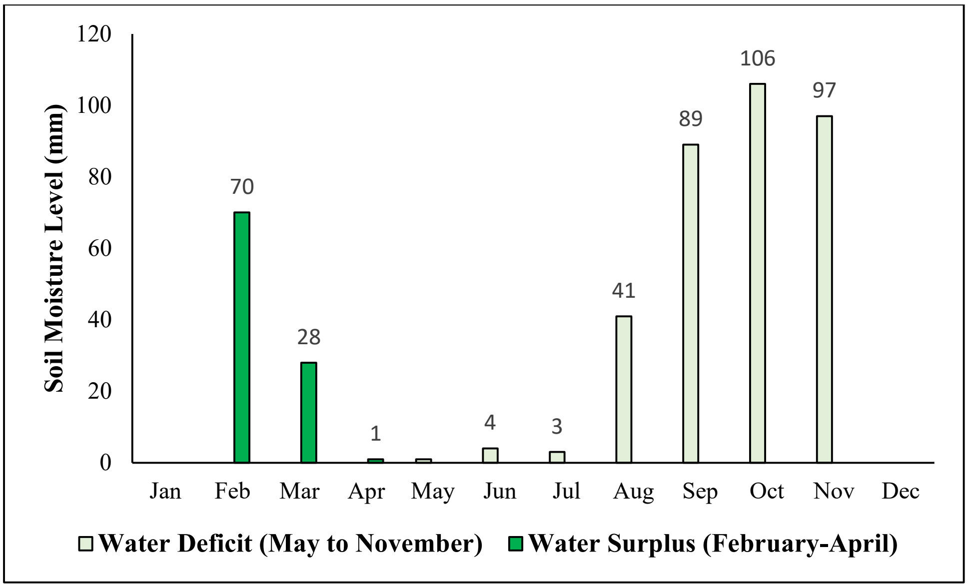

Figure 2. Water deficit and surplus periods in the Lolong Guba area

Planting Season

The purpose of determining the planting season in a place is to be able to choose the ideal time for planting, when soil and climate conditions are not inhibiting factors. Short-lived plants and long-lived plant seedlings are the main emphasis in this planting season. Short-lived plants are more sensitive to water shortages compared to plants that are more than 1 year old. Long-lived plants are more resistant to drought stress and are able to survive if drought occurs, among other things because their root system is deeper so that they can absorb water better (Laimeheriwa, 2015).

One of the components considered in determining the planting season for a particular area is the optimal soil water content (SWCopt), where for the Lolong Guba area the SWCopt value is determined at 245 mm. Referring to the calculation of the water balance in Table 1 previously, the monthly SWC in the Lolong Guba area is as presented in Figure 3.

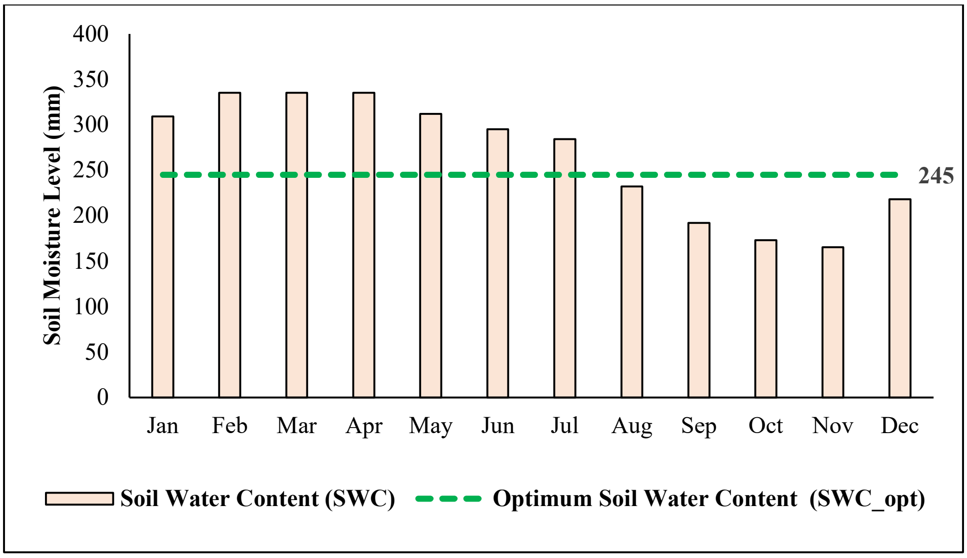

Figure 3. Soil water content in the Lolong Guba area

Other factors that are also considered are the month/period as there is no water deficit, and the stage of plant development. In Figure 2 above, it can be seen that in the period from May to July there is a relatively small water deficit, which is ≤ 4 mm/month; while in that period the soil water content is at its optimal state. Furthermore, although in December the soil water content is below its optimal state, there is no water deficit in that month. Thus, the months of December, May, June, and July can be considered to be included in the planting season period in the Lolong Guba area. The beginning of the planting season begins in December, where at the beginning of growth, the plant's need for water is relatively small. July is considered the end of the planting season period; thus the effective planting season in the Lolong Guba area occurs for 8 months (December to July). In the period from August to November, it is not recommended to carry out planting activities due to the fairly high water deficit (41 mm - 106 mm/month); unless there is another water source besides rain. The following is stated about the time of plant cultivation activities in the Lolong Guba Area.

Figure 4. Time of plant cultivation activities in the Lolong Guba area

<table>
<tr><th>Oct</th><th>Nov</th><th>Dec</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th></tr>
<tr><td colspan="2">Land Preparation</td><td colspan="8">Planting Season Period</td><td colspan="2">Fallow Period</td></tr>
</table>

Based on the results of determining the planting season, the cultivation intensity of several important vegetable and food crop commodities in the Lolong Guba area is shown in Table 2; planting intensity does not only depend on the length of the planting season but also on the harvest age of each plant. The types of vegetable and food crops that are usually cultivated by farmers in the Lolong Guba area whose water needs only depend on rainfall, namely food crops: "dryland rice, corn, cassava, sweet potatoes, peanuts, and vegetable crops: chili, tomato, eggplant, and long beans".

Table 2. Intensity of planting vegetables and food crops in the Lolong Guba area

Harvest Age (month)	Commodity	Planting Intensity (times)
2	corn, long beans	3-4
3-4	dryland rice, corn, peanuts, chili, tomatoes, eggplant	2
4-5	sweet potatoes	1-2
≥ 6	cassava, other tubers	1

CONCLUSION

Soil water deficit in Lolong Guba area is very small during the period of May to July, which is less than 5 mm/month and in December there is no water deficit. The optimal soil water content period lasts for 7 months, namely January to July. Thus, Lolong Guba area has an effective planting season of 8 months starting in December and ending in July. The preparation period can be done in October-November, and planting can begin in December. Between August and November, planting is not recommended due to the high water deficit; unless there is a water supply from sources other than rain.

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