Identification of potential groundwater and determination of sugarcane planting period in Pantura of West Java

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Abstract. The sugar industry faces several serious problems, including global climate change, which may cause drought. For this reason, research has been carried out in dryland sugarcane plantations to organize the potential planting period in several Sugar Factories (SF) in Tersana Baru, Karangsuwung, Sindang Laut, Jati Tujuh, and Subang. This research aims to (1) identify groundwater potential to determine the depth, distribution, and discharge of groundwater resources and (2) determine the best sugarcane planting period. Identification of groundwater potential is carried out through a geoelectric survey using Terrameter. To calculate the potential of water resources and the amount of water deficit in each phase of sugarcane growth, an analysis of the potential for the planting period was carried out using a crop simulation model by calculating the ETa/ETc ratio. Identifying groundwater potential base on aquifer conditions indicates that shallow aquifer dominates Karang Suwung SF, whereas deep aquifer dominates Tersana Baru SF and Sindang Laut SF. Non-aquifer dominates Jati Tujuh SF and Subang SF. The best planting period for Tersana Baru SF and Karang Suwung SF in November II, for Sindang Laut SF in January I-II, for Jati Tujuh SF in November I-II and for Subang SF on December III.

1. Introduction
The need for sugar increases once a year along with the increasing population and consumption in the manufacture of food and beverages. Therefore, the national sugar industry is required to improve its efficiency to meet the national sugar needs and compete in the global market. In fact, the sugar industry is currently unable to fulfill the requirements of domestic sugar consumption because production continues to decline [1]. The sugar industry on a micro-scale faces several potential problems that require serious attention including, the difficulty of world global climate change, which ends up in long droughts so that the provision of water for sugarcane cultivation is very limited, and also the problem of land resources in certain locations.

The rise in sugar production and sugarcane yield through cultivation systems (soil tillage, fertilization, and the use of recent varieties) has reached its maximum, marked by the stagnation of sugarcane production and sugarcane yield since 1994 [2]. The decline of production and yield has to be anticipated due to the relatively large gap between sugarcane production and actual and potential sugar yields [3]. To enhance the quality of sugarcane production (yield/tons of sugar and production/tons of cane), three things are needed: (1) determining the potential planting period supported by climatic and soil conditions, (2) providing supplementary irrigation through water supply according to space and time, and (3) improving soil quality by applying organic matter [4].
The potential planting time is closely associated with the availability of water needs for the growth and production of a plant. The fulfillment of water requirements for plants is going to be directly proportional to the rise in plant growth to maximum vegetative growth and will decrease during the harvest phase [5]. Determining the potential planting time is closely related to the potential of available water resources, so identifying potential water resources is very important to understand the distribution, volume, and depth so that water management scenarios will be dole out within the area [6]. The water resource identified during this study is groundwater. Groundwater is a crucial component in meeting plant water requirements. Groundwater is created from hydrological processes, stored, and moves within the soil called aquifers. The existence of groundwater is very dependent on geological conditions, climate, and soil permeability [7, 8, 9]. The number of groundwater resources are limited, and its damage may result in wide-ranging impacts, and recovery is difficult. In Indonesia, groundwater use is increasingly important and widespread to fulfill the requirements of households (domestic), industry, mining irrigation and has become an economic commodity; even in some places, it’s become a strategic need. Groundwater is the main water source because of its good quality and comparatively low investment costs, and its utilization can be done where needed (in situ) [10].

Identification of groundwater potential in sugarcane fields is important since its presence indicates the potential for water availability. Information on water availability is required to determine the potential planting period to reduce the risk of drought, especially during critical crop periods, so sugarcane production and yields increase. The identification of groundwater potential with the geoelectric method has been widely applied both by sounding and mapping because it’s relatively simple, economical, and has various alternative imaging techniques associated with the presence of groundwater [11, 12, 13]. This study aims to identify the potential for groundwater to determine its distribution, volume, and depth and to determine the sugarcane planting period.

2. Materials and Methods
2.1. Research Sites
The research was carried out in a sugar factory within the scope of RNI I West Java Company (Tersana Baru, Sindang Laut, Karang Suwung, Jati Tujuh, and Subang Sugar Factory) covers 4 regencies in West Java (Cirebon, Kuningan, Majalengka, and Subang Regency).

2.2. Materials and Tools
Materials and tools needed are topographic maps, soil maps, hydrogeological maps, Global Positioning System (GPS), ABEM-1000 Terrameter, and its equipment. Meanwhile, for data analysis, a set of computers, plotters, and digitizers is required, ArcToolbox ver software. 8.2, ArcMap software ver. 8.2, ER Mapper software ver. 6.3, IPI2WIN software, and Global Mapper software ver. 5.0.

2.3. Methodology
Measurement of groundwater characteristics in sugarcane areas was carried out by detecting the apparent resistance of species and the depth of overburden and aquifers in the field using a resistivity meter/terrameter known as a geoelectric survey (Figure 1). The geoelectric method was carried out by injecting currents into the soil with varying resistivity to obtain information about the subsurface soil layer and the possibility of groundwater and minerals at a certain depth [14].

Measurement of groundwater characteristics was carried out in the field by determining the meter detection point based on the type of soil, geological and hydrogeological conditions. For the accuracy of point determination and to facilitate detection, first, the point positioning using GPS (Global Positioning System) was carried out. Detection is carried out to determine the apparent resistance of the species and the depth of overburden and aquifers in the field. The detected points are those that meet the following criteria: (a) located on a 600 m stretch with flat topography, (b) far from barbed wire and iron in the ground, and (c) far from high voltages. The terrameter operates using a power battery and shoots an electric current into the ground through the electrodes (with an output display
sufficient for current electrode separation of 1000 m), and takes the resistance value in the response time dimension, depth of more than 200 meters without going through drilling [15].

From the data on the electrical properties of underground materials, especially rocks in the form of obstacles, each part must consider it by considering the existing geological condition data. The size of the subsurface boundary using the Vertical Electrical Sounding (VES) method is carried out to determine the vertical arrangement of underground rocks by providing an electric current into the soil and recording the potential difference. The resistance value that is measured directly in the field is the apparent resistance value (visible resistivity), so the resistance in the field must be calculated and analyzed to get the real resistance (true resistivity). Furthermore, computer software is used to process and calculate the data to get the actual resistance value and interpretation of depth and thickness. Based on the actual strength, it is possible to interpret various types of rock, depth, thickness, and possible soil air content, so that it can be found an overview of areas that may contain water, groundwater drilling point plans [6].

![Figure 1. Prototype of ABEM 1000 Terrameter](image)

The sugarcane planting period was mapped by calculating the crop water requirements during the deficit period, which is indicated by an ETa/ETc ratio of less than 0.65 [16]. If the ETa/ETc is close to one, it means that the plant is using water effectively so that its production is high, but if the ETa/ETc is less than 0.65, it means that the plant lacks water results in low production [17].

Maximum crop water requirements can be calculated using potential evapotranspiration (ETP) data and crop coefficient (Kc). ETP is calculated using the Penman-Monteith method.

\[
ETc = Kc \times ETP
\]

Meanwhile, the actual plant water requirement (ETa) can be calculated using the Eagelman equation which has been modified by Forest and Reyniers in CIRAD [17].

\[
ETa/ETc = A + B (HR)^1 + C (HR)^2 + D (HR)^3
\]

Where :

\[
A = \frac{-0.050 + 0.732}{ETP}
\]

\[
B = 4.97 - 0.661 ETP
\]

\[
C = -8.57 + 1.56 ETP
\]
D = 4.35 – 0.880. ETP

HR i.e. the relative humidity of the soil is calculated using the equation:

\[ HR = \frac{HM - HPF}{HCC - HPF} \]

with HM soil moisture content measured in the field, HCC soil moisture at field capacity (pF 2.54), and HPF soil moisture content at permanent wilting point (pF 4.2). Furthermore, by inputting the planting date data, the ETa/ETc ratio and the duration of the deficit period can be calculated. So the total water volume deficit is calculated by equation 4:

\[ De = P - ETP \times A \times T \]

Where De is the water volume deficit, P is precipitation, ETP is potential evapotranspiration, A is the area, and T is the length of the deficit period.

Based on the results of the analysis of the water adequacy index (ETa/ETc close to one (> 0.65) and the potential yield loss of less than 20% on sugarcane land, the potential for sugarcane planting period was arranged. Flowchart of analysis for determining the potential of water resources and the potential for sugarcane planting time presented in Figure 2. To determine the soil moisture content at pF 2.54 and soil moisture content at pF 4.2 a ring sample was taken. The determination of the sampling point was based on different soil types at two depths (0-20 cm and 20-40 cm) each with 3 replicates at priority sites.

**Figure 2.** Flowchart of potential water resource analysis for determining sugarcane planting period

### 3. Results and Discussion

#### 3.1. Potential Groundwater Resources

The results of the identification of groundwater resources characteristic at each observation point in Tersana Baru, Sindang Laut, Karang Suwung, Jati Tujuh, and Subang Sugar Factory (SF) is presented in Table 1-5. The results of soil geoelectrical interpretation containing aquifers and suggested drilling locations are presented in Table 6.
Table 1. Groundwater characteristics (rock type, aquifer) in Tersana Baru SF.

| No | Point Code | Village | Sub-district | Regency | Depth (m) | Rock Type                  | Groundwater Conditions |
|----|------------|---------|--------------|---------|-----------|---------------------------|------------------------|
| 1  | TB01       | Tonjong | Waled        | Cirebon | 20-45     | Gravel, sand               | Aquifer                |
| 2  | TB02       | Tonjong | Waled        | Cirebon | 105-125   | Conglomerate, breccia      | Aquifer                |
| 3  | TB03       | Tonjong | Waled        | Cirebon | > 5       | Rock, tuffaceous sand      | Non-aquifer            |
| 4  | TB04       | Cilemkrang | Waled     | Cirebon | > 5       | Rock, tuffaceous sand      | Non-aquifer            |
| 5  | TB05       | Cilemkrang | Waled      | Cirebon | > 5       | Rock, tuffaceous sand      | Non-aquifer            |
| 6  | TB06       | Cilemkrang | Waled      | Cirebon | > 90      | Conglomerate               | Aquifer                |
| 7  | TB07       | Cigobang | Waled        | Cirebon | > 15      | Tuffaceous clay            | Non-aquifer            |
| 8  | TB08       | Cigobang | Waled        | Cirebon | > 5       | Tuffaceous clay            | Non-aquifer            |
| 9  | TB09       | Cigobang | Waled        | Cirebon | > 15      | Tuffaceous clay            | Non-aquifer            |
| 10 | TB10       | Cigobang | Waled        | Cirebon | > 5       | Tuffaceous clay, tuffaceous sand | Non-aquifer          |
| 11 | TB11       | Cigobang Plasa | Waled | Cirebon | > 5       | Tuffaceous clay, tuffaceous sand | Non-aquifer          |
| 12 | TB12       | Pasaleman | Waled      | Cirebon | > 15      | Tuffaceous sand, clay      | Non-aquifer            |

Based on the lithological profile resulting from the geoelectrical interpretation of the Tersana Baru SF, there are 3 observation points containing aquifers that have the potential to contain groundwater, namely TB01 (20-45 m), TB02 (105-125 m), and TB06 (> 90 m). In general, this area is dominated by non-aquifers, with a various depth from 5 - 125 meters, and the rock type is dominated by tuffaceous clay.

Table 2. Groundwater characteristics (rock type, aquifer) in Karang Suwung SF.

| No | Point Code | Village | Sub-district | Regency | Depth (m) | Rock Type                  | Groundwater Conditions |
|----|------------|---------|--------------|---------|-----------|---------------------------|------------------------|
| 1  | KS01       | Curug   | Susukan Lebak | Cirebon | 10-22     | Sandy clay                | Shallow aquifer        |
| 2  | KS02       | Tambolang | Karangsebang | Cirebon | 20-40     | Sandy clay                | Shallow aquifer        |
| 3  | KS03       | Kalimeang | Karangsebang | Cirebon | > 15      | Clay, Sandy clay          | Non-aquifer            |
| 4  | KS04       | Blender  | Karangsebang | Cirebon | 100-120   | Conglomerate              | Aquifer                |
| 5  | KS05       | Seusepan | Karangwareng | Cirebon | > 5       | Tuffaceous sand, clay     | Non-aquifer            |
| 6  | KS06       | Karangwangi | Karangwareng | Cirebon | > 15      | Clay, Tuffaceous sand     | Non-aquifer            |
| 7  | KS07       | Gubangdhelek | Karangwareng | Cirebon | > 5       | Clay, Sandy clay          | Non-aquifer            |
| 8  | KS08       | Cisat   | Waled        | Cirebon | > 20      | Tuffaceous clay, clay     | Non-aquifer            |
| 9  | KS09       | Karangsari | Waled       | Cirebon | > 10      | Tuffaceous sand, conglomerate | Non-aquifer          |
| 10 | KS10       | Ciyah   | Waled        | Cirebon | 13-30     | Tuffaceous sand           | Shallow aquifer        |
| 11 | KS11       | Karangsari | Waled       | Cirebon | > 15      | Tuffaceous clay, clay     | Non-aquifer            |
| 12 | KS12       | Cisat   | Waled        | Cirebon | 16-34     | Tuffaceous sand           | Shallow aquifer        |
| 13 | KS13       | Ciyah   | Waled        | Cirebon | 10-18     | Tuffaceous sand           | Shallow aquifer        |
| 14 | KS14       | Tugu    | Waled        | Cirebon | > 10      | Tuffaceous sand, clay     | Non-aquifer            |
| 15 | KS15       | Kadurama | Ciawi Gebang | Kuningan | 10-30     | Sand                      | Shallow aquifer        |
| 16 | KS16       | Geresik | Ciawi Gebang | Kuningan | 10-25     | Tuffa, sandy tufa         | Shallow aquifer        |
At Karang Suwung SF, there are 14 observation points containing aquifers that have the potential to contain groundwater, namely KS01 (10-22 m), KS02 (20-40 m), KS04 (100-120 m), KS10 (13-30 m), KS12 (16-34 m), KS13 (10-18 m), KS15 (10-30 m), KS16 (10-25 m), KS17 (6-24 m), KS18 (5-34 m), KS19 (10-30), KS20 (10-20 m), KS21 (7-30), and KS22 (6-22 m). In general, this area is dominated by shallow aquifers, the soil containing aquifer depth from 5 – 120 meters, and the rock type is dominated by tuffaceous sand.

Table 3. Groundwater characteristics (rock type, aquifer) in Sindang Laut SF.

| No | Point Code | Village | Sub-district | Regency | Depth (m) | Rock Type | Groundwater Conditions |
|----|------------|---------|--------------|---------|-----------|-----------|-----------------------|
| 1  | SL01       | Kodasari| Beber        | Cirebon | > 12      | Clay and sand | Non-aquifer           |
| 2  | SL02       | Kodasari| Beber        | Cirebon | 12-25     | Sandy clay  | Shallow aquifer        |
| 3  | SL03       | Tangkil | Susukan      | Cirebon | > 160     | Rock, Tuffaceous sand | Aquifer              |
| 4  | SL04       | Wiyong  | Susukan      | Cirebon | > 25      | Clay and sand | Non-aquifer           |
| 5  | SL05       | Wiyong  | Susukan      | Cirebon | > 85      | Tuffaceous sand | Aquifer               |
| 6  | SL06       | Kedondong| Susukan     | Cirebon | > 5       | Clay and sand | Non-aquifer           |
| 7  | SL07       | Sindanglaut| Lemahabang | Cirebon | > 10      | Sandy clay  | Non-aquifer           |
| 8  | SL08       | Sindanglaut| Lemahabang | Cirebon | > 10      | Tuffaceous clay | Non-aquifer         |
| 9  | SL09       | Sindanglaut| Lemahabang | Cirebon | 12-70     | Sand        | Aquifer               |
| 10 | SL010      | Asem    | Lemahabang   | Cirebon | 7-45      | Sand        | Aquifer               |
| 11 | SL011      | Mertapada| Astanajapura| Cirebon | > 10      | Sandy tuffa | Non-aquifer           |
| 12 | SL012      | Lemahabang| Leuwetan    | Cirebon | > 5       | Clay        | Non-aquifer           |
| 13 | SL013      | Karang Mekar| Karangsemubng| Cirebon | > 5       | Sandy clay, clay | Non-aquifer |
| 14 | SL014      | Kubang | Karangsemubng| Cirebon | > 20      | Sandy clay, clay | Non-aquifer        |
| 15 | SL015      | Sara Jaya| Lemahabang  | Cirebon | > 20      | Clay        | Non-aquifer           |
| 16 | SL016      | Beringin| Pangunan     | Cirebon | > 10      | Tuffaceous clay, clay | Non-aquifer |
| 17 | SL017      | Sigong  | Lemahabang   | Cirebon | > 13      | Clay        | Non-aquifer           |
| 18 | SL018      | Japura Kidul| Astanajapura| Cirebon | > 5       | Clay        | Non-aquifer           |
| 19 | SL019      | Japura Bakti| Astanajapura| Cirebon | > 10      | Clay, tufa clay | Non-aquifer        |
| 20 | SL020      | Curug   | Karangsemubng| Cirebon | 13-50     | Tuffaceous sand | Shallow aquifer      |
| 21 | SL021      | Mertapada| Astanajapura| Cirebon | > 15      | Tuffaceous clay, clay | Non-aquifer |
| 22 | SL022      | Sindang Laut| Lemahabang | Cirebon | 27-78     | Compact sand, Tuffaceous sand | Aquifer    |
Table 4. Groundwater characteristics (rock type, aquifer) in Jatitujuh SF.

| No | Point Code | Village       | Sub-district | Regency   | Depth (m) | Rock Type         | Groundwater Conditions |
|----|------------|---------------|--------------|-----------|-----------|--------------------|------------------------|
| 1  | JT01       | Palasah       | Kertajati    | Majalengka| > 5       | Sandy clay, clay  | Non-aquifer             |
| 2  | JT02       | Palasah       | Kertajati    | Majalengka| 98-120    | Sand               | Aquifer                |
| 3  | JT03       | Palasah       | Kertajati    | Majalengka| > 35      | Sandy clay, clay  | Non-aquifer             |
| 4  | JT04       | Palasah       | Kertajati    | Majalengka| > 7       | Clay               | Non-aquifer             |
| 5  | JT05       | Kertawinangun | Kertajati    | Majalengka| > 8       | Sandy clay, clay  | Non-aquifer             |
| 6  | JT06       | Kertawinangun | Kertajati    | Majalengka| > 10      | Clay               | Non-aquifer             |
| 7  | JT07       | Kertawinangun | Kertajati    | Majalengka| > 12      | Sandy clay, clay  | Non-aquifer             |
| 8  | JT08       | Babakan       | Kertajati    | Majalengka| > 12      | Sandy clay, clay  | Non-aquifer             |
| 9  | JT09       | Kertawinangun | Kertajati    | Majalengka| > 8       | Sandy clay, clay  | Non-aquifer             |

Based on the lithological profile resulting from the geoelectrical interpretation of Sindang Laut SF, there are 8 observation points containing aquifers that have the potential to contain groundwater, namely SL02 (12-25 m), SL03 (> 160 m), SL05 (> 85 m), SL09 (12-70 m), SL10 (7-45 m), SL20 (13-50 m), and SL22 (27-78 m). In general, the depth from 5 – 160 meters, it has various rock type, and this area is dominated by non-aquifers.

Jatitujuh SF, there is only 1 observation point that contains an aquifer so that it has the potential to contain groundwater, namely JT02 (98-120 m). In general, this area is dominated by non-aquifers, with various depth from 5-120 meters and the rock type is dominated by sandy clay and clay.

The construction of deep groundwater wells at Tersana Baru SF should be prioritized in TB 02, namely in Tonjong Village, Waled Sub-district, Cirebon Regency, and TB06 (Cilengkrang Village, Waled Sub-district Cirebon Regency). Meanwhile at Karang Suwung SF the construction of deep groundwater wells should be prioritized in KS04, namely Blender Village, Karangsembung Sub-district, Cirebon Regency.

At Sindang Laut SF, the construction of deep groundwater wells should be prioritized in SL03 (Tangkil Village, Susukan Sub-district), SL05 (Wiyong Village, Susukan Sub-district), SL09 and SL22 (Sindanglaut Village, Lemahabang Sub-district) Cirebon Regency. Whereas at Jatitujuh SF, it is better to prioritize in JT02, namely Palasah Village, Kertajati Sub-district, Majalengka Regency. Meanwhile, at five points detected in the Subang SF area is entirely a non-aquifer area so it is not suitable for deep wells.

Table 5. Groundwater characteristics (rock type, aquifer) in Subang SF.

| No | Point Code | Village      | Sub-district | Regency | Depth (m) | Rock Type         | Groundwater Conditions |
|----|------------|--------------|--------------|---------|-----------|--------------------|------------------------|
| 1  | SB01       | Kerta Mukti  | Pabuaran     | Subang  | > 15      | Sandy clay, clay  | Non-aquifer             |
| 2  | SB02       | Kerta Mukti  | Pabuaran     | Subang  | > 5       | Sandy clay, clay  | Non-aquifer             |
| 3  | SB03       | Kerta Mukti  | Pabuaran     | Subang  | > 12      | Clay, Sandy clay  | Non-aquifer             |
| 4  | SB04       | Kerta Mukti  | Pabuaran     | Subang  | > 5       | Sandy clay, clay  | Non-aquifer             |
| 5  | SB05       | Kerta Mukti  | Pabuaran     | Subang  | > 15      | Sandy clay, clay  | Non-aquifer             |
Table 6. Geoelectric interpretation results of soils containing aquifers and suggested drilling locations.

| No | Sugar Factory | Location Code | Depth (m) | Village | Sub-district | Regency |
|----|---------------|---------------|-----------|---------|--------------|---------|
| 1  | Tersana Baru  | TB01          | 20-45     | Tonjong | Waled        | Cirebon |
|    |               | TB02          | 105-125   | Tonjong | Waled        | Cirebon |
|    |               | TB06          | >90       | Cilengkang | Waled | Cirebon |
| 2  | Karang Suwung | KS01          | 10-22     | Curug    | Susukan Lebak| Cirebon |
|    |               | KS02          | 20-40     | Tambolang| Karangsembung| Cirebon |
|    |               | KS04          | 100-120   | Blender  | Karangsembung| Kuningan|
|    |               | KS10          | 13-30     | Ciuyah   | Waled        | Kuningan|
|    |               | KS12          | 16-34     | Cisaat   | Waled        | Kuningan|
|    |               | KS13          | 10-18     | Ciuyah   | Waled        | Kuningan|
|    |               | KS15          | 10-30     | Kudarama | Ciawi Gebang | Cirebon |
|    |               | KS16          | 10-25     | Geresik  | Ciawi Gebang | Cirebon |
|    |               | KS17          | 6-24      | Keramat Mulya | Ciawi Gebang | Cirebon |
|    |               | KS18          | 5-34      | Keramat Mulya | Ciawi Gebang | Cirebon |
|    |               | KS19          | 10-30     | Cikandang | Larangung    | Cirebon |
|    |               | KS20          | 10-20     | Cikandang | Larangung    | Cirebon |
|    |               | KS21          | 7-30      | Cieurih  | Cidahu       | Cirebon |
|    |               | KS22          | 6-22      | Datar    | Kertawinangun| Kuningan|
| 3  | Sindang Laut | SL02          | 12-15     | Kodasari | Beber        | Cirebon |
|    |               | SL03          | >160      | Tangkil  | Susukan      | Cirebon |
|    |               | SL05          | >85       | Wiyong   | Susukan      | Cirebon |
|    |               | SL09          | 12-70     | Sindanglaut | Lemahabang | Cirebon |
|    |               | SL10          | 7-45      | Asem     | Lemahabang   | Cirebon |
|    |               | SL20          | 13-50     | Curug    | Karangsembung| Cirebon |
|    |               | SL22          | 27-78     | Sindanglaut | Lemahabang | Cirebon |
| 4  | Jatitujuh     | JT02          | 98-102    | Palasah  | Kertajati    | Majalengka|

Note: the grey color is drilling priority

3.2. Potential Planting Period

The potential planting period was determined based on the plant water adequacy index and the relative yield loss potential. If the ETa/ETc is greater than or equal to 0.65 with a relative yield loss of less than 20%, the period is determined as the potential planting period in an area. The ETa/ETc ratio time series allows knowing the time and amount of water deficit that occurred. Water deficit which causes low ETa/ETc results in high yield loss [18].

The results of potential planting period analysis which was calculated based on the plant water requirement factor by determining the water adequacy index in the critical phase of sugarcane (shoot formation and vegetative phase) in the Sugarcane Farm plantation area of Tersana Baru SF shows that the potential planting period in the area is generally between September third ten days (September III) to January second ten days (January II) with the best planting time in November II, while outside this time it is not recommended for planting sugarcane due to the potential loss of yield (RYL) will reach more than 20% due to a decrease in the Value of the Water Adequacy Index (ETa/ETc Ratio) with the peak of potential yield loss occurring at planting in early May II to late July ranging from 64 – 72%. To increase the Water Adequacy Index at the time of planting, supplementary irrigation of 2.2-2.7 mm/day is needed.

The results of potential planting period analysis in Karangsuwung SF show that the potential planting period in the area is generally between September III to January II with the best planting time in November II. The decline in the value of the Water Adequacy Index (ETa/ETc Ratio) occurred one to two bases earlier than Tersana Baru SF. During that period, the Water Adequacy Index value decreased sharply and fluctuated below its critical value, so that the peak potential for yield loss occurred at planting in early May II to early July, ranging from 65 – 67%. If planting is carried out, a supplementary irrigation supply of 1.8 – 2.4 mm/day must be prepared to prevent water shortages in the critical phase.
The results of potential planting period analysis in farmers’ sugarcane plantation area of Sindang Laut SF were carried out in the area that belongs to Susukan, Ciawigebang, and Lemahabang Sub-districts. For Susukan Sub-district, it shows that the potential for planting in the area where sugarcane does not experience a water deficit (relatively safe) if planted in September III to January III with the best planting time in January I. Sugarcane planting should be done no later than January I because after that period (January III – July III) it causes water stress in the critical phase which causes the peak yield loss to range from 66 – 67%. If planting is carried out, a supplementary irrigation supply of 2.4 – 2.7 mm/day must be prepared to prevent water shortages in the critical phase. Ciawigebang Sub-district has the potential for a longer planting period, starting from September III to February I with the best planting period in January II, the peak potential for yield loss occurs in planting from July II to August I, which is between 58 - 67%. If planting is carried out, a supplementary irrigation supply of 2.0 – 2.4 mm/day must be prepared. Lemahabang Sub-district has the potential for the planting period between September III to February I with the best planting period in January II, the peak potential for yield loss occurs in the planting of June I to July III, which is between 61 - 67%. If planting is carried out, a supplementary irrigation supply of 2.3 – 2.6 mm/day must be prepared.

The results of potential planting period analysis in farmers’ sugarcane plantation area of Jati Tujuh SF was carried out in an area that belongs to the Palasah and Kertawinangun Village, Kertajati Sub-district, Majalengka Regency. For Palasah Village, it shows that the potential for the planting period in the region is generally from September I to January III with the best planting period in November I. Sugarcane planting should be done no later than May II because after that period (May III – June II) causes water stress in the critical phase which causes the peak yield loss ranges from 56 – 58%. If planting is carried out, a supplementary irrigation supply of 1.4 – 1.6 mm/day must be prepared to prevent water shortages in the critical phase. Kertawinangun Village has the potential for a planting period in general from August III to January III with the best planting period in November II. Sugarcane planting should be done no later than May II because after that period (May III – June II) it causes water stress in the critical phase which causes yield losses ranging from 56 – 58%. If planting is carried out, a supplementary irrigation supply of 1.5 – 1.67 mm/day must be prepared.

The results of the analysis specifically showed that sugarcane in Subang SF does not have a water deficit (relatively safe) if planted in August III to February I with the best planting period in December III, sugar cane planting should be done no later than May III, because after that period (June I - June III) causes water stress in the critical phase (shoot formation and vegetative phase) which causes a peak yield loss of 71-75%. If planting was carried out, a supplementary irrigation supply of 2.3–2.5 mm/day must be prepared.

4. Conclusion
Potential groundwater in Tersana Baru SF and Sindang Laut SF were dominated by the deep aquifer, Karang Suwung SF was dominated by a shallow aquifer, Jati Tujuh SF and Subang SF were dominated by non-aquifer.

Determination analysis of the best planting period for the sugarcane at Jati Tujuh SF area of Palasah Village in November I, Jati Tujuh SF area of Kertawinangun Village, Tersana Baru SF, and Karang Suwung SF in November II, Subang SF in December III, Sindang Laut SF area of Susukan Sub-district in January I, Ciawigebang and Lemahabang Sub-districts in January II.

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5. References

[1] D T Setiyawan et al 2019 IOP Conf. Ser.: Earth Environ. Sci. 230 012057

[2] Heryanto M A and Suryatmana E R 2020 Dinamika agroindustri gula Indonesia: tinjauan analisis sistem (in Bahasa) J. Agribuss. and Agri. Soc. Eco UNPAD 5 (2) 195

[3] Irianto G, Surmaini E, Estiningtyas W and Kaslan 2002 Technical Report of Dam Technology to Increase Dryland Sugarcane Production and Yields (Bogor : IAHRI) p 3

[4] Rejekiningrum P, Heryani N, Apriyana Y, Sosiawan H, Sawijo S, Haryanti K S, Jayanto G, Ramadhani F, Nugroho W T and Rahayu B 2006 Technical Report of Characterization and Zoning of Groundwater Potential Areas for Developing Sugarcane Supplementary Irrigation in West Java and South Sumatera (Bogor : IAHRI) p 1

[5] Musyadik, Agussalim and Marsetiyowati T 2014 Determination of soy beans planting time based on water balance sheet analysis in South Konawe regency, Southeast Sulawesi Widyariset 17 (2) 277

[6] Rejekiningrum P, Ramadhani F, Apriyana Y and Haryono 2005 Identification and characterization of groundwater potential for developing supplementary irrigation in Rendeng and Trangkil in Central Java J. Agromet 19 (1) 49

[7] Muhardi, Perdana R and Nasharuddin 2019 Determination of shallow aquifer depth in TPA Manggar area using geoelectric method Wenner configuration J. App. Sci 5 (2) 131

[8] Layade GO, Ogunkoya C O and Ogundete O R 2018 Investigation of road failure at Ogun-Osun-Alabata road, Nigeria, using vertical electrical sounding technique J. Env. Tech 11 (1) 69

[9] Baron F, Perez P and Maraux F 1995 Module sarrabil guide d’utilization (Montpellier: Unite de Recherche“Gestion de l’ea”)