Soil electrical conductivity mapping system using intelligence sensor at young oil palm area

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Abstract: Soil electrical conductivity (EC) is a measurement that links with the soil properties that will affect crop productivity. With advances in technology for precision agriculture, Veris Technologies introduce the on-the-go sensors for measuring level of Soil EC. The combination of sensor with EC help in improving our farming system. This study was conducted at Share Farm UiTM Jasin, Melaka in Young Oil Palm area and used to measure the level of EC. This implements (Veris 3100) connected along with Auto Pilot Tractor (New Holland TD575). It works together with GPS to get an accurate location before it converted to map form. The collected data contain shallow and deep. Each data shows different amounts of EC. Shallow measure from 0-30 cm while Deep from 0-90 cm and the data measure by millisiemens. Then do an interpolation by using the kriging method by using ArcGIS. Function of this software to digitize the data to get it clearer. With the development of ArcGIS software, it improves our map from simple to fully functioning system. Based on the result, it shows that they’re no much different of EC in that area. Besides, the fact that sands have a low conductivity, silts have a medium conductivity and clays have a high conductivity.

Keyword: deep, shallow, Soil EC, Intelligence sensor, Veris 3100, GPS, ArcGIS

Citation: Author names. 2021. Soil electrical conductivity mapping system using intelligence sensor at young oil palm area. Agricultural Engineering International: CIGR Journal, 23 (1):274-283.

1 Introduction

Oil palm is one of the major crops produced in Malaysia. Our plantation is more focus on Oil Palm. The type of soil affects the performance of plants and reflects towards its yield. The advances in technology usually give many advantages to the farming system. Veris 3100 is one of the product from Veris technologies that develops in helping farmer measure the level content of soil electric conductivity (Soil EC) and at the same time doing a mapping system. The mapping system is one of a system that we transfer into map form. Veris 3100 is an on the go sensor that will get the data immediately. There are two ways on how to measure EC, through direct contact and non-contact. The application of geospatial measurements of apparent soil particle conductivity (EC) combined with the use of GPS and GIS is one of the most reliable techniques to characterize spatial patterns (Fountas et al., 2004; Corwin and Lesch, 2005). Precision Agriculture is slowly being adopted in Malaysia. Before this, farmers tend to collect

Received date: 2019-05-15 **Accepted date:** 2019-11-05

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data on their own and need more time to finish it but with this improvement in technology, it helps to cover a large area in a shorter time.

2 Literature review

2.1 Oil palm

2.1.1 History of oil palm

Oil palm gives the highest yield per hectare. Oil palm or Elaies guinensis came from three main areas which are in Africa, southeast Asia, and south and central America. There is a fossil historical and linguistic evidence for an African origin of the oil palm. There was some argument where some researcher said that African origin had been found by the pollen in Miocene sediments in Nigeria (Zeven, 1964). But in Congo, they reported that they already used oil palm for food due to the increasing number of population. The original habitat of oil palm, not in Savannah or primary forest, but in the forest where people can start to clear the area. Planting oil palm helping to increase the soil quality and Oil palm does not tolerate with the salinity. The oil palm, Elaeis guinensis Jacq is grouped with Cocos (the coconut) and other genera in the subfamily, Arecoinideae, and tribe Cocoseae (Dransfield et al., 2005). According to Wessels Boer 1995, there are two current species, Elaeis E.guinensis and Elaies oleifera which respectively the African and American oil palm. Malaysia is known as a tropical country that suitable to plant oil palm (Zeven, 1964). Basiron (2007) reported that, oil palm was firstly taken in Malaysia in 1875. But for the commercial purposes, it's been planton 1917 at Tennamaran Estate in Kuala Selangor. (Basiron, 2007; Jagoe, 1952).

2.1.2 Mechanical tools in oil palm

According to Razali et al. (2008), in oil palm industry, harvesting and transportation of fruits give an impact on the performance and important operations. The quality of oil depending on these. Castillo et al. (2017) stated that, during the harvesting process, the fruits would be scattered on the floor, so this situation made workers do another job to pick all the fruits. It can reduce the time and more losses in time. The cost for the operation of harvesting also increases. By modifying the harvesting procedure, it can give additional advantages to us. Bernal (2001) stated that the cut bunches need to be sent to the production the same days as it harvests, less than 24 hours to prevent the increase of fatty acid that called as acidification. As reported by Ishak et al. (2011), by using the old methods on harvesting which looking on the fruits loose between 40-60 pieces at ground so, the innovation is needed in avoiding the losses and improving our technologies.

2.1.3 How technologies help in oil palm

Oil palm industry is relying on the foreign worker. One way to help to minimize the foreign workers by increasing the adaptation of technology and mechanization in oil palm plantation. According to Paper et al. (2017) and Hudzari et al. (2011), they stated that, machine helping the worker to carry out their task and activities was more faster and increased the productivity.

Rahim et al., (2020) stated that, their aims of the technologies to increase the productivity, reduced the relying on workers and at the same time minimized the cost of operation. Related to some study, harvesting one of the current issues that need to be solved, the current method by using a chisel and sickle that increase the labour. According to Rahim et al. (2020), MPOB did a collaboration with another engineer in developing a harvesting machine.

Figure 1 The mechanical harvesting machines

2.1.4 Characteristic of soil that suitable in oil palm area

Oil palm can grow in all types of soil. According to Goh et al. (2016), optimal conditions for oil palm was well drained, water holding capacity and more being suitable for cultivation is loamy to loam clay soil.

Peat soil was not only suitable for planting purposes, but the problem has already been solved. In melentang Bagan Datok, the area was a flat coastal terrain of clay soil (Yahya et al., 2012).

2.2 Precision farming

2.2.1 Introduction

Precision farming can be described as the easier way to make everything accurate and controlled when it goes to growing crops. Precision farming is some systems that use for site specific management (SSM) crop production systems. Managing each crop production input, including fertilizer, herbicide and insecticide. On a site specific basis to reduce waste, increase profit and maintain the quality of the environment. Regarding to some study, the use of PA help in yield sector. Better yield management practices resulting in more precision in agricultural operations from tillage to harvesting to reduce inputs, increase profits, and protect the environment (Rains and Thomas, 2009; Ismail et al. 2012). Besides, the term Precision Agriculture (PA) or precision farming comprises these improved management technologies such as soil sensing and mapping, yield monitoring and mapping, remote sensing, field and crop scouting, geographical information systems (GIS), variable rate application, and automatically steering (Rains and Thomas, 2009).

2.2.2 Adaptation of PA

From the previous study, PA helps in improving our management. Wan et al. (2011) reported that, farmers use, and auto guidance tractors could reduce the working hours, time saving and also could reduce the operating cost, which was fuel. When the input reduces, it can increase the yield and performance of work. But in the same study, certain farmers reject PA, because they don’t have enough knowledge and, of course the equipment cost is higher (Blackmore, 2002). According to Leonard (2014) in Australia, almost 80% of the farmers (grain growers) used automatic guidance. Also, Steele (2017) reported that 98% of surveyed farmers in Canada used GPS guidance for their farming activities. It can show the similarity among these three countries on how they adapt the PA. Mostly the size of farm tends them to use this management. The main similarity among these three countries (the US, Australia, Canada) is that the farm sizes are bigger in these countries, making the farmers more willing and able to adopt new technologies (Keskin, 2013; Keskin and Sekerli, 2016). Regarding to Fountas et al. (2005) farmers that have a larger field, tend to be invest in technologies due to the capacity of their area. Meanwhile, for Paustian and Theuvsen (2017), it stated that, for the farmers that had less than 100 hectares and more in producing barley, it showed the negative influence in the adaptation of PA in Germany.

2.3 Soil electrical conductivity

Soil electrical conductivity refers to the ability of soil to conduct electrical current in the soil. EC used to measure soil salinity. According to Aimrun et al. (2007), Lund et al. (2000), stated that, the EC and yield had a relationship. Furthermore, the EC can determine the soil properties like water content in the soil, clay, depth and organic matter. It can be proven by Bin Haji Razali and Bin Mohd Azhan (2019), Dabas and Tabbagh (2003), EC can be as the tools for identifying the soil Properties in the area needed. Ohio university stated that, there were two ways on how to measure EC, by contact sensor and non-contact sensor both giving different results (Blackmore, 2000).

2.3.1 Contact sensor

The use of electrodes to make a direct contact with the soil and at the same time to measure the EC. The data collected along with GPS So, location data provided (Muhammad et al., 2019). One of the models is a Veris 3100 from Veris Technologies.

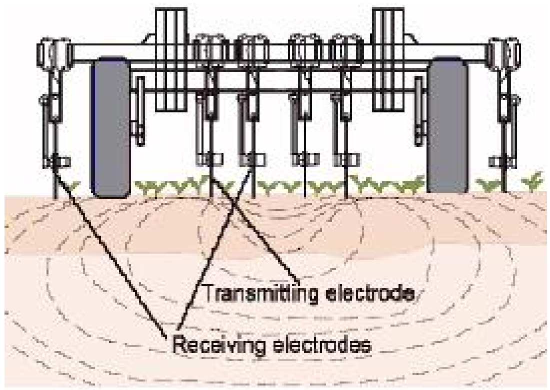

Figure 2 Contact sensor

2.3.2 Non-contact sensor

The use of principle electromagnetic. According to Ohio University, this type of sensor hasn't made a direct contact into the soil surface.

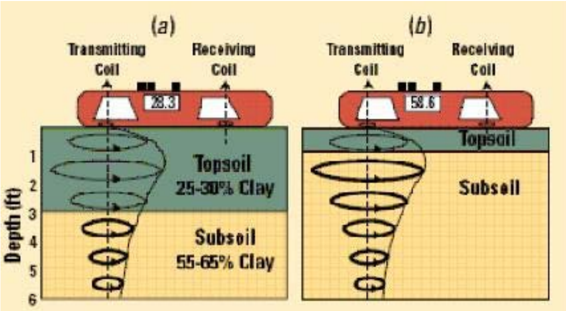

Figure 3 Principle of operation for the non-contact type EC sensor (Aimrun et al., 2007)

3 Research methodology

3.1 Research background

3.1.1 Location of study

This study was conducted in Share Farm UiTM Melaka Campus Jasin. A plot that has been chosen for research located at Young Oil Palm. That plot estimates about 290 of trees with 4.55 acres. Regarding from previous study, that area is a newly area, then it converts to planting oil palm.

Figure 4 Location of study

3.2 Data collection

For this study, the data were collected by using Auto pilot tractor and Veris Technology. The data were taken on 20th November 2018. It takes about 2 hours to complete 4.55 acres. The data has been taken by each row with the distance between measurement 20 to 60 ft. Total data that have been collected around 1338 data.

3.2.1 Auto pilot tractor (New Holland TD 5575)

Autopilot is an automated steering system or called as unman tractor. It will combine with RTK -Real time kinematic, that will give an accurate location. The Autopilot system can be integrated into most brands of tractor and harvesting machinery, and it uses the machine's electro hydraulic circuit to provide automatic guidance. By using this autopilot, it can increase the efficiency during harvesting activity, field preparation, and able to drive more accurately and consistently. This data was collected by using auto pilot and Veris 3100. Veris 3100 is an implement that cannot stand alone, it needs something to pull out. Usually, some plantation they use 4-wheel vehicles, but in this study, 3100 connect along with the tractors were used. This machine helps in doing a mapping and at the same time to measure the available amount of electrical conductivity. It is an innovation in agriculture with no present of driver or driverless.

3.2.2 Veris technologies (Veris 3100)

Veris Technologies is a company that is specialized in doing a mapping. It was built in 1996 and products are used in more than 40 states and 40 foreign countries. Before starting, managing input by different ways, need to make a map, and map can capture the variations.

Figure 5 New holland tractor

With the development of Veris 3100, it helps famers to measure the amount of Soil EC and form into the map. Veris is implements that will connect with GPS to get an actual location before it converts into Map form. If the GPS function not well, data can be errors. It is a proven technology of soil electrical conductivity to identify the area with specific soil properties. There are two ways on how to measure EC, 3100 is a direct contact sensor, where it makes connections directly towards the soil. It measures on two depths, by shallow and deep. Shallow is measured from 0-30 cm depth. Meanwhile, for deep from 0-90 cm depth.

Figure 6 Veris 3100

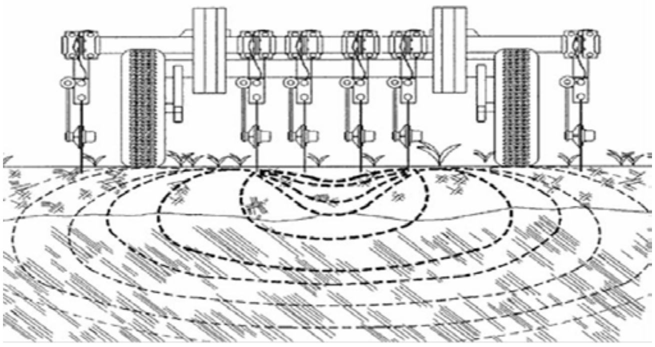

Figure 7 An example of electrical conductivity

Figure 8 The example of line that get from collection of data

The ways Veris3100 process it has 3 pairs of electrodes. As the Veris 3100 cart is pulled through the field, one pair injects electrical current into the soil, meanwhile, the others measure the voltage drop. While these coulter-electrodes only need to penetrate the soil a few inches, the electrical arrays employed by the Veris system investigate the soil as represented in this schematic. Need to be alert that, during the collection of data, GPS must be in ready mode and avoid from making too much movement cause, connections can loss. Connections loss can delay the process.

After the cart being pulled into the soil, this line appeared. It is called direct contact. Where 3100 make a contact with soil doing an electrical conductivity. The more compact the soil, good for EC.

3.3 Data analysis

In this part, it is a more complex method, where all the data that been get need to be analysed into form of map or graph. It will summarize collected data. In this study, the use of Veris soil viewer and ArcGIS is needed.

3.3.1 Veris soil viewer

This software is provided by the Veris technology in doing a mapping system. Total data collected are 1338 data, and all the data was key in into this software to convert into the map, colour form. To make it more clear and easy to digitize. Besides, it can do a management zone. Specific area with specific management.

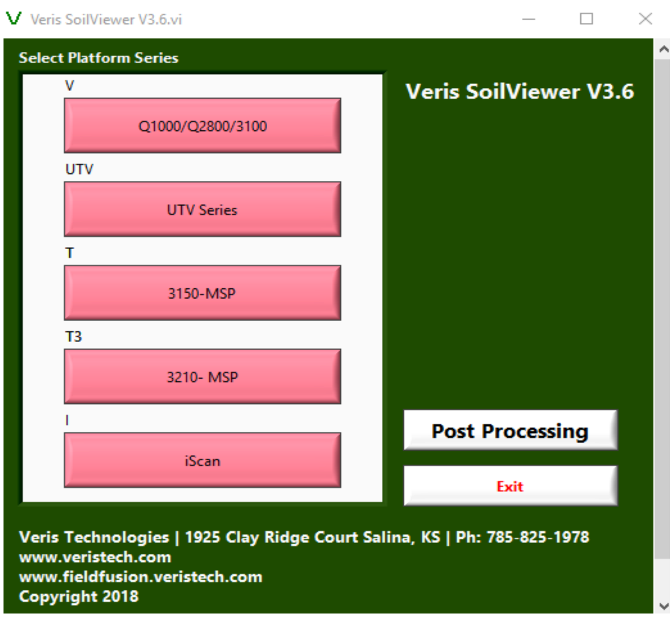

Figure 9 Veris software

It is a picture of the data that insert into Veris software. It has three colours, red, yellow and green. All the colours can be changed based on our preference. The lines showed our route during collecting data. The distance between one point to another point is 20ft to

60ft.

Figure 10 Result from EC software

3.3.2 Mapping system using ArcGIS software

ArcGIS is a physical information system that works with maps and geographic information. This system allows and provides some infrastructure for creating maps and physical information. ArcGIS used for the mapping purpose, data collected is inserted into this software to get an actual map. From the map, any decision can be done in a way to improve our farming area. The numerical values change into the map.

1	long	lat	shallow	deep	elevation
2	102.461	2.22945	1.4	1.9	16.5
3	102.461	2.229448	1.4	1.9	16.5
4	102.461	2.229448	1.3	2	16.6
5	102.461	2.229448	1.1	1.8	16.6
6	102.461	2.229448	1	1.2	16.7
7	102.461	2.229448	1.2	1.3	16.7
8	102.461	2.229448	1.2	1.2	16.7
9	102.461	2.229448	1.2	1.5	16.7
10	102.461	2.229445	0.9	1.4	16.6
11	102.461	2.229442	1.2	1.4	16.7
12	102.4609	2.22944	1.5	1.7	16.8
13	102.4609	2.229438	1.8	2	16.9
14	102.4609	2.229435	1.6	2	17
15	102.4609	2.229432	1.4	1.6	17.1
16	102.4609	2.22943	1.3	1.5	17.2
17	102.4609	2.229427	1.6	1.3	17.3
18	102.4609	2.229425	1.8	1.6	17.4
19	102.4609	2.229422	2.1	1.7	17.5
20	102.4609	2.229418	1.9	2.1	17.4
21	102.4609	2.229415	1.5	1.7	17.3
22	102.4609	2.229412	1.8	1.8	17.3
23	102.4609	2.229408	1.7	1.9	17.2

Figure 11 Data collected from Veris 3100

An example of numeric raw data collects, data need to insert into ArcGIS software for digitize and get real map. It's easier and people feel more attractive. The use of kriging methods in doing an interpolation. Kriging assumes the distance of the area.

4 Results and discussion

4.1 Soil electrical conductivity

Soil electrical conductivity is related to the crop performance, which is yielding. By measuring soil electrical conductivity, it can determine soil properties like texture, for example sand, silt and clay. Sandy soil the EC is around 0-8 milisiemens. Meanwhile, for silt 8-50 milisiemens and clay from 10 -1000 miliesimens. The facts of soil conductivity, sand has a low conductivity, silt have medium and clay have higher conductivity. The electrical conductivity has proven to relate closely to other soil properties that determine a field productivity. In this study, the Veris 3100 is a direct contact sensor and measure in two different depths. Shallow was measured from 0-30 cm and deep 0-90 cm. Each depth indicates different levels of EC in that area. According to Aini et al. (2014), EC deep could be used as an estimate to measure soil PH compared to shallow.

This is the result for Soil electrical conductivity in Young Oil Palm area.

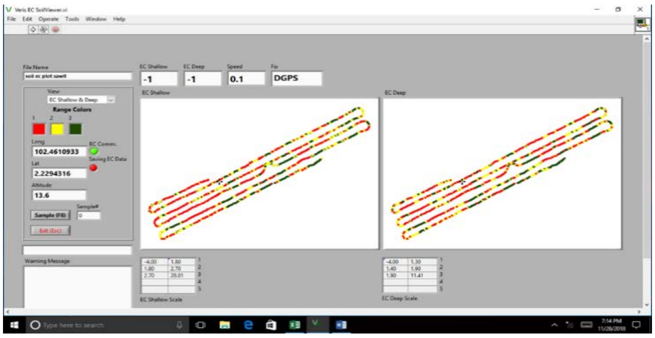

Figure 12 Result obtains from veris. Deep and shallow

4.2 Soil electrical conductivity - Shallow

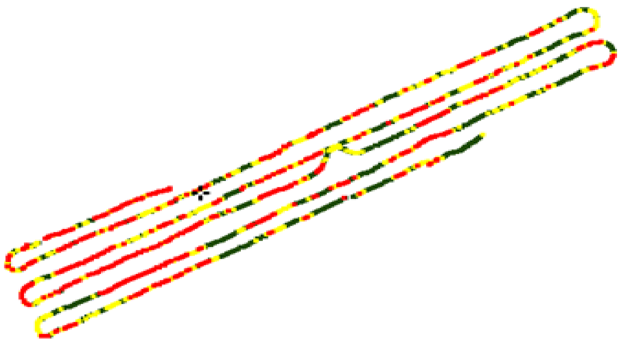

Figure 13 Shallow

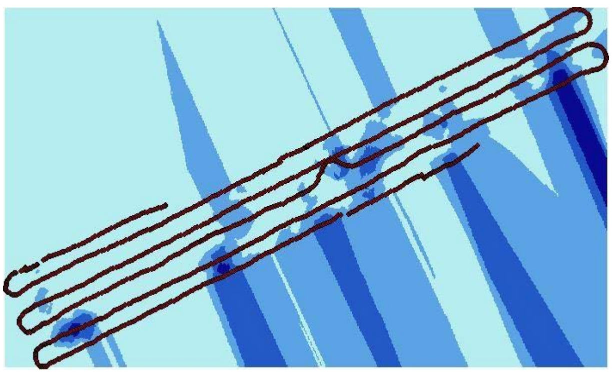

Figure14 Result from ArcAGIS

Shallow is a depth of 0-30 cm inside the soil. It is a short distance from the top to the bottom. Each colour indicates different levels of EC. From low to high. Red contains a low EC and green has a high EC. In that area, contain low EC, so when it goes to low EC the texture of soil is a sandy soil. It can be seen more clearly when convert into ArcGIS by different colour levels .

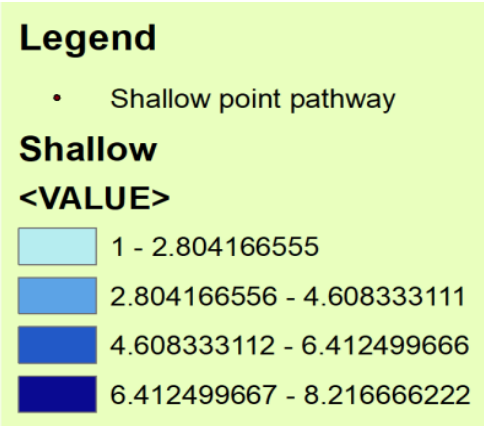

Figure 15 Legend for the shallow Veris

4.3 Soil electrical conductivity – Deep

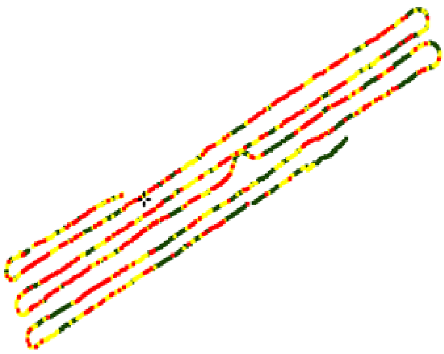

Figure 16 deep

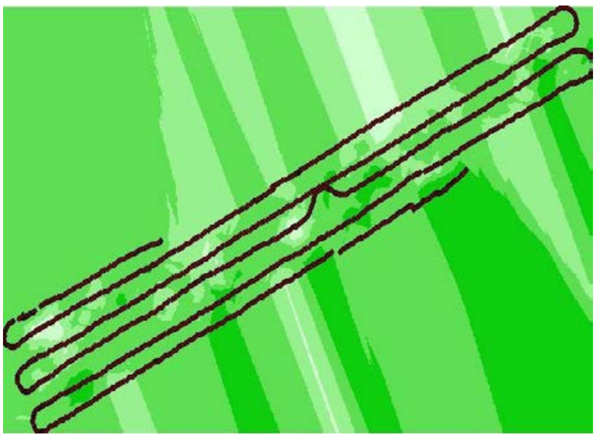

Figure 17 Deep result from ArcGIS

Deep is the depth of 0-90 cm inside the soil. Different colour give different levels of EC. High EC is recommended, but not too high. Good soil affects the yield performances. From this result, it shows in that area, level of EC also low. Red colour indicates low EC Which is leading to low water holding capacity.

When the data being converted into ArcGIS, it can see clearly different based on value. The darker, contain higher of EC. The legend helps in reading the data faster.

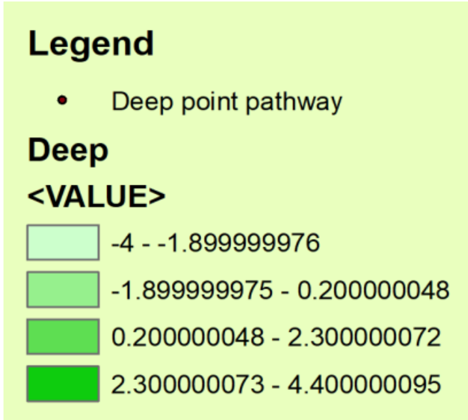

Figure 18 Legend for the deep Veris

5 Discussion

Soil electrical conductivity (EC) is the way to measure the ability of soil to conduct current in the soil. EC can be related to the yield of plants, and based on certain study EC is an indication of the availability of nutrients in the soil (Kitchen et al., 2002). According to Aimrun et al. (2007), EC value was directly influenced by the amount of dissolved salts. Regarding to this study, result obtained from Veris Soil Viewer and ArcGIS are related to EC and soil Properties. A map shows contrasting soil in the field of colour form. In Veris Soil Viewer, it contains three colour which are red, yellow and green. Red indicates a low level of EC, for yellow medium and green is a high in that area. The distance between point is 20 to 60 ft. It can be concluded from this result, the EC level in that area is low. Which means not very good for planting purposes. For oil palm, clay, sandy clay, clay loam and silt clay are suitable for oil palm planting. The oil palm root system needs to be well-developed to avoid from felt. Soil texture gives an impact to the performance of the plant. Not all types are suitable, one of them is a peat soil. But majority oil palm area from a peat soil, with proper management, it can be used. Medeiros et al. (2018), mentioned that the texture of the soil will affect towards yield, water holding capacity, and also the cation exchange capacity. Regarding to the research, the area contains low EC, which means that, they are poor in holding water. Like a sandy soil, the probability of holding water is less because of soil structure. So, when the ability to hold water is not good, nutrient that has been added also leach due to this problem. Meanwhile, for high EC, the texture is clay loam. Good for planting because can hold water for a long time and affect the nutrient. The pores are small, so electric is easy to be transmitted in a shorter time. From the result, certain area has less than 1 milisiemens, which is -4. It is meant, on that area there is a present of rocks. And in a certain area, it reaches until 18 milisiemens, it can be concluded on that area, contain a puddle, so the EC higher. There are some factors that influence the EC of soil, first is pores, facts are, soil with full water was have compact pores, so soil pores tend to conduct electricity more readily. Soil with high clay, usually conducts electricity ways better than sandy soil. Refers to the Islam et al. (2012), Corwin and Robinson (2005), the representation of higher EC, higher water holding capacity while low in EC indicates low in the water holding same as EC. So, it shows the relationship between EC and soil properties. Curiously, compaction will normally increase soil EC. Water content gives different results, dry soils are much lower compared to moist soils. Aimrun et al. (2007) and Hudzari et al. (2012) stated that, in Soil EC, it was related to the salinity level. To measure the salt in the soil and increasing concentrations of salts in soil water will increase soil EC. Too much salt is not very recommended because it can lead to acidity. Regarding to Lund et al., (2000), they said that there was a relationship between EC and yield because soil attended as a primary growth medium for crops. So, it can be related to map of soil physical properties and yield map that dosen't have so much different and correlation. Soil EC can serve as a representation for soil physical properties such as organic matter (Aini et al., 2014), clay content (Ssomad et al., 2015), and cation exchange capacity (McBride et al., 1990). Based on Sudduth et al., (1998), on his study, all these properties gave a significant effect on water and nutrient. The relationship between soil EC and yield has been reported and quantified by others (Aimrun et al., 2007). To prove the Veris 3100, researchers do a comparison between Dualem and Veris. Dualem is a non-contact sensor while Veris is a contact sensor. So, the result shows that, Dualem is higher than Veris. All the data were measured into miliesimens. But there is no much different between contact and non-contact.

6 Conclusion and recommendation

From the study conducted, we can see that, some of our objectives are achieved. Using Veris 3100, it can determine the levels of EC in the location of the study. Based on the amount of EC, it can identify the soil properties and texture of the soil. Either sand, clay or silt. From the texture of the soil, all the elements like CEC, water holding capacity and porosity can be identified. PA provides better management practices that may help in better result, from operations, better yield, reduce inputs and at the same time protect the environment and nature. The adaptation of PA starts to increase in developing countries. The factors that help in adaptation is a farm size.The use of the technology helps them in the best management practice. By doing mapping system, easy for farmers do the management zone, by dividing into specific crop management because Each area contain different amounts of EC. Precision agriculture is a good to be implemented in Malaysia. Farmers or any plantation company should slowly adapt this type of innovation and implements in their plantation. For sure we need to encourage more plantation company, because they can attract others include small farmers to do this type of technique. Mapping system using Veris 3100 recommend for a newly area or new open area. Decision can be done after we know some background of the soil. Soil giving big effect towards our growth performance, yield and nutrients. Refers to the type of soil in that area, then we can suggest what type of plant that was suitable to be planted in that area. Future recommendation, as we know, this machine or implement only have in UiTM Jasin and Universtiy Putra Malaysia. So UiTM can take an initiative to do rental or custom work on this machine to the small farmer or any plantation industry. The cost of buying this machine is not higher and probably the use of this machine is not frequent compared to harvesting machine or others.

Acknolwegement

The authors would like to acknowledge the role of Ministry of Science, Technology and Innovation (MESTECC) and Universiti Teknologi MARA (UiTM) for providing grants funding of 100-IRMI/GOV 16/6/2 (025/2019) and 600-RMC/LESTARI SDG-T 5/3 (077/2019), and all staff in Faculty of Plantation and Agrotechnology, UiTM Melaka, in facilitating the field trials and allow to conduct this research.

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