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RELATIONSHIP BETWEEN PADDY SOIL MOISTURE AND IMAGE TEXTURE

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ABSTRACT

Different soil moisture content gives different soil texture. Texture of dry soil is rougher compared to the moist soil. In this paper, statistical analysis has been done to the paddy soil images to determine the relationship between soil moisture content and its texture. Two hundred and sixty five paddy soils samples with the soil moisture content range from 12% to 80% were used. Eight texture features namely mean, variance, homogeneity, dissimilarity, entropy, contrast, second moment and correlation were extracted from CIELuv soil image. CIELuv was used as it has the advantage as a device independent where the soil color is less affected by its surrounding. Results from the ANOVA test has shown that only mean did not give significant relationship. Entropy and second moment give the value of correlation greater than 0.5. Second moment give better performance in predicting the soil moisture content using linear regression model with the value of $R^2 = 0.4$.

***Keywords**: Texture, Soil moisture, Entropy*

INTRODUCTION

Soil moisture is important not only for assessing the available water content needed for plant utilization, but also to identify the best practice to improve the yield production. In order to get the high yield, an irrigation management program should irrigate water at the right time and in the right amount. It is because applying too much water reduces yields by carrying nitrates below depths of root penetration and by displacing soil air for too long causing a lack of oxygen to the roots [1, 2]. Texture is an important characteristic of many types of images in many applications. Generally, it can be defined as a regular repetition of an element or pattern on a surface. Image textures are complex visual patterns composed of entities or regions of sub patterns with the characteristics of brightness, color, shape, size, etc. A gray image texture provides valuable information on the finest spatial detail that can be discerned within the image [3]. Spatial gray level co-occurrence estimates image properties related to second order statistics which considers the relationship between groups of two (usually neighbouring) pixels at a time, called the reference and the neighbour pixel in the original image. The variation of soil particles shape and size may produce different pattern in each captured image. For example, a fine textured soil which contains more clay particles with smaller size give a smooth texture surface compared to a coarse textured soil with larger sandy particles. As the color in soil image changes when soil moisture changes, Han and Hayes [4] also reported that gray-level co-occurrence matrices (8x8) for dark and light soils were different. Color co-occurrence method texture statistics were used by Burks et al. [5] for discriminating different weed species and soil. It was found that texture statistics could be used in a generalized square distance classifier to discriminate between the data classes [6].

In this paper, the texture features were extracted from gray image of CIELuv soil image. CIELuv was used because it has the advantage as a device independent where the soil color is less affected by its surrounding. Eight texture properties i.e., mean, variance, homogeneity, dissimilarity, entropy, contrast, second moment and correlation will be used in this research.

MATERIALS AND METHODS

Soil Image

The paddy soil samples were taken from Sawah Sempadan, Selangor. The image of each soil samples were captured using a digital camera and saved in a RGB color with JPEG format. The images were then converted to CIELuv color space. These images were then transformed into a grayscale images and used as an input in ENVI programming to extract the texture features.

(a) (b) (c)

Fig. 1: Image of soil in RGB color. (a) MC=12% (b) MC=30% (c) MC=50%

Soil Moisture Content

The American Society for Testing and Materials (ASTM) standard methods of soil moisture content determination has been used during a laboratory test. The samples were placed in a can and weighted before being oven dry at 105°C for 24 hours. It is then weighted again in order to get the mass of dry soil. The calculation for moisture content determination is as follow:

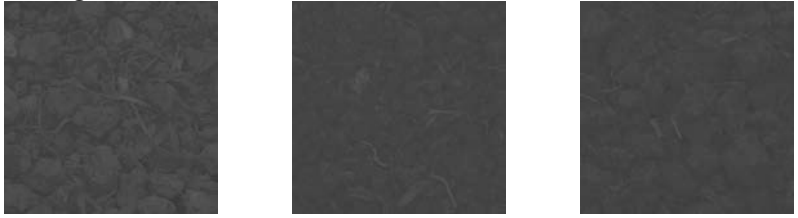
$$w = \frac{M_{ms} - M_d}{M_d - M_c} \times 100 \quad (1)$$

where, w = moisture content
M_{ms} = mass of moisture soil
M_d = mass of dry soil
M_c = mass of can

RESULTS AND DISCUSSIONS

Soil Image

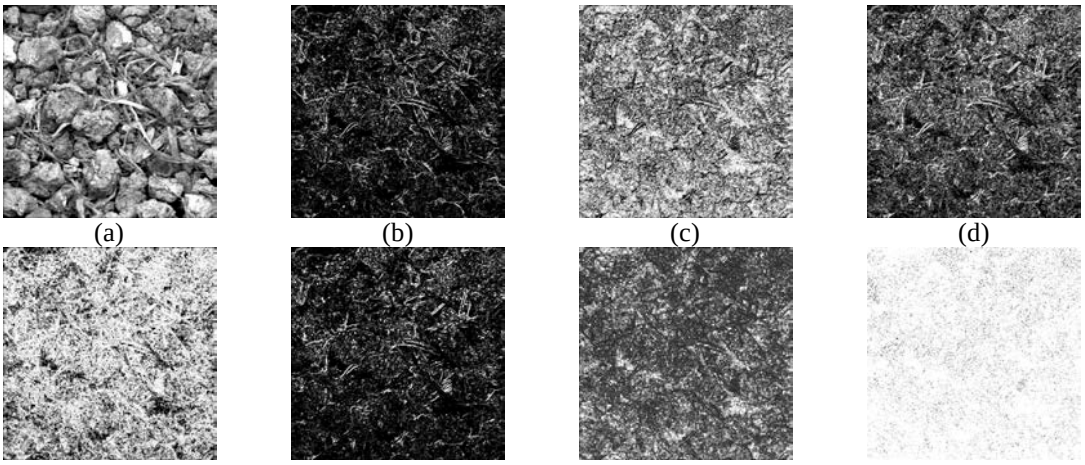
Figure 2 shows grayscale image of the soil in CIELuv. It can be seen that different amount of moisture content give different image texture. The soil texture become finer as the soil moisture increase.



(a) (b) (c)

Fig. 2: Image of soil in grayscale. (a) MC=12% (b) MC=30% (c) MC=50%

Figure 3 show the soil image that has been analyzed using ENVI software in different texture parameter. It can be seen that each parameter give different effect to soil image. Statistical analyses has been done using SPSS software to identify the most significant relationship of the textural properties with its soil moisture content.



(a) (b) (c) (d)

(e) (f) (g) (h)

Fig. 3: Image of soil in different texture parameter. (a) mean (b) variance (c) homogeneity (d) dissimilarity (e) entropy (f) contrast (g) second moment (h) correlation

Table 1 shows that entropy give the highest correlation value (-0.522) and second moment rank the second (0.510). Homogeneity (0.474), and correlation (0.264) provide significant positive correlation while variance (-0.444), dissimilarity (-0.456), and contrast (-0.428) provides significant negative correlation. Only mean (-0.041) did not give significant correlation. The significant value of correlation shows that the correlation is not the result of random sampling error.

Table 1: The Pearson Correlation value for texture properties with moisture content.

Property	***r* value**
mean	-0.041
variance	-.444**
homogeneity	.474**
dissimilarity	-.456**
entropy	-.522**
contrast	-.428**
second moment	.510**
correlation	.264**

**Correlation is significant at the 0.01 level (2-tailed).

Figure 4 shows the value of all 242 soil moisture content taken from laboratory work. They were range from 12% to 80% with the mean value of 39.73%. The soil moisture content in soil samples were varied as it taken from different paddy plot.

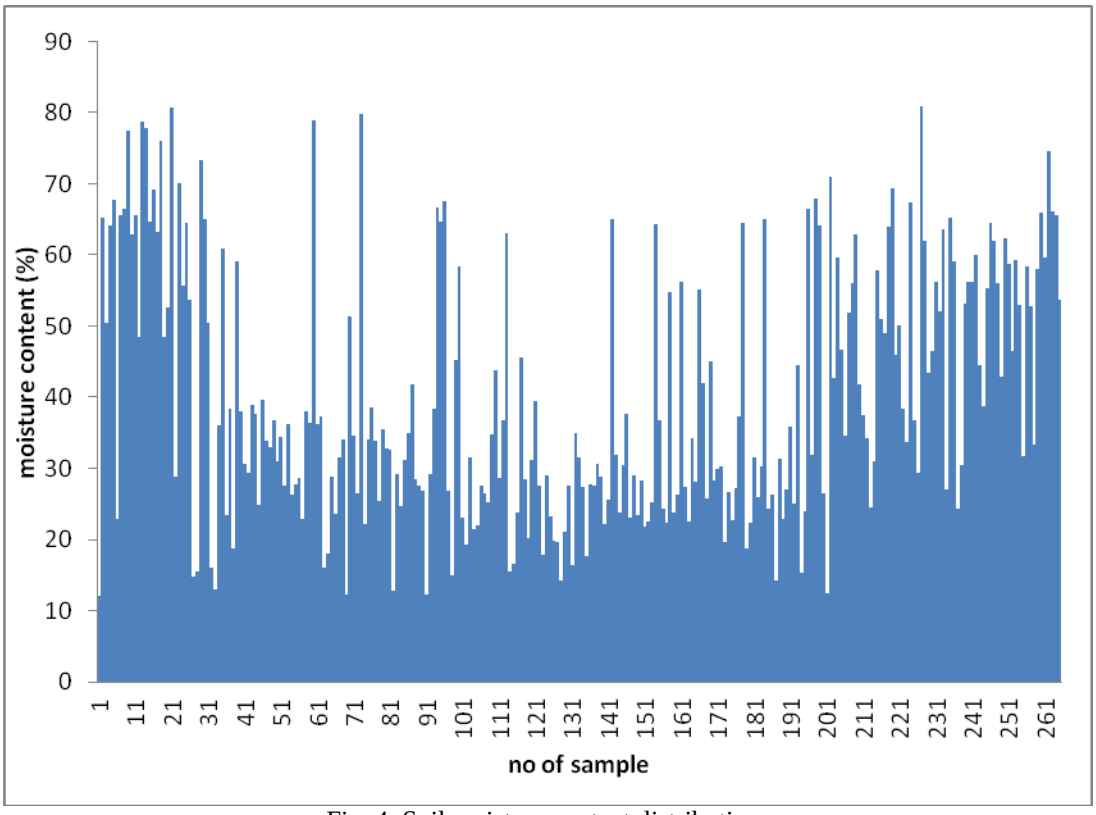


Fig. 4: Soil moisture content distribution.

Soil Texture and Soil Moisture Linear Relation

Textural properties with the value of correlation greater than 0.5 were chosen to predict the soil moisture content based its linear regression model. Figure 5 and 6 shows the scatter plot for entropy and second moment versus soil moisture, respectively.

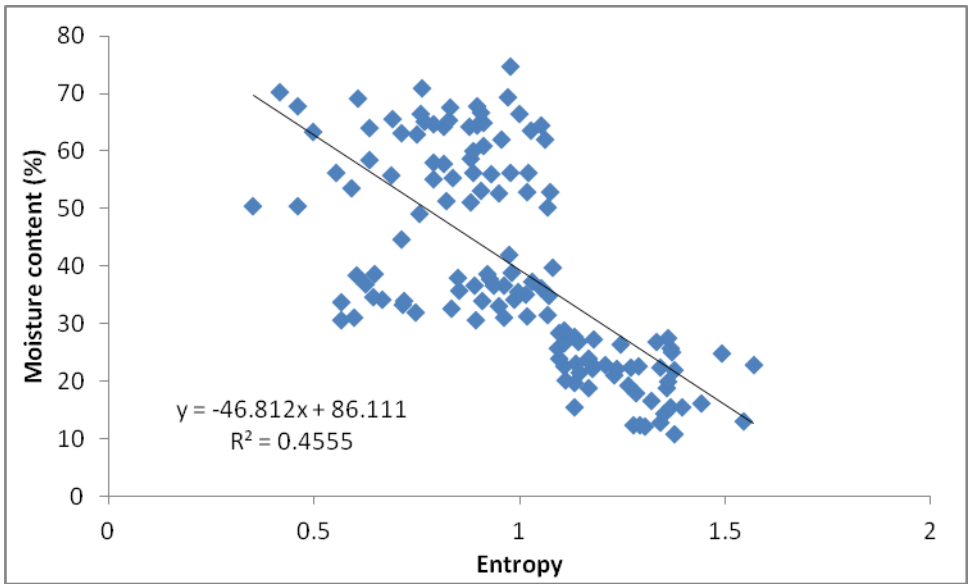


Fig. 5: Soil moisture content versus entropy

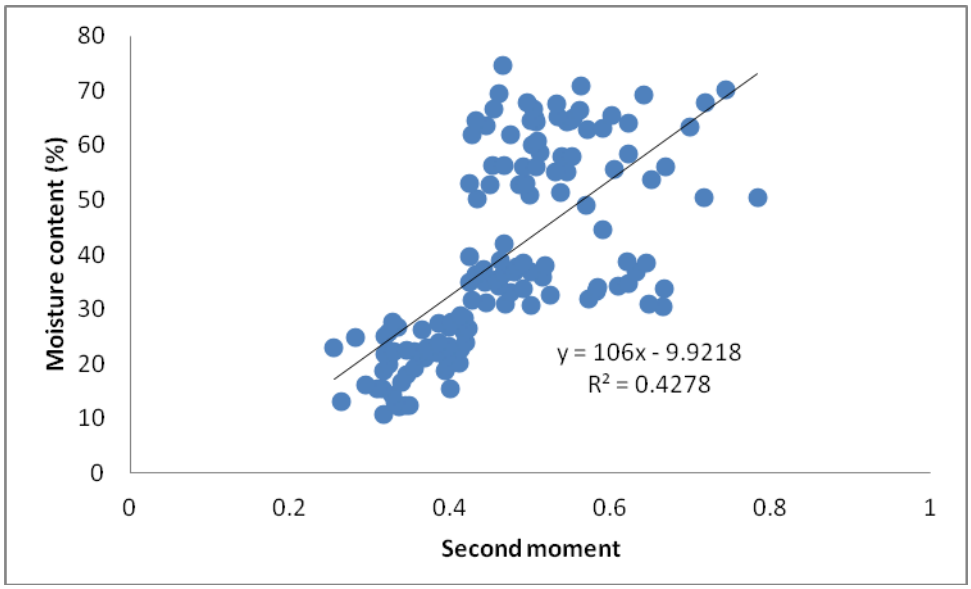


Fig. 6: Soil moisture content versus second moment

It can be seen from Figure 5 that entropy give negative R^2 value which mean when the soil moisture content is increase, the entropy value will be decreased. The scatter plot also shown that, for soil with moisture less than 30%, the entropy value is higher than 1.0. Meanwhile, second moment which values range from 0.0 to 1.0 gives positive relationship. From both scatter plots, it also can be seen that, entropy give slightly higher value of R^2 (0.455) compared to second moment (0.427). Linear regression is used to model the relationship between soil moisture content with texture properties. Therefore, the soil moisture content is predicted by using the following equations:

$$Y_{mc} = -46.81X_{ent} + 86.11 \quad (2)$$

$$Y_{mc} = 106X_{mmt} - 9.921 \quad (3)$$

Where, Y_{mc} = predicted moisture content
X_{ent} = entropy texture feature
X_{mmt} = second moment texture feature

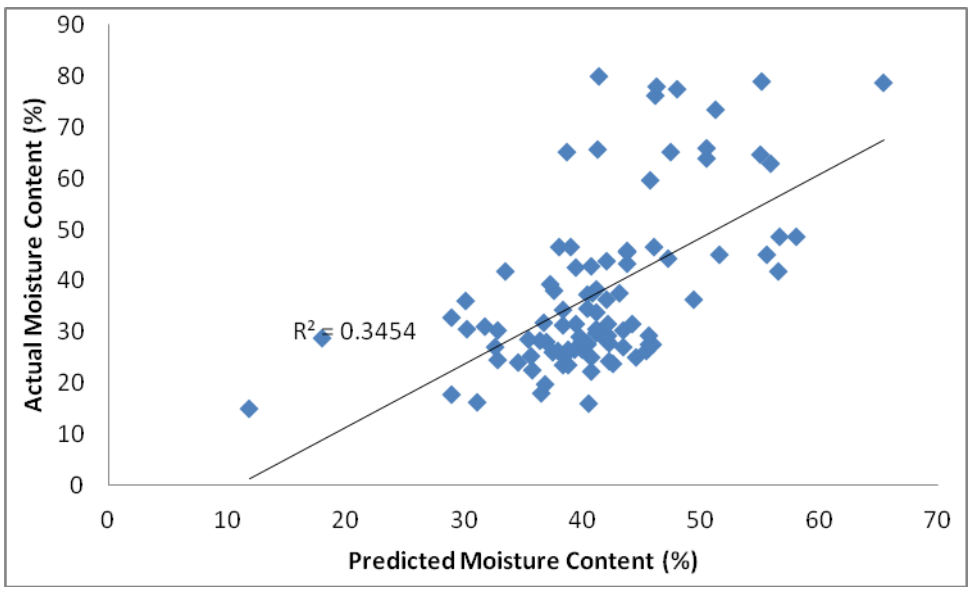


Fig. 7: Predicted moisture content versus actual moisture content for entropy.

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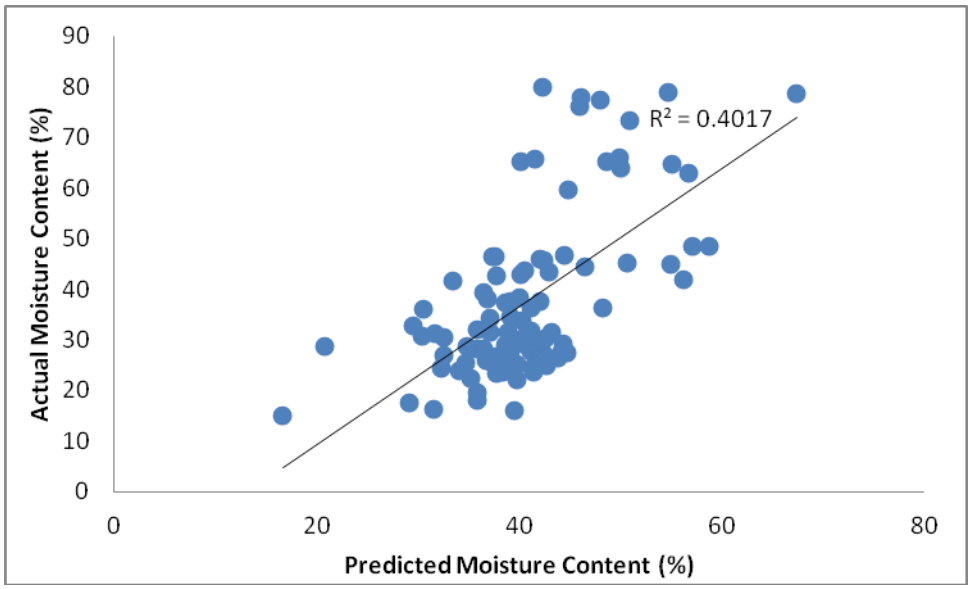

Fig. 8: Predicted moisture content versus actual moisture content for second moment.

The predicted moisture content calculated from both equations was then plotted against the actual moisture content taken from laboratory work. It can be seen from Figure 7 and Figure 8 that the predicted moisture content using either entropy or second moment give positive relation against actual moisture content with the value of $R^2 = 0.345$ for entropy and $R^2 = 0.401$ for second moment. Since the value of R^2 gathered from both properties is quite small, therefore in future work, the non-linear relationship is suggested to be used to improve the prediction model.

CONCLUSIONS

In this paper, image texture properties had been used for soil moisture content determination. The texture features had been extracted from CIELuv soil image. Variance, homogeneity, dissimilarity, entropy, contrast, second moment and correlation give significant relationship. Entropy and second moment perform the best with the value of correlation greater than 0.5. Results from the linear regression model has shown that second moment give the best result of prediction with the value of $R^2 = 0.4$.

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