



Effects of Extraction and Fractionation Period on the Yield of a Tropical Peat Soil (Hemists) Humic Acids

¹Susilawati Kasim, ¹Osumanu Haruna Ahmed, ¹Nik Muhamad Ab. Majid and ²Khanif Yusop

¹Department of Crop Science, Faculty of Agriculture and Food Science, University Putra Malaysia
Bintulu Campus, Sarawak, 97008 Bintulu, Sarawak, Malaysia

²Department of Land Management, Faculty of Agriculture, University Putra Malaysia, 43400 Serdang,
Selangor, Malaysia

Abstract: The isolation of humic acids from soils is laborious and time consuming. Factors that affect the yield of humic acids isolated from soils include extraction, fractionation and purification periods. This study was conducted to investigate whether a relationship could be separately established between extraction time, fractionation time, and the yield of humic acids of a tropical peat soil (Hemists), as well as the relationship between both variables on the yield of humic acids of this soil. Modified standard procedures using 0.1 M KOH were used to isolate humic acids from a tropical peat soil. Even though there was a quadratic relationship between extraction period and yield of humic acids, there was no relationship between fractionation period and yield of humic acids. There was negative correlation between the yields of extraction and fractionation periods. This finding enables the isolation of humic acids of Hemists in less than 10 h instead of the existing average period of 48 h, therefore helping in facilitating the idea of producing for instance ammonium-humate or K-humate (N and K foliar organic fertilizers) from peat soils.

Key words: Humic acids, tropical peat soils, humic substances isolation

INTRODUCTION

About 2.5 million ha of peatland can be found in Malaysia out of which 1.7 million is in Sarawak^[1]. Pineapples and oil palms are among the major crops grown on this soil. However, the inherent nature of tropical peat soils has militated against sustainable cultivation of most crops on it as desired. For instance, mature oil palms tend to lean and in some cases fall. In addition, lack of good anchorage leads to oil palm yield reduction on these soils. In the case of pineapple cultivation on tropical peat soils, the yield decreases with time notwithstanding high application of fertilizers even though the practice is not economically viable^[2] and environmentally friendly. Besides these impediments, frequent burning of tropical peat soils (naturally or human cause) with the accompanied undesirable economic losses cannot be overemphasized. Being organic in nature, they are however high in humic and fulvic acids. These substances play a major role in soil cation exchange capacity, complexation of heavy metal ions and pesticides^[3] soil conditioning,

carbon and nitrogen cycles, plant and growth development^[4] and reduction of ammonia volatilization from soil applied urea^[5]. However, the extraction, fractionation, and purification processes in isolating these substances are laborious and time consuming. For example, the extraction, fractionation, and purification periods of humic acids vary from 12 hours to 7 days^[3,6,7,8,9,10] even though an extraction time of 24 hours^[11,12,13,14] is the usual practice. Fractionation time ranges between 12 hours and 24 hours^[3,8,14], although most studies usually use 24 hours^[2,3,12,14]. Recent studies have shown that isolation of humic acids from composted pineapple leaves could be reduced from 7 days to 1 day^[15, 16]. These studies also established relationship between humic acid yield and time of extraction or fractionation time, and the relationship between these two variables and compost humic acids yield. To date these valuable information are lacking for tropical peat soil humic acids. These relationships are important because they enable the calculation of the maximum and optimum humic acids yield with extraction or fractionation or both procedures as it is

Corresponding Author: Osumanu Haruna Ahmed, Department of Crop Science, Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus, Sarawak, Malaysia, Tel: +6086855406, Fax: +608685415

known that the yield of humic acids from soils increases with increasing extraction time^[3].

This study was carried out to investigate whether a relationship could be separately established between extraction time, fractionation time, and the yield of humic acids of tropical peat soils.

MATERIALS AND METHODS

Peat soil (Hemists) samples were taken at 0-15 cm in a 50 m² plot at Kuala Tatau, Sarawak, Malaysia using a peat augur. The humic acid extraction was carried out by the methods of ^[2,3,15] with some modifications. Five gram (dry-weight basis) peat soil samples were placed into polyethylene centrifuge bottles and 0.10 M KOH solution was added and the bottles stoppered tightly with rubber stoppers. The samples were equilibrated at room temperature on a reciprocal mechanical shaker. At the end of each extraction period, the samples were centrifuged at 10000 rpm for 10 min. The dark-coloured supernatant liquors was decanted, the pH of the solutions adjusted to 1.0 with 6N HCl, and the humic acids allowed to stand at room temperature (about 25 °C). The extraction (shaking) periods used were 2 h (Et₂), 4 h (Et₄), 6 h (Et₆), 8 h (Et₈), 10 h (Et₁₀), 12 h (Et₁₂), 14 h (Et₁₄), 16 h (Et₁₆), 18 h (Et₁₈), 20 h (Et₂₀), 22 h (Et₂₂), and 24 h (Et₂₄).

The fractionation periods used immediately after acidification were 2 h (Ft₂), 4 h (Ft₄), 6 h (Ft₆), 8 h (Ft₈), 10 h (Ft₁₀), 12 h (Ft₁₂), 14 h (Ft₁₄), 16 h (Ft₁₆), 18 h (Ft₁₈), 20 h (Ft₂₀), 22 h (Ft₂₂), and 24 h (Ft₂₄). At the end of each fractionation period, the excess supernatant liquors referred to as fulvic acid^[11,12,13,14] were siphoned off from the acidified extracts. The remainder of the suspensions containing the humic acids were transferred to polyethylene bottles, and centrifuged at 10000 rpm for 10 min. The humic acids samples were purified following the procedures described by^[2,15]. The purification was done by washing the humic acids in 50 mL of distilled water through centrifugation at 10000 rpm for 10 min to reduce mineral matter such as K and HCl used during extraction and acidification, respectively. The entire procedure was repeated 5 times and afterwards, the washed humic acid samples were oven dried at 40 °C to a constant weight, weighed, and yields expressed as percentage by weight of humic acids in the peat soil used. The complete process of extraction and fractionation for this experiment was replicated 3 times. Therefore, values reported in this study were the means of these replications.

The relationship between extraction period, fractionation period, and yield of humic acid in addition to the relationship between both extraction period and

fractionation period on the yields of humic acids were evaluated using the statistical analysis system (SAS) version 9.1.

The organic matter and total organic carbon were determined by the combustion method^[17] while standard procedure was used for pH determination of the soil and supernatant liquors (before acidification) extracted from peat soil.

RESULTS AND DISCUSSION

The pH in water and 1 M KCl of the peat soil were 3.84 and 2.67, respectively. These low values were typical of tropical peat soils^[1,18,19]. The organic matter and total organic carbon contents of the soil were 64.70 and 37.52 %, respectively. These values also are typical of Hemists of Sarawak, Malaysia^[1].

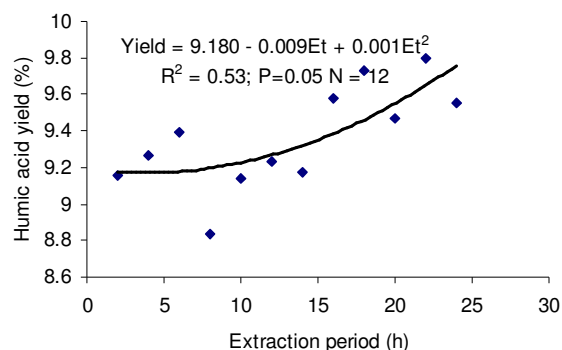


Fig.1 : Relationship between extraction period (Et) and humic acid yield (yield)

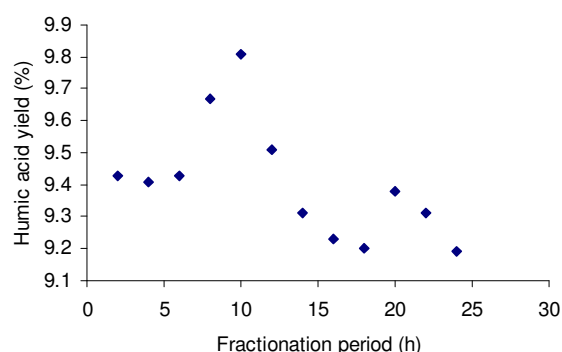


Fig.2 : Relationship between fractionation period (Ft) and humic acid yield (yield)

As presented in Figure 1, there was a quadratic relationship between extraction period and the yield of humic acids from the peat soil investigated. Although this finding is in agreement with several observations that the yield of humic acids increases with extraction time^[9,15], it must however be stressed that in this work, the maximum extraction period was relatively shorter

(4.5 h). Apart from retarding or minimizing depolymerization of high molecular-weight complexes, the solubilization of the peat soil increased with increasing time. This could be attributed to the fact that the exchange process of K ions at the exchange sites of for instance hydroxyl (alcoholic and phenolic) and carboxylic functional groups of the peat soil progressed with extraction period till a the maximum period when most of the exchange sites may have been saturated with K ion. This process might have made the peat soil highly soluble and therefore the maximum yield at the extraction of period of 4.5 h. Another reason could be the difficulty of extracting the humic acids in the initial shorter period such as 2 h due to the difficulty of wetting the peat soil because of irreversible drying associated with peat soils when dried.

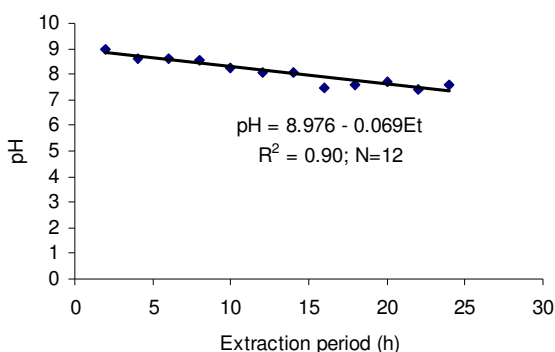


Fig.3 : Relationship between extraction period (Et) and pH

At this juncture, it is appropriate to stress that in a situation where characterization of the humic acids is of interest instead of the quantity of humic acids isolated, an optimum extraction period, 4.05 (i.e. less 10 % of maximum extraction period of 4.5 h; corresponding to optimum yield of 9.23 %) or less could be considered because the longer the extraction period, the greater will be the chemical changes^[3]. Optimum extraction period was estimated as 90 % of the maximum extraction period^[15] equivalent to humic acids yield of 9.23 %, above which this yield will not be significantly different in terms of time from the maximum yield and, hence, economically not viable.

Contrary to period of extraction, there was no significant relationship between the period of fractionation and yield of humic acids (Fig. 2) regardless of extraction periods investigated. This suggests that the humic acids yield was not affected by fractionation period. As a result, it is reasonable to assume that the maximum period in this study is 2 h because the fractionation period was sufficient for the hydrogen ions to displace potassium ions and other

cations in order to saturate the exchange complexes of the humic acids immediately after acidification of the extracted humic and fulvic acid solutions (supernatant). Furthermore, even though there was a linear relationship between extraction period and pH of supernatant (Fig. 3) and also a negative correlation between yield of humic acids and pH ($r = -0.76^{**}$, $N = 12$; $P=0.01$), fractionation period did not relate to humic acids yield. It could be that other hydrogen ions displaced by K ions during the extraction process may have come from other organic compounds such as fulvic acids which were excluded during the fractionation process.

The humic acids yields of extraction and fractionation periods correlated negatively ($r = -0.75^{**}$, $N = 12$; $P=0.01$), suggesting an interaction between these factors. This observation is under investigation.

CONCLUSIONS

The relationship between period of fractionation and yield of humic acids from peat soil (hemists) in this study is quadratic. The optimum and maximum yields of humic acids can be obtained at extraction periods of 4.05 and 4.50 h, respectively. There is no significant relationship between period of fraction and yield of humic acids. Therefore, for economic reasons, 2 h is sufficient to equilibrate humic acids immediately after acidification only for this peat soil. The significance of this study is that humic acids can be isolated in less than 10 h instead of the existing average period of 48 h. This in a way may facilitate the idea of producing ammonium-humate or K-humate (N and K organic fertilizers) from peat soils.

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