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EFFECT OF HASIL TANI ORGANIC COMPOUND PRODUCT (HTOC) ON THE RECOVERY OF SOFT SOIL IN RICE FIELD MADA ALOR SENIBONG, KEDAH, MALAYSIA

(KESAN PRODUK HASIL TANI ORGANIC COMPOUND (HTOC) KE ATAS PEMULIHAN TANAH JERLUS DI SAWAH PADI MADA ALOR SENIBONG, KEDAH, MALAYSIA)

Muhammad Rendana, Wan Mohd Razi Idris, Zulfahmi Ali Rahman, Sahibin Abdul Rahim, Tukimat Lihan & Habibah Jamil

Abstract

Soft soils are generally the major problem in decreasing rice production in Kedah. A study was conducted to recovery of soft soil in rice cultivation area using "Hasil Tani Organic Compound" (HTOC) product. The study was conducted within at selected rice field with soft soil problem under Lembaga Kemajuan Pertanian Muda (MADA) area in Alor Senibong Kedah, Malaysia. The sampling period was divided by two phases; before applying HTOC (May 2016) and after applying HTOC (September 2016) during one season. High moisture content of soft soils caused soft and weak soil strength, which delay the formation of hardpan layer. The application of HTOC could increase soil strength and reduced moisture content. The Zeolite material of HTOC was useful for assisting water infiltration and retention due to its porous properties and the capilary suction. HTOC was a good soil amendment which was that unlike gypsum and lime, it did not break down over time but remain in the soil to help improving nutrient and water retention permanently. HTOC required to increase soil strength (≥ 0.40 MPa) in order to support the load of heavy agricultural machines was 0.25 t ha $^{-1}$. Due to the HTOC application, recovery of soft soil could be done successfully. After being treated with HTOC, soil strength increased from 0.24 to 0.43 MPa at 0-100 cm soil depth. Bulk density and hydraulic conductivity values increased 1.01-1.04 g cm^{-3} and 0.19-0.30 cm hr^{-1} respectively, while soil moisture content decreased 11.87-6.58 %. In general, the application of HTOC product could be highly recommended to recovery of soft soil in rice cultivation areas and consequently enhanced rice yield.

Keywords: Rice production; soft soil; soil amendment; soil moisture; soil strength

Abstrak

Tanah jerlus adalah masalah utama dalam penurunan pengeluaran beras di Kedah. Satu kajian telah dijalankan untuk memulihkan tanah jerlus di kawasan penanaman padi menggunakan produk "Hasil Tani Organic Compound" (HTOC). Kajian ini dijalankan di kawasan sawah padi terpilih yang didapati masalah tanah jerlus di bawah kawasan Lembaga Kemajuan Pertanian Muda (MADA) di Alor Senibong Kedah, Malaysia. Tempoh persampelan dibahagikan kepada dua fasa iaitu; sebelum aplikasi HTOC (Mei 2016) dan selepas aplikasi HTOC (September 2016) dalam satu musim. Nilai kandungan kelembapan yang tinggi pada tanah jerlus menyebabkan kekuatan tanah menjadi lemah dan jerlus, yang *mana melambatkan pembentukan lapisan hardpan. Penggunaan HTOC boleh meningkatkan kekuatan tanah dan mengurangkan kandungan lembapan. Bahan Zeolit HTOC berguna untuk membantu penyusupan dan pengekalan air disebabkan oleh sifat berliang dan sedutan kapilari yang dimiliki bahan tersebut. HTOC adalah bahan pembaikpulih tanah yang baik, tidak seperti gipsum dan kapur, yang mana ia tidak hilang dari masa ke masa tetapi tetap ada di dalam tanih bagi membantu meningkatkan pengekalan nutrien dan air dalam tanih secara kekal. HTOC yang diperlukan untuk meningkatkan kekuatan tanah (≥ 0.40 MPa) untuk dapat menyokong berat mesin pertanian adalah 0.25 t ha^{-1}. Kerana aplikasi HTOC tersebut, pemulihan tanah jerlus boleh dilakukan dengan jayanya. Selepas dirawat dengan HTOC, kekuatan tanah meningkat dari 0.24 hingga 0.43 MPa pada kedalaman tanih 0-100 cm. Nilai ketumpatan pukal dan kekonduksian hidraulik tanih meningkat 1.01-1.04 g cm^{-3} dan 0.19-0.30 cm hr^{-1} masing-masing, manakala peratus kandungan kelembapan tanih menurun 11.87-6.58%. Secara amnya, penggunaan produk HTOC boleh disyorkan untuk pemulihan tanah jerlus di kawasan-kawasan penanaman padi dan seterusnya meningkatkan hasil padi.*

Kata kunci: *Kekuatan tanih; Kelembapan tanih; pembaikpulih tanih; pengeluaran padi; tanah jerlus*

INTRODUCTION

Increasing population and economic development are continuing to put a great challenge and pressure on global demand for rice particularly in developing countries. Rice is a primary food for Malaysians. Therefore, the government of Malaysia realizes that it needs to increase in rice production. One of the rice production issues that need to be solved is the problem of soft soil in rice cultivation areas. Soft soil is distinguished by high compressibility and low strength (Wang et al. 2014). The depth and width of soft zone are governed by high soil moisture, causing low structural porosity and high structural deformation. It is well documented that decreased in bulk density coupled with increasing in soil moisture caused reduction in permissible ground pressure of agricultural machines for field activities (Hakansson & Lipiec 2000; Chehaibi et al. 2012). High moisture content and low permeability of soft soil also cause the waterlogged patches of water in the rice field. The waterlogged condition will result in poor seed germination and also causes soft and weak soil strength, which delay the formation of hardpan (Azizul 2008). This condition hinders the working efficience in the field due to the ground is not able to support the load pressure of agricultural machines (Glab & Szewczyk 2015). Lembaga Kemajuan Pertanian Muda (MADA) has stopped the agricultural activities on the fields that encountered to soft soil problem. This way is conducted to make time range in order to hardpan layer dried and harden, but this process takes a long period of time, which it will definitely decline the rice production. Raising soil strength and soil properties will mitigate the soft soil problem. Organic matter plays important role in raising soil strength by binding soil particles in order to avoid the dispersion and slaking processes which are common occurred in soft soils. High organic matter will cause high stability index, high soil properties and productivity (Wortman & Jasa 2003). There are two types of lime often used to increase the soil properties is dolomite and limestone. Lime treatment for rice cultivation is normally about 3 t ha^{-1} yr^{-1} (MARDI 2002). An alternative product that could potentially act as lime to increase soil strength and physical and chemical properties of soil in rice field is the Hasil Tani Organic Compound (HTOC). This product is manufactured by using organic component consisting of wood residuals as well as humic acid and zeolite mineral in a specific ratio (Sahibin et al. 2016). Both of components have role to increase the stability of soil structure and absorb the exceess water in soil pores to expedite the formation of hardpan layer. The study of this product has been done in the laboratory and in the field during rice cultivation period. This paper reports the results of studies that have been done.

MATERIAL AND METHOD

Soft soil samples for this study were collected from the MADA rice cultivation area. A field of study with soft soil problem was located at Alor Senibong, Langgar, Kedah (6°6'15.19"N and 100°27'55.74"E). A total of three soil core samples (0-30 cm soil depth) at selected soft soil zones was taken from the field. Then, they were brought to the laboratory for analysis. In-situ measurement of soil strength has been done by using a specific tool namely Hand Penetrometer Eijelkamp with the cone size approximately 5 cm^2. In this study, the soft soils from the field were sampled and measured their strength twice during one season that were before applying HTOC (May 2016) and after applying HTOC (September 2016). For field study the rate of soil treatment using the HTOC is 0.25 t ha^{-1}. HTOC was applied after the first plowing activities using a portable sprayer with capacity of 200 L. In the laboratoiy the core samples were dried, ground and sieved with 2 mm siever. Analysis of physical and chemical properties of the soft soil and the HTOC product were carried out. The physical and chemical properties of the soil that was determined such as particle size distribution, moisture content, organic matter content, hydraulic conductivity, bulk density, cation exchange capacitiy, pH, electrical conductivity and nutrients contents. All determination was done using standard methods.

RESULT AND DISCUSSION

BASIC PROPERTIES OF HASIL TANI ORGANIC COMPOUND (HTOC)

Hasil Tani Organic Compound (HTOC) product had a high organic matter content of 41.59 % with a pH as high as 7.98. Electrical conductivity was around 1.11 dS m^{-1}. Total macronutrients occupied by C, S, Mg, N, K, Na, Ca and P in decreasing concentration order. Cation exchange capacity was as high as 234 $cmol_c\ kg^{-1}$, the value was affected by cation exchange capacity of pure organic matter of HTOC that was also high around 200 $cmol_c\ kg^{-1}$. While some common zeolite minerals like clinoptiolite was well documented with owning high cation exchange capacity around 71.30 $cmol_c\ kg^{-1}$ (Perumal et al. 2015).

Table 1. Basic properties of Hasil Tani Organic Compound (HTOC) product

Parameter	HTOC
Organic matter (%)	41.59±0.02
pH	7.98±0.01
Electrical conductivity (dS m^{-1})	1.11±0.02
Total C (%)	25.80±0.01
Total S (%)	2.12±0.01
Total N (%)	0.89±0.01
Total P (%)	0.03±0.01
Total K (%)	0.78±0.01
Total Mg (%)	1.14±0.02
Total Ca (%)	0.10±0.01
Total Na (%)	0.76±0.01
Cation exchange capacity ($cmol_c\ kg^{-1}$)	234±0.02

EFFECT OF HTOC ON SOFT SOIL PHYSICAL PROPERTIES

In Table 2 the initial moisture content of soft soil was high around 11.87 % but after being treated with HTOC, soil moisture has decreased around 6.58 %. Decreasing in soil moisture was caused by the isolated components (zeolite and humic acid) of the HTOC which capable to absorb the excess water in the soil. Soil moisture was the most critical factor that makes soil susceptible to loosen, as soil strength decreases and soil water potential increases. In other words, rising soil moisture caused reduction in macropore spaces and lead to decline in load support capacity of the soil and permissible ground pressure. The application of HTOC also resulted in increasing bulk density. The result of study reported that HTOC has altered bulk density and porosity of soft soil by increasing soil aggregates formation. Bulk density was related to soil strength as it was able to be an indicator to soil compaction. The hydraulic conductivity of soft soil tested was very slow around 0.19 cm hr^{-1}. This shows that soil permeability decreased and soil became waterlogged upon wetting. After being treated with HTOC the hydraulic conductivity value increased around 0.30 cm hr^{-1}. HTOC assisted water infiltration and retention; it gave high hydraulic conductivity to clay. Organic matter of soil increased from 3.31 to 4.76 % after being treated with HTOC. The humic acid of the HTOC attached to soil particles, especially clay particles and binded microsoil and macrosoil aggregates, thus preventing soil from become loosen by the action of heavy agricultural machines.

EFFECT OF HTOC ON SOFT SOIL CHEMICAL PROPERTIES

The soil under investigation was low in pH and high in exchangeable Al. This low pH was consistent with the presence of jarosite in the soil, which qualified it to be classified as an acid sulphate soil. After being treated with the HTOC product, pH of soft soil has risen from 3.20 to 3.34 (Table 2). The initial cation exchange capacity of the soil was 15.43 $cmol_c$ kg^{-1} after being treated with HTOC the value slightly increased around 15.86 $cmol_c$ kg^{-1}. Base saturation exceeded 80%, with the cation exchange sites occupied by Na, Mg, K and Ca in decreasing concentration order. The ratio of sodium to other ions at these changes sites is high, thus clay particles (> 50 % composition in this soil) were less tightly bound to each other and the soil aggregates easily dispersed when the soil become wet. Sodium was a poor flocculator, it would make clay tend to dispersed and plugged soil pores resulting in reduced soil permeability. This showed in the study areas, which there were waterlogged patches on the surface of soft soil zones. Surface crusting was also characteristic of sodium affected soil, which also found at the study area when the rice field dried. After treatment, high cation exchange capacity of the HTOC acted to exchange sodium for calcium of HTOC, while humic acid of the HTOC helped to buffer the effects of high salt by dissolving calcium compounds that naturally occured in the soil. This was proven by exchangeable sodium decreased at 6.25 $cmol_c$ kg^{-1}. The humic acid of HTOC assisted to increase total C in soil ranging from 1.69 to 3.01 %. Electrical conductivity of soft soil tested increased from 0.21 to 0.23 dS m^{-1}, while total S decreased from 0.09 to 0.06 %.

Table 2. Effect of HTOC on soft soil physical and chemical properties at 0-30 cm depth

Parameter	Before Applying HTOC (*May 2016*)	After Applying HTOC (*September 2016*)
Sand (%)	13±0.62	8±0.54
Silt (%)	31±2.50	35±2.62
Clay (%)	56±2.45	57±2.69
Texture	Clay	Clay
Moisture content (%)	11.87±3.28	6.58±0.98
Organic matter (%)	3.31±1.43	4.76±0.62
Bulk density (g cm^{-3})	1.01±0.01	1.04±0.01
Hydraulic conductivity (cm hr^{-1})	0.19±0.01	0.30±0.13
pH	3.20±0.18	3.34±0.01
Electrical conductivity (dS m^{-1})	0.21±0.03	0.23±0.26
Exchangeable Al ($cmol_c$ kg^{-1})	1.97±0.44	1.73±0.44
Exchangeable H ($cmol_c$ kg^{-1})	0.84±0.12	0.92±0.50
Exchangeable Ca ($cmol_c$ kg^{-1})	2.33±0.51	1.72±0.48
Exchangeable Mg ($cmol_c$ kg^{-1})	1.96±0.21	3.17±1.12
Exchangeable Na ($cmol_c$ kg^{-1})	6.43±0.34	6.25±0.02
Exchangeable K ($cmol_c$ kg^{-1})	1.90±0.07	2.07±0.13
Cation exchange capacity ($cmol_c$ kg^{-1})	15.43±0.72	15.86±0.61
Base saturation (%)	82±3.79	83±4.07
Total C (%)	1.69±0.89	3.01±0.14
Total S (%)	0.09±0.01	0.06±0.02

EFFECT OF HTOC ON SOFT SOIL STRENGTH

The effect of HTOC on soft soil strength at 0-100 cm depth was presented in Figure 1. This figure showed an increase in the soil strength as HTOC added to the soil. The initial of mean soil strength value was 0.24±0.03 MPa which then changed to 0.43±0.07 MPa when added with HTOC. The threshold value of soil strength where it could induce high pressure from agricultural machines was 0.40 MPa. This means that the use of 0.25 t HTOC ha^{-1} was sufficent to raise the soft soil strength to 0.43 MPa, which exceeding the threshold value. In this study, it was observed that soil strength was affected by moisture content, bulk density and exchangeable Na. It means that as the exchangeable Na and moisture content increase, the soil strength decreases. The soil strength negatively correlated with exchangeable Na (Figure 2a) and moisture content (Figure 2b) and the corresponding relationship was given by equation Y= -0.1507x + 1.2889 (R^2=0.14) and Y= -0.0175x + 0.4967 (R^2=0.36), respectively. On the other hand, soil strength and bulk density showed a highly positive correlation (Figure 2c) with the equation was given by Y= 6.6998x - 6.5178 (R^2=0.89).

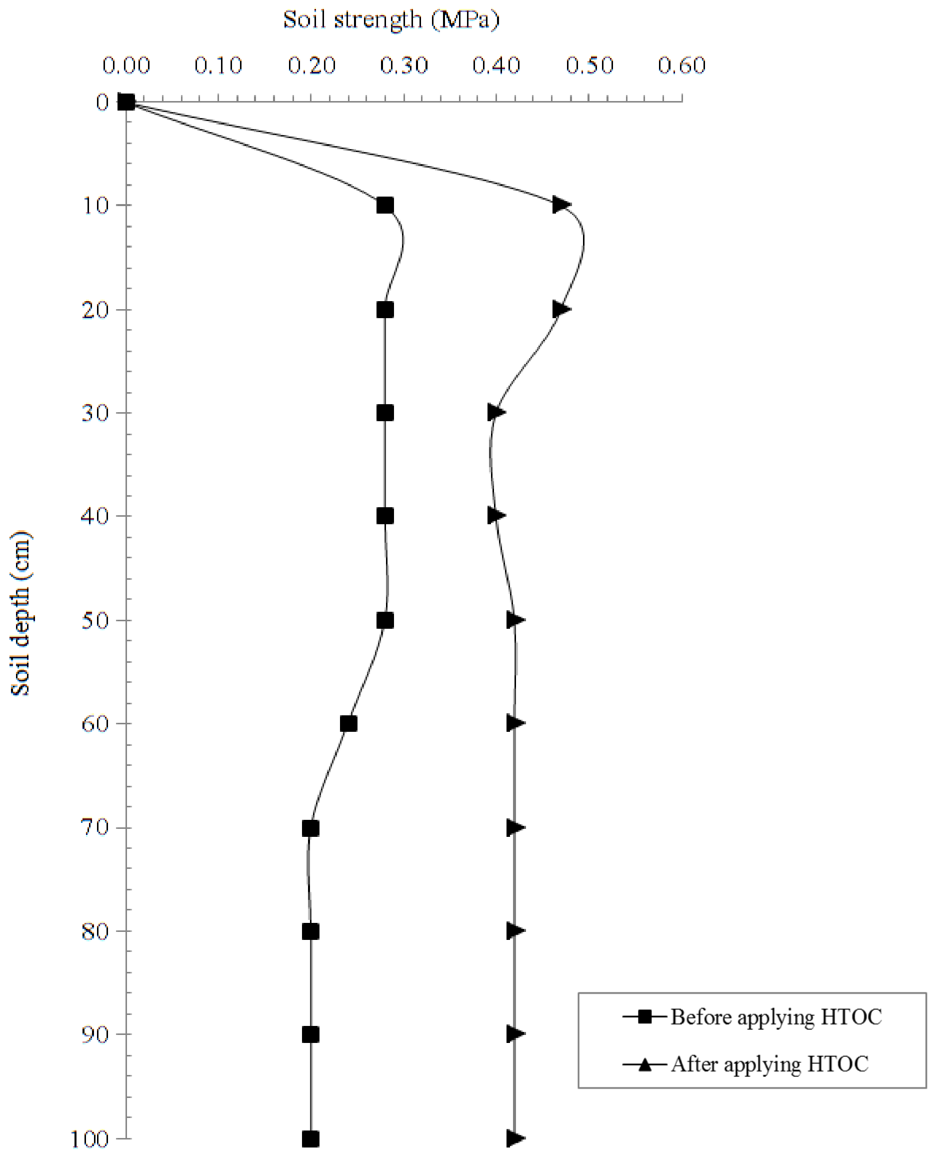

Figure 1. Effect of HTOC on soft soil strength at 0-100 cm depth

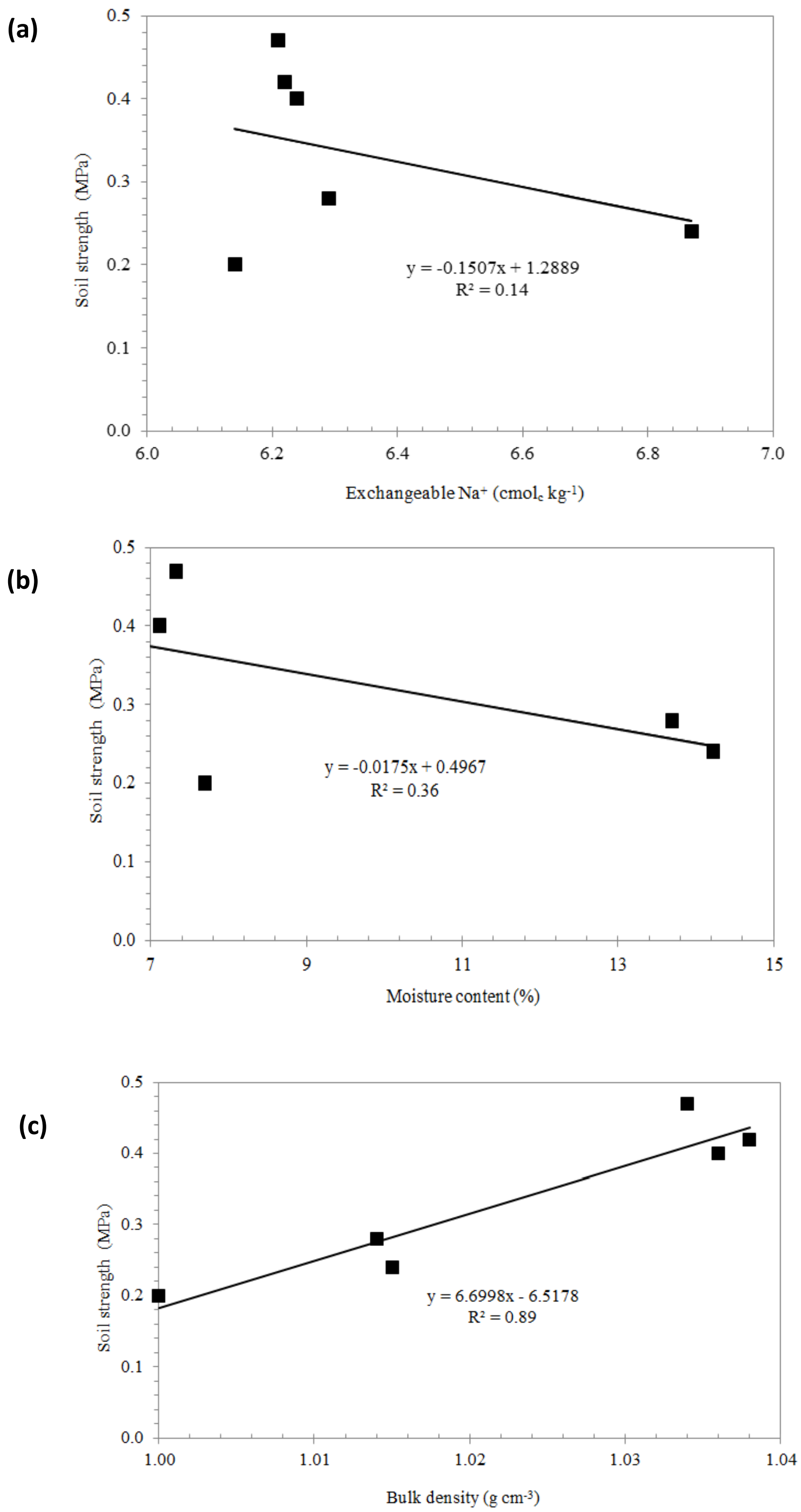

Figure 2. Relationship between soil strength and (a) exchangeable Na, (b) moisture content (c) and bulk density

CONCLUSIONS

Result of studies showed the use of Hasil Tani Organic Compound (HTOC) product, a branded land reconditioning material available in the market have the potential to recovery of soft soil which has been occurring in rice field areas with increasing soil strength and changing some critical physical and chemical properties of soil such as moisture content, organic matter and exchangeable cations to a range that was high soil stability index, high soil quality and productivity for rice cultivation.

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Muhammad Rendana
School of Environmental and Natural Resource Sciences,
Faculty of Science and Technology,
The National University of Malaysia,
43600 Bangi, Selangor Malaysia
Email: P89046@siswa.ukm.edu.my

Wan Mohd Razi Idris
School of Environmental and Natural Resource Sciences,
Faculty of Science and Technology,
The National University of Malaysia,
43600 Bangi, Selangor Malaysia
Email: razi@ukm.edu.my

Zulfahmi Ali Rahman
School of Environmental and Natural Resource Sciences,
Faculty of Science and Technology,
The National University of Malaysia,
43600 Bangi, Selangor Malaysia
Email: zarah1970@ukm.edu.my

Sahibin Abdul Rahim
School of Environmental and Natural Resource Sciences,
Faculty of Science and Technology,
The National University of Malaysia,
43600 Bangi, Selangor Malaysia
Email: haiyan@ukm.edu.my

Tukimat Lihan
School of Environmental and Natural Resource Sciences,
Faculty of Science and Technology,
The National University of Malaysia,
43600 Bangi, Selangor Malaysia
Email: matt@ukm.edu.my

Habibah Jamil
School of Environmental and Natural Resource Sciences,
Faculty of Science and Technology,
The National University of Malaysia,
43600 Bangi, Selangor Malaysia
Email: bib@ukm.edu.my

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