EFFECT OF SOIL AMENDMENTS AND CHICKEN MANURE ON THE GROWTH AND YIELD OF TR-9 PADDY VARIETY PLANTED ON BRIS SOIL

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ABSTRACT

This study was carried out at the Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, Sandakan Campus from April 2015 to October 2015 to evaluate the effect of different type of soil amendments incorporated with different application rates of chicken manure on the growth and yield of TR-9 paddy variety planted on Beach Ridges Interspersed with Swales (BRIS) soil and to evaluate the effect of different types of soil amendments and different application rates of chicken manure on nutrient content of the BRIS soil at the end of the experiment. Treatment were three soil amendments (nil (control), biochar and vermicompost) and four chicken manure rates (0, 15, 30 and 45 t ha^{-1}) that were arranged in complete randomized design with three replications. Data collected was analyzed with two- ways Analysis of Variance (ANOVA) at 5 % significance level. These results revealed that there was no significance effects of soil amendments and chicken manure rates on vegetative growth, yield components and BRIS soil chemical properties. There was a significant effect of soil amendments or significant effect of chicken manure rates on mean plant height (91.04 - 115.37 cm), mean number of tillers (26.22 - 38.11), mean culm height (63.45 - 75.69 cm), mean number of panicles (26.11 – 37.00), mean length of panicles (22.15 - 24.95 cm), mean percentage of filled grains (83.59 - 87.71 %), mean percentage of empty grains (12.31 - 16.40 %), mean weight of 1000 grains (25.28 - 26.22 g) and mean extrapolated yield (5.25 - 11.79 tons ha^{-1}). There was no significant effect (percentage of productive tillers) on soil amendments and effect on chicken manure (66.59 - 77.60 %). There was also no significant effect (mean percentage of dry matter) on soil amendments and effect on chicken manure (61.79 % - 66.11 %). After application of different soil amendments incorporated with different chicken manure rates to BRIS soil, value for pH change from 4.46 to 4.30 - 5.49, soil organic matter change from 5.49 % to 5.20 - 5.67 %, soil total nitrogen increase from 0.167 % to 0.219 - 0.231 %, soil available phosphorus change from 1.27 ppm to 0.29 - 3.94 ppm, soil cation exchange capacity increase from 7.77 $cmol_{(+)}$ kg^{-1} to 17.78 - 23.37 $cmol_{(+)}$ kg^{-1}. Recommendations that can be suggested to farmers are biochar incorporated with 45 t ha^{-1} chicken manure (E2C4) and vermicompost incorporated with 45 t ha^{-1} chicken manure (E3C4). This is because E2C4 gave highest mean extrapolated yield (E2 =9.91 tons ha^{-1}, C4 = 11.79 tons ha^{-1}), highest mean percentage of filled grains (E2 = 86.78%, C4 = 87.71%) and highest mean soil organic matter (E2 = 5.62 %, C4 = 5.67 %).

KESAN BERLAINAN JENIS PEMBAIK TANAH DAN BERLAINAN KANDUNGAN NAJIS AYAM TERHADAP PERTUMBUHAN DAN HASIL PADI VARIETI TR-9 YANG DITANAM PADA TANAH BRIS

ABSTRAK

Kajian ini dijalankan di Fakulti Pertanian Lestari, Universiti Malaysia Sabah Kampus Sandakan (UMSKS) dari April 2015 hingga Oktober 2015 untuk menilai tentang kesan berlainan jenis pembaik tanah disebatikan dengan baja organik najis ayam terhadap pertumbuhan dan hasil padi varieti TR-9 yang ditanam pada tanah BRIS dan menilai tentang kesan berlainan jenis pembaik tanah disebatikan dengan baja organik najis ayam terhadap kandungan nutrisi tanah BRIS selepas kajian. Rawatan tersebut adalah tiga jenis pembaik tanah (nil, sekam padi, vermikompos) dan empat kadar baja organik najis ayam (0, 15, 30 dan 45 t ha^{-1} najis ayam) diatur menggunakan reka bentuk rawak secara keseluruhan (CRD) dengan tiga replikasi. Data yang dikumpul akan dianalisis dengan menggunakan analisis varians dua hala atas keertian 5%. Keputusan bagi kesan pembaik tanah disebatikan dengan najis ayam tidak menunjukkan perbezaan min yang signifikan terhadap pertumbuhan vegetatif, komponen hasil pokok padi dan sifat kimia tanah BRIS. Keputusan bagi kesan pembaik tanah atau kesan baja organik najis ayam menunjukkan perbezaaan min yang signifikan terhadap purata ketinggian pokok padi (91.04 - 115.37 sm), purata bilangan anakan padi (26.22 - 38.11), purata ketinggian batang padi (63.45 - 75.69 sm), purata bilangan tangkai (26.11 - 37.00), purata panjang tangkai (22.15 - 24.95 sm), purata peratusan bilangan butiran padi penuh (83.59 - 87.71 %), purata bilangan butiran padi kosong (12.31 - 16.40 %), purata berat 1000 butiran padi (25.28 - 26.22 g) dan purata unjuran hasil (5.25 - 11.79 tan ha^{-1}). Keputusan bagi purata peratusan anakan padi yang produktif (66.59 - 77.60 %) tidak menunjukkan perbezaaan min yang signifikan dalam kesan pembaik tanah dan baja organik najis ayam. Keputusan bagi purata peratusan berat kering (61.79 % - 66.11 %) tidak menunjukkan perbezaan min yang signifikan dalam kesan pembaik tanah dan baja organik najis ayam. Selepas rawatan, pH tanah BRIS berubah dari 4.46 ke 4.30-5.49, kandungan bahan organik tanah berubah dari 5.49 % ke 5.20 - 5.67 %, jumlah nitrogen kandungan tanah meningkat dari 0.167 % ke 0.219 - 0.231 %, kandungan fosforus tanah berubah dari 1.27 ppm ke 0.29 - 3.94 ppm dan bilangan kapasiti pertukaran kation meningkat dari 7.77 smol kg^{-1} ke 17.78 - 23.37 smol kg^{-1}. Rawatan yang dapat dicadangkan kepada petani ialah sekam padi disebatikan dengan 45 t ha^{-1} najis ayam (E2C4) dan vermikompos disebatikan dengan 45 t ha^{-1} najis ayam (E3C4). Ini disebabkan E2C4 memberikan purata unjuran hasil yang tertinggi (E2 =9.91 tan ha^{-1}, C4 = 11.79 tan ha^{-1}), purata peratusan butiran padi penuh yang tertinggi (E2 = 86.78%, C4 = 87.71%) dan purata kandungan bahan organik tanah yang tertinggi (E2 = 5.62 %, C4 = 5.67 %).

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%	Percentage
ANOVA	Analysis of Variance
BRIS	Beach Ridges Interspersed with Swales
CEC	Cation Exchange Capacity
$cmol_{(+)}\ kg^{-1}$	Centimole per kilogram
CRD	Completely Randomized Design
DNA	Deoxyribonucleic acid
FAO	Food and Agricultural Organization
FSA	Faculty of Sustainable Agriculture
ha	Hectare
IRRI	International Rice Research Institute
K	Potassium
K_2O	Potassium oxide
m	meter
m^2	Meter square
MOP	Muriate of Potash
N	Nitrogen
OECD	Organization for Economic Co-operation and Development
P	Phosphorus
P_2O_5	Phosphorus pentoxide
ppm	Part per millions
RHB	Rice Husk Biochar
RNA	Ribonucleic acid
SHC	Saturated Hydraulic Conductivity
SSL	Self Sufficient Level
t	tons
TSP	Triple Super Phosphate
WHC	Water Holding Capacity
XSF	Xylem Sap Flow

CHAPTER 1

INTRODUCTION

1.1 Background

Rice is the staple food in Asia and nearly 90 - 91% of the world's rice is produced and consumed in this region (Maclean *et al.*, 2002). It provides an average of 32% of total calories uptake (Maclean *et al.*, 2002). In Asia, irrigated lands cover approximately 271 million hectares of crops with rice cultivation accounting up to 46% of the total land area (Dawe, 2005). 75% of the global rice produced in the irrigated lowlands and 50% of that irrigated rice are produced in Asia (Maclean *et al.,* 2002). Total rice production in Malaysia on 2011 was estimated at 2.58 million tonnes with total rice consumption at 2710 tonnes and produced about 3530 tonnes of rice waste after production (FAOSTAT, 2014). Currently, Malaysia has achieved 72 % of rice self-sufficiency (Rusli *et al.*, 2013). However, Existing areas of rice cultivation have been redeveloped for plantation purpose as well as for housing and industrial real estate. Moreover, the Malaysian government acknowledge the need to increase self-sufficiency level (SSL) in rice production from 73% to 86% (Elisa *et al.*, 2014). Therefore, in order to increase SSL, there are two possible solutions in increasing SSL through expansion of rice cultivation area and increasing yield per unit area. At present condition, with scarcity of good and fertile lands, minimal expansion in rice area can be expected, coupled with slow increase in rice yield. In reality, growth in rice production is in contrast to demand. In such situation, farmers need to increase their rice production on land that is previously idle and less fertile such as Beach Ridges Interspersed with Swales (BRIS) soil land which is being abandoned will be look forward again for rice cultivation.

Additional components added through soil amendments such as rice husk biochar helps to improve BRIS soil fertility. It can acts as a better soil amendment in order to increase soil fertility, carbon sequestration potential and to reduce the negative effects of rice-based wetland systems on global climate. Biochar is a carbon-rich product obtained when biomass is heated in a closed container with little or no available air. Besides that, biochar can act as a soil conditioner, enhancing plant growth by retaining nutrients in order to provide various services such as improving the physical and biological properties of soils (Glaser *et al.*, 2005). Addition of biochar into soil improves soil fertility (Rodríguez *et al.*, 2009), reduces green house gas emission and increases carbon sequestration (Lehmann *et al.*, 2007). Besides that, biochar as one of the soil amendment are able to increase seedling from wilting (Mulcahy *et al.*, 2013). It can increase water holding capacity with additions of only 5% biochar in mass of top soil (Case *et al.*, 2012). Asai *et al.* (2009) also directly measured the influence of biochar on the water holding capacity in two separate locations in Laos and the saturated hydraulic conductivity of the surface soil and the xylem sap flow of rice plants.

In addition, vermicomposting is a simple bio-technological process of composting where only selected species of earthworms are used that will undergo the process of waste conversion and produce a best quality end product. Vermicomposting differs from composting in several ways (Gandhi *et al.*, 1997). It is a mesophilic process, utilizing microorganisms and earthworms that are active at 10 – 32°C (not ambient temperature but temperature within the pile of moist organic material). This process is faster than composting because the material passes through the earthworm gut. Furthermore, earthworm castings (worm manure) are rich in microbial activity and plant growth regulators, and able to fortify with pest repellence attributes. Besides that, earthworms through a type of biological alchemy are capable of transforming plant or animal residue into 'gold' (Tara, 2003). It can improved seed germination, enhanced seedling growth and development and increased overall rice plant productivity. Vermicompost can help to increase rice plant height, leaf area index, panicle length and grain yield.

Chicken manure can also be used to improve soil quality as it helps to speed up the release of nutrients. This enriches the soil and helps for the growth of plants. The most vital benefit of using chicken manure is the ability to condition the soil. On the other hands, mixing chicken manure with sandy soils helps to retain moisture levels and help to loosen the soil. Chicken manure helps to increase soil carbon that is a high source of energy used by plants in absorption of nutrients. The use of manure also reduces runoffs and nitrate leaching (Nikki, 2014). The narrower carbon-nitrogen chain ratio (C:N) in chicken manure enable faster mineralisation allowing quicker availability of nutrients for plants.

1.2 Justification

BRIS soil is a problematic soil which is highly sandy and low water holding capacity and low fertility. Thus, soil amendments like biochar and vermicompost which proves that, it can help to improve the problematic soil with the incorporation of chicken manure.

Wastes can be converted into nutrient rich bio-fertilizer (vermicompost) for sustainable land restoration practices. At the same time, vermicompost can improve soil structure, improve nutrient exchange and maintain soil health. Vermicompost contains nitrogen, phosphorous, potassium and micro nutrients. Microbial and enzyme activities and growth regulators as continuous and adequate use with proper management can increase soil organic carbon, soil water retention and transmission and improvement in other physical properties of soil like bulk density, penetration resistance and aggregation as well as beneficial effect on the growth of a variety of plants.

Biochar has beneficial effects on the chemical, physical and biological soil properties, besides contributing to enhance crop biomass and yield. Biochar incorporation can alter soil physical properties such as structure, pore size distribution and density, with implications for soil aeration, water holding capacity, plant growth, and soil workability. Evidence suggests that biochar application into soil may increase the overall net soil surface area and consequently, may improve soil water and nutrient retention and soil aeration, particularly in fine-texture soils. Thus it can help to improve water holding capacity on BRIS soil.

At the same time, the addition of chicken manure in BRIS soil will be able to increase water holding capacity and reduce nitrate leaching. It also provides essential nutrients for the growth of rice plants.

1.3 Significance of the Study

This study seeks to improve the quality of sandy soil to enable agriculture cultivation in areas with poor sandy soil content. BRIS soil can be exposing to the agriculturists and farmer for rice cultivation. As fertile soils are cultivated for other industrial crops such as oil palm and rubber trees, and etc. which left only poor land for rice cultivation. Throughout exposing with organic fertilizers and chemical fertilizers, BRIS soil fertility can be improved and suitable to be a rice field. Successful growth of rice plant in BRIS soil which can lead to a bright future for rice cultivation and food security problem can be solved.

Besides that, Tuaran, Sabah was the district that have large areas of rice field especially there are several locations in Kampung Serusup such as Padawan, Lok Bagiang and Taun Pinang by coastal fisherman come from rice farmer since its initial cultivation in 1990's but left abandoned in early 1970's due to no replacement of old generation. As same goes to those BRIS wet rice field once found at Kampung Shahbandar situated surrounds the area of Tuaran River. Besides that, a younger generation had earned a stable income which are affordable to buy the goods like rice to sustain in daily living thereby planting of rice for self-sufficient was relinquish. Abandon field can be re activate in order to solve the crisis of rice production and compete with other crops planted on fertile land.

Nevertheless, despite the high sandy content in BRIS soil, it is still able to cultivate crops such as watermelon, banana and chilli. This proves that, rice cultivation also can be culture in this soil. Succeed growth of rice plant in BRIS soil are able to overcoming the scarcity of rice production.

1.4 Objectives

The main objectives for this study are:

1) To evaluate the effect of different types of soil amendments and application rates of chicken manure on the growth and yield of TR-9 paddy variety planted on BRIS soil.

2) To evaluate the effect of different types of soil amendments and application rates of chicken manure on the nutrient content of the BRIS soil at the end of the experiment.

1.5 Hypotheses

H_{01}: Different types of soil amendments and application rates of chicken manure do not affect on the growth and yield of TR-9 paddy variety planted on BRIS soil.

H_{a1}: Different types of soil amendments and application rates of chicken manure do affect on the growth and yield of TR-9 paddy variety planted on BRIS soil.

H_{02}: Different types of soil amendments and application rates of chicken manure do not affect on the nutrient content of the BRIS soil at the end of the experiment.

H_{a2}: Different types of soil amendments and application rates of chicken manure do affect on the nutrient content of the BRIS soil at the end of the experiment.

CHAPTER 2

LITERATURE REVIEW

2.1 Paddy (*Oryza sativa*) Morphology

Rice plant is a semi aquatic annual grass that survives as a perennial in the tropics by producing new tiller from nodes after harvest (ratooning). At maturity stage, rice plant will produce a main stem and a number of tillers. Each productive tiller bears a terminal flowering head or panicle. Sessile leaf blades joined to the leaf sheaths with collars, well defined, sickle shaped and hairy auricles (Appendix A, 1) (IRRI, 1965). Plant height varies by variety and environmental conditions, ranging from approximately 0.4 m to over 5.0 m in some floating rice.

The rice grain (seed) consists of true fruit (caryopsis) and hull, which encloses the rice. Rice seeds consist of embryo and endosperm. Furthermore, the surface of rice seeds contain thin layers of differentiated tissues that enclose the embryo and endosperm. The hull of *indica* rice constitute the palea, lemmas and rachilla while in *japonica* rice, the hull includes rudimentary glumes and pedicel. A single grain weights about 10-45 mg in dry weight. Grain length, width, and thickness vary widely among varieties. Hull weight averages about 20% of the total grain weight.

Germination and seeding development begin when seeds absorbs adequate water and are exposed to temperature ranging from 10 to 40^{0}C. Germination begins physiologically when the radical or coleoptiles (embryonic shoot) emerges from the ruptured seed coat. *Oryza sativa* has three varietal types. Three types of varieties such as *indica, japonica* and *javanica. Oryza sativa indica* is suitable in tropical climate. It is sensitive to photoperiod and the grain shape are long and narrow. Plant colour are light green and tall. There have moderate number of tillers and susceptible to shedding of grain. Furthermore, it has medium to high yield potential and variable to seed dormancy. Additionally, it is susceptible to lodging.

2.2 Plant Growth and Development

The growth of rice plants undergoes three different phases: vegetative phase, reproductive phase and ripening phase (Appendix A, 2). Each phase is further divided into different stages as discussed below (IRRI, 1965).

The vegetative phase consists of four stages which are seedling, transplanting, tillering and vegetative lag phase. Seedling stage the rice seed are started to sprout into young seedling. Transplanting stage where it covers the time of uprooting and transplanting up to complete seedling. The tillering stage starts with the appearance of the first tiller from the axillary bud in one of the lowermost nodes. The increase in tiller number continues as a sigmoid curve until the maximum tiller number is reached, some tillers will death and the tiller number declines followed with levels off. The visible elongation of lower internodes may begin considerably earlier than the reproductive phase or at about the same time. Vegetative lag stage also known as photoperiod sensitive phase end with panicle initiation.

The second phase which is the reproductive phase consists of four stages: panicle initiation stage, booting stage, heading stage and flowering stage. Panicle initiation stage is the beginning of reproductive phase for maximum tillering stage. The internodes elongates during the booting stage due to the increase in auxin activity. Heading stage is the emergence of panicle tip or heading takes place after booting stage. Flowering stage is occur about 20-25 days after booting and followed by pollination and fertilization.

Third phase known as ripening phase. It consists of milk, dough and maturity stage. Milk stage occur after anthesis the watery content of the grain begins to turn thick milky between 7-12 days. Dough stage is milky grain turns into soft dough and then into hard dough stage in 14-21 days. Finally, maturity stage, grains turns into hard, clear, translucent colour.

2.3 Wetland Rice (Lowland Rice)

Rice can be grown under irrigated (lowland) or rain-fed (upland or lowland) conditions. Most classifications of rice environments are based on altitude (upland versus lowland) and water source (irrigated or rainfed). Rainfed lowland rice is grown in river deltas and coastal areas, using dike fields that are flooded with rainwater for at least part of the cropping season (Table 2.1). Rainfed upland rice is grown in mixed farming systems without irrigation and puddle. Upland environments are highly heterogeneous, with climates ranging from humid to sub-humid, soils from relatively fertile to highly infertile, and topography from flat to steeply sloping.

Table 2.1 Comparison between lowland and upland rice varieties

Lowland rice	Upland rice
Cultivated on level, dike, undrained soils	Cultivated on undulating or levelled
Water supply through rainfall or irrigation	Water supply through rainfall only
Direct seeding or transplanting	Direct seeding
Thin and shallow root system	Vigorous root system
Stable and high yield	Unstable and low yield

Source: Reddy, 2006

2.4 Characteristics of TR-9 Paddy Varieties

TR-9 paddy varieties also known as Seri Sabah and it was produced by International Rice Research Institute (IRRI), Los Banos, Philippines. The pedigree lines (IR 32809-26-3-3) of the variety are derived from a cross between BG90-21, IR 19661-131-1-12 and IR 4215-301-2-2-6. It takes about 123 to 133 days to mature. The number of grain per panicle is about 114-139. Additionally, the length of Rice is 9.9 mm with 2.9 mm width while rice is 7.3 mm long and 2.1 mm width. The grain quality is oval long while 1000 - grains weight is 23.5-25.5 g. Furthermore, shattering is moderate and percentage of milled rice is about 67-70%. Average extrapolated yield is 5.0-7.2 tons ha^{-1} (Appendix D, 1).

2.5 Soil Distribution in Malaysia

Malaysia covers an area of about 329,758 km^2 occupying the Malay Peninsula, which lies on the southern shores of the Asian land mass, and the States of Sabah and Sarawak in the northwestern coastal of Borneo Island (Nopparat, 2009).

Peninsular Malaysia consists of steep hills and mountain ranges, rolling to undulating land the coastal and riverine flood plains (Tej, 2004). The hill and mountain ranges cover about one-third of the plain surface of the Peninsula and run more or less parallel to the long axis of the country. The rolling to undulating land is found generally a seaward flanks and the intervening areas between the mountain ranges. The riverine flood plains are found as narrow belts of alluvium gently sloping away from the major rivers. Towards the coast they merge with the marine alluvium of the coastal plains.

Sabah is surrounded on three sides by seas. The physical pattern consists of narrow alluvial coastal plains backed by hilly, forested areas (Nieuwolt, 1982). The mountain of the interior have acted as barriers to inland penetration. The coastal plains and river valleys consist of marine and fluvial alluvium. Although the coastal plains form a small proportion of the total area they are the most important parts of the State in terms of settlement and agricultural and economic development.

Sarawak consists of a flat and swampy coastal area and steeply undulating hills in the interior (Nieuwolt, 1982). The coastal plains comprise deep peat and muck soils, and at various points along the coast raised beaches occur some distance inland from the coastline.

The major soils of Malaysia include acrisols, ferralsols, fluvisols, gleysols, luvisols, nitosols, lithosols, regosols, combisols and histosols. These include the shallow soils of the highlands, most of which are not utilized for agriculture, and the regosols of the alluvial plains. The acrisols and the ferralsols make up the major agricultural soils of the country. The fluvisols and gleysols are important in that they are being extensively cultivated with rice. Most of the sedentary soils with topography up to 20° slopes are cultivated with perennial crops such as rubber, oil palm, cocoa, spices and fruit tree (Tej, 2004). A clearly understanding on soil types in Malaysia which will help to reduce cost loss due to cash crop planted in unsuitable soil.

2.6 BRIS (Beach Ridges Interspersed with Swales) Soil

BRIS soil is a problematic soil and should be handle in terms of the physical capability classification and constraints like, limited ability to support crop growth, poorly structured, low water retention due to excessive accumulation of sediments and sand from undulating sea during the monsoon seasons that carries along coarse sand particles. BRIS (Beach Ridges Interspersed with Swales) soils in Peninsular Malaysia are mostly found near the coastal area in Terengganu with area of 67,582.61 ha, in Pahang around 36,017.17 ha, and Kelantan about 17,806.20 ha (Usman *et al.,* 2014). The total area of BRIS soils spread along the east coast of the Peninsular and the coastal area of Sabah is about 200,000 ha in total with 155,400 ha in Peninsular Malaysia and 40,400 ha in Sabah respectively (Appendix B, 2, 3 and 4). BRIS soil can be dividing into two orders, namely Entisol and Spodosol. Entisol is a young soil without a podogenetic horizon. It is found nearby sea area and has a high sand content. Spodosol is acidic soil with a sandy texture but unconstructed with a humus (acidic humus) content. The Department of Agriculture of Malaysia has identified and recommends seven types of BRIS soil based on depth, drainage and serial profile such as Rusila, Rhu Tapai, Rompin, Rudua, Baging, Jambu and Merchang (Shamsuddin, 1990). The BRIS soil series of Rompin, Rusila, Baging and Jambu are classified as sandy Entisol with a quartz composition, whereas only Rudua is included in the Spodosol order. Part of the country is covered by bris soils and these soils are derived from marine sands and have extremely low inherent soil fertility. Coconut, cashew and fruits are grown on the soils, and with some supplementary irrigation tobacco, groundnut, vegetables and watermelon are also cultivated. When economical methods to ameliorate the soils are available they could become potential areas for future agricultural development. BRIS soil is highly sandy, poor water holding capacity, low pH and low cation exchange capacity as compared to paddy soil (Table 2.2).

Table 2.2 Physical and chemical properties of paddy soil and bris soil

Properties	Paddy soil	BRIS soil
Sand texture (%)	Low	82-99
Water holding capacity	High	Low
pH	5.5-6.5	4.3-4.4
Cation Exchange Capacity (CEC)	>20 $cmol_{(+)}$/kg soil	< 5 $cmol_{(+)}$/kg soil

Source: Jabatan Pertanian Perak, 2010

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