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ในภาคตะวันออกเฉียงเหนือ

Study on Physical and Hydraulic Properties of Major Soil Series
in Northeast, Thailand

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ABSTRACT

The most important soil series in the Northeast are Korat and Roi-et soil series which cover 20% and 17% of the whole area respectively. Korat soil series represents upland soil while Roi-et soil series corresponds to lowland soil. Since the physical and hydraulic properties of soils are necessary for calculation, design, and modeling of many kinds of work, e.g. irrigation, drainage, hydrology, and the likes, this project was set up to study, experiment and compile physical and hydraulic properties of both soil series. The study was done to a depth of 100 cm of soil. Texture of both soils were analysed by sedimentation analysis for fine particles and sieve analysis for coarse particles. After analysis, the textural name given to Korat soil is sandy loam and Roi-et soil is loam. The soil water characteristic curves were determined by the hanging column method for the soil samples at low water potential and by the pressure plate method for those soils with high water potential. From the curves, the water content at field capacity of Korat soil is about 0.12, for Roi-et soil the value is 0.18 at the soil surface and about 0.30 deeper than 75 cm. The water content at permanent wilting point of Korat soil is 0.05 and of Roi-et soil is 0.06 at the soil surface and 0.16 at a depth of greater than 75 cm. Bulk density values,

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measured from soil cores of 100 cm^3, were about 1.47gm/cm^3 and 1.55 gm/cm^3 for Korat and Roi-et soil series respectively. Total soil porosity values, measured by using cored samples of 100 cm^3 which were weighed at saturation and weighed again after oven drying, were found to be 0.25 for Korat soil and 0.36 for Roi-et soil. The falling head method was used to obtain the values of saturated hydraulic conductivity (K_{sat}) of both soils. The average K_{sat}-value for Korat soil is 103 cm/day but for Roi-et soil the values vary from 29 cm/day at soil surface to 0.9 cm/day at a depth lower than 75 cm. By using the double ring method, the constant infiltration rate of Korat and Roi-et soils are 78 mm/hr and 6 mm/hr respectively. The hydraulic conductivity and infiltration rate values of Roi-et soil are much lower than those of Korat soil. This means that water loss by percolation is greater in Korat soil than Roi-et soil. Roi-et soil series is more suitable for paddy rice cultivation than Korat soil series.

บทคัดย่อ

ชุดดินในภาคตะวันออกเฉียงเหนือที่สำคัญที่สุดได้แก่ ชุดดินโคราชและชุดดินร้อยเอ็ด ซึ่งครอบคลุม 20% และ 17% ของพื้นที่ตามลำดับ โดยที่ชุดดินโคราชเป็นตัวแทนของดินไร่และชุดดินร้อยเอ็ดเป็นตัวแทนของดินนา เนื่องจากคุณสมบัติทางกายภาพและชลศาสตร์ของดินมีความสำคัญต่อการคำนวณออกแบบ และสร้างแบบจำลอง ที่เกี่ยวข้องกับการชลประทานและอุทกวิทยา การศึกษานี้จึงศึกษา ทดลอง รวบรวมคุณสมบัติทางกายภาพและชลศาสตร์ของดินทั้งสองชุดดินดังกล่าวโดยศึกษาในระดับความลึกตั้งแต่ 0-100 ซม. ได้ผลการศึกษาดังนี้ ใช้วิธี Sieve analysis และ Sedimentation analysis ได้เนื้อดิน (soil texture) ของชุดดินโคราชเป็น sandy loam ส่วนชุดดินร้อยเอ็ดเป็น loam ในการหาเส้นอัตลักษณ์ของน้ำในดิน (Soil water characteristic curves) ได้ใช้วิธี hanging column และวิธี pressure plate เมื่อดินมีพลังงานศักย์ของน้ำในดินต่ำและสูงตามลำดับ พบว่าค่าความชื้นที่ความจุสนาม (field capacity) ของชุดดินโคราชคือ 0.12 และของชุดดินร้อยเอ็ด 0.18 ที่ผิวดินและ 0.3 ที่ความลึกเกิน 75 ซม. ค่าความชื้นที่จุดเหี่ยวอย่างถาวรของพืช (permanent wilting point) ของชุดดินโคราชคือ 0.05 ของชุดดินร้อยเอ็ดมีค่า 0.06 ที่ผิวดินและ 0.16 ที่ระดับลึกกว่า 75 ซม. ค่าความหนาแน่นรวมของดิน (Bulk density) หาจากกระบอกเก็บตัวอย่างดิน (soil core) 100 ลบ.ซม. ได้ค่าเฉลี่ย 1.47 กรัม/ลบ.ซม. สำหรับชุดดินโคราช ส่วนชุดดินร้อยเอ็ดมีค่า 1.55 กรัม/ลบ.ซม. ความพรุนของดิน (Total soil porosity) หาจากกระบอกเก็บตัวอย่างดินโดยการทำให้ดินอิ่มตัวและอบแห้งได้ค่า 0.25 สำหรับชุดดินโคราช และ 0.36 สำหรับชุดดินร้อยเอ็ด สัมประสิทธิ์การนำน้ำของดินที่อิ่มตัวด้วยน้ำ (Saturated hydraulic conductivity) หาโดยวิธี falling head ได้ค่าเฉลี่ยสำหรับดินโคราชเป็น 103 ซม./วัน ส่วนดินร้อยเอ็ดมีค่าเฉลี่ย 29 ซม./วัน ที่ผิวดิน และ 0.9 ซม./วัน ที่ความลึกเกิน 75 ซม. ค่าการแทรกซึมของน้ำในดิน (Infiltration) ใช้วิธี Double ring ได้อัตราการแทรกซึมของน้ำในดินโคราชและดินร้อยเอ็ดเป็น 78 มม./ซม. และ 6 มม./ซม. ตามลำดับ จะเห็นว่าค่าสัมประสิทธิ์การนำน้ำของดินที่อิ่มตัวด้วยน้ำและอัตราการแทรกซึมของน้ำในชุดดินร้อยเอ็ดมีค่าต่ำกว่าชุดดินโคราชมาก ทำให้เกิดการสูญเสียน้ำเนื่องจากการซึมในชุดดินร้อยเอ็ดมีน้อยกว่าชุดดินโคราช นี้เป็นสาเหตุให้มีการทำนาในชุดดินร้อยเอ็ดได้ดีกว่าชุดดินโคราช

คำหลัก : คุณสมบัติทางฟิสิกส์ของดิน ชุดดินร้อยเอ็ด
ชุดดินโคราช ฟิสิกส์ของดิน ภาคตะวัน
ออกเฉียงเหนือ

Introduction

Korat and Roi-et soil series are the two major soil series which covered 20% and 17% respectively of total area in the Northeast of Thailand. Both of soil series often are the typical of soil type in the Northeast region. Korat soil series is the representative of upland soils whilst Roi-et soil series is the representative of lowland soils. (Keerati-Kasikorn, 1984)

Soil physical and hydraulic properties greatly are essential for design, calculation and simulation for irrigation schedule, drainage, hydrology and agricultural land use such as estimation of crop water requirement or water use efficiency must know data from soil water characteristic curve and saturated hydraulic conductivity (Boonyatharokul, 1983; Taesombat, 1988) which there values are directly concerned with soil physical and hydraulic properties.

Keerati-Kasikorn (1984) reported a lot of information in Northeast soils i.e. soil genesis, soil type, some soil physical and chemical properties, some problem soils, etc. Arunin (1989) collected a lot of academic articles which most of them were saline soils in Northeast region. Rattakate (1983) generally described about the Northeast soils and also explained relationships between soil conditions and agricultural production. Pairintra et al., (1985) collected academic

research papers about Northeast soils. Akratanakul (1985) presented experimental results of some soil physical and hydraulic properties in major soil series of Northeast. Overall of literature cited except the article of Akratanakul (1985) were scarcely concerned with soil physical and hydraulic properties. Akratanakul 's article was very useful for agricultural crop production particularly plant water use efficiency. However, this article studied at soil depth only 60 cm. and had not some soil physical properties. Objectives of this study are to find out physical and hydraulic properties of major soil series in the Northeast which are greatly useful for agricultural irrigation.

Methodology

Considered to fix the soil sampling spots of both soil series from soil map 1:50,000 scale of Land Development Department. Collected soil samples in both of undisturbed soils and disturbed soils at 5 soil depths 2-7, 8-13, 25-30, 75-80 and 95-100 cm. from soil surface and 3 replications in December 1996. Disturbed soil samples were taken to analyse in laboratory of soil physical and hydraulic properties for particle size analysis by sieve and sedimentation analysis, soil water characteristic curve at lower waterpotential (Ψ_w) (< -1 atm) by pressure plate apparatus. For undisturbed soil samples were taken to analyse soil water characteristic curves at high water potential (> -1 atm) by hanging column method, bulk density by core method

and saturated hydraulic conductivity (K_{sat}) by falling head method. Only soil water in filtration rate was determined by double ring method in the agricultural fields. (Smith and Mullins, 1991)

Particle size analysis by hydrometer were analysed by using of sedimentation method of Stoke's law which this is to say that when the soil suspensions were completely dispersed through and then allowed to gravitationally flocculate. Larger particle size was previously sedimented smaller particle size. By this method, it could be calculated% sand,% silt and% clay. Soil water characteristic curves were the relationships between soil water potential (ψ_w) and soil water content (θ_v) which soil water content must be balanced with ψ_w (-pressure) at each level and then could plot soil water characteristic curves in semi-log scale. Soil bulk density (ρ_b), undisturbed soil cores were taken into oven dry for dry weight and measured height and diameter for total volume of soil. ρ_b was calculated by the following formula to $\rho_b = M_s/V_b$ (M_s = oven dry weight of soil, V_b = bulk volume of soil). Total porosity was ratio of total soil pore space by total volume of soil. Undisturbed soil core samples were taken to be soil saturation and then were taken into oven dry weight. The lost weight was the total soil pore space. For K_{sat}, the undisturbed soil core samples were taken to be soil saturation and then installed on falling head apparatus. The 3 replicated time was recorded when water level in tube moved from upper mark to lower mark. K_{sat} values were calculated from water flow through porous media

theory which was showed this following to

$$-\frac{\partial V}{\partial t} = Av \qquad (1)$$

(V = volume of water flow through pipe, t = time, v = specific velocity, A, l = cross section area, length of soil core respectively, a = cross section area of pipe, h = height of water level from reference level). From equation (1) instead of ∂V by ∂ (ah) and from Darcy 's law.

$$-a\partial h/dt = AK_{sat} h/l \qquad (2)$$

intregation in (2)

$$-\int_{h_o}^{h_t} \frac{1}{h} dh = \frac{AK_{sat}}{al} \int_o^t dt$$

$$-\ln h \Big|_{h_o}^{h_t} = (AK_{sat}/al) t \Big|_o^t$$

$$\ln(h_o/h_t) = (AK_{sat}/al) t$$

So, $\quad K_{sat} = \dfrac{al}{At} \ln \dfrac{h_o}{h_t}$

In the case of soil water infiltration, they were determined by using of 2 metallic cylindrical pipe at 50, 30 cm. diameter. Both of pipes were put in the soil at 10 cm. depth and then put water in outer and inner pipes. Measured water height in inner pipes at various times until 50 min. From water height and time could plot the curves which were the relationships between infiltration rate and time.

Results and Discussions

Soil texture

For particle size analysis of both Korat and Roi-et soil series (Table 1), the results showed that Korat soil series were sandy loam at every soil depth which had the highest of% sand at soil surface (70%) and slightly decrease into further depth until 95-100 cm. had the lowest of % sand (64%). Roi-et soil series were loam at every soil depth except only 8-13 cm.. Which it would be a sandy loam but mostly close in loam textural level scale. % Sand decreased from soil surface (52%) to deeper 75 cm. (40%) and on contrast,% clay increased at soil surface (9%) to be 40% at deeper 75 cm. This study indicated that% clay of both soil series would increase in the following to soil depth. However, Roi-et soil series,% clay increment was higher. This study is attributed to water flow into subsoil of Roi-et soil series were lower and would finally be soil saturation in the profile. This study agrees with the work reported by Hillel and Talpaz (1977).

Table 1 Average of% sand, silt and clay of Korat and Roi-et soil series. Korat soil series Roi-et soil series

soil dept (cm.)	Korat soil series				Roi-et soil series			
	% soil particle			soil	% soil particle			soil
	% sand	% silt	% clay	texture	% sand	% silt	% clay	texture
2-7	70 ± 1.03	24 ± 1.70	6 ± 0.73	sandy loam	52 ± 1.89	39 ± 2.28	9 ± 0.44	loam
8-13	69 ± 1.28	25 ± 1.38	6 ± 0.15	sandy loam	55 ± 3.40	34 ± 1.74	11 ± 2.14	sandy loam
25-30	67 ± 0.12	24 ± 0.54	9 ± 0.58	sandy loam	44 ± 0.68	37 ± 1.01	19 ± 0.38	loam
75-80	63 ± 1.58	25 ± 0.96	12 ± 0.62	sandy loam	39 ± 1.86	36 ± 1.05	25 ± 0.84	loam
95-100	64 ± 1.18	23 ± 1.49	13 ± 0.38	sandy loam	41 ± 0.97	34 ± 1.99	25 ± 1.31	loam

Soil water characteristic curves

With soil water characteristic curves of Korat soil series (Fig. 1), the resulted showed that at higher -100 cm. H_2O of ψ_w, the curves quite suspended whist more soil water content (θ_v) at soil surface. But more increase soil depth, more decrease θ_v except θ_v at 25-30 cm. were close to θ_v at 95-100 cm. Regarding to suspending curves at over -100 cm. H_2O of ψ_w were attributed to the total soil porosity (soil structure) was the key factor to control θ_v (Baver et al., 1972 ; Hillel, 1998). At lower -100 cm. H_2O of ψ_w, the curves trend to face each other because the main factor, controlled θ_v during this range, was soil texture (% clay). % Clay in soil profile of Korat soil series was quite very low although it would increase in following to soil depth. But at slightly increased and did not

effect on soil water retention in each soil depth.

The curves of Roi-et soil series were quite different from Korat soil series (Fig. 2). This is to say that the curves did not suspend at higher -100 cm. H_2O of ψ_w which it means that θ_v did not different from each ψ_w higher -100 cm. H_2O. However, at soil surface was higher θ_v than the further depth because total porosity at soil surface was the highest (0.37) and greatly different from the other horizons. For the curves of lower -100 cm. H_2O of ψ_w were suspended due to more deeper soil horizon, more retained water and evidently ranked to soil depth. This is attributed to% clay increased from soil surface (9%) to the last soil depth (25%) and it could retained water in the soil. This finding agrees with the work discussed by Kutilek and Nielsen (1994) and Perrier *et al.* (1996).
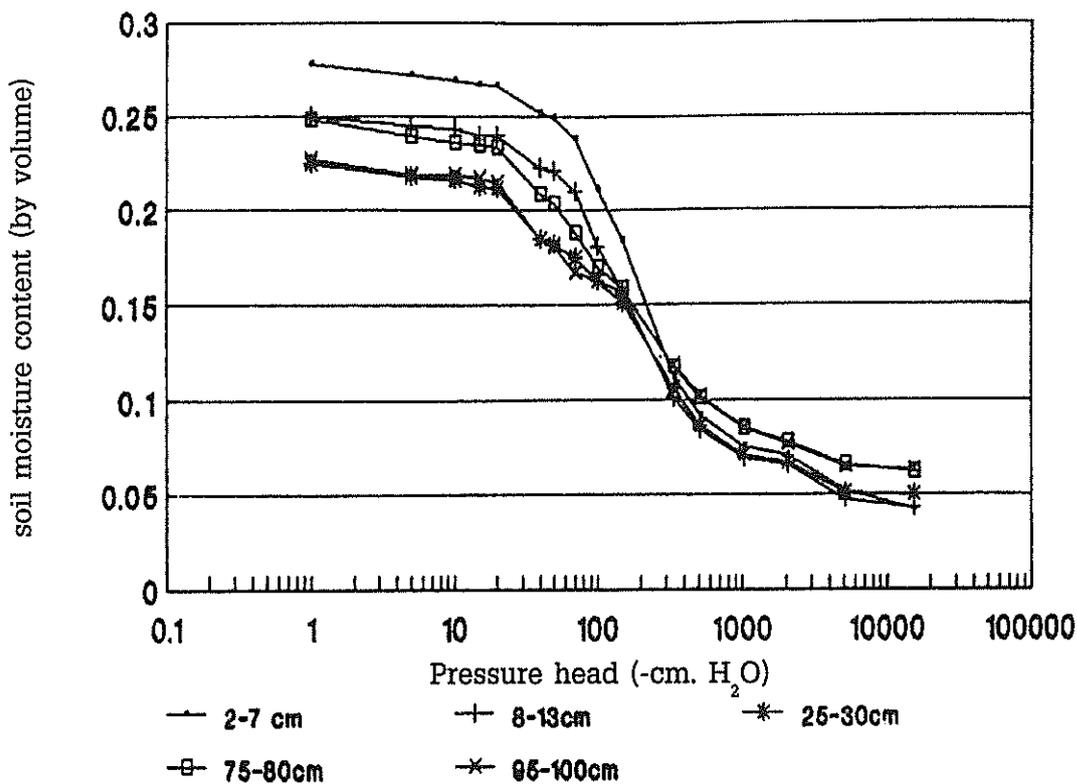

Figure 1 Soil water characteristic curves of Korat soil series.
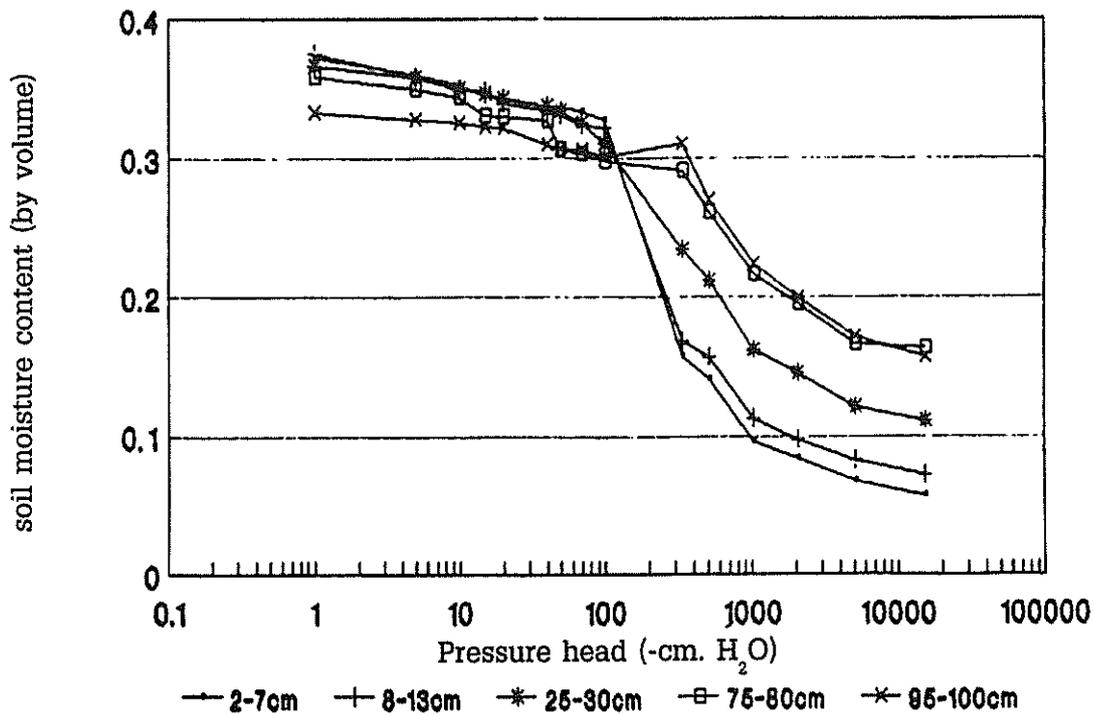
Figure 2 Soil water characteristic curves of Roi-et soil series.

Bulk density (ρ_b)

Bulk density of Korat soil series did not vary to soil depth and average of ρ_b is 1.47 gm/cm³ (Table 2). On contrast, ρ_b of Roi-et soil series varied to soil depth from soil surface (1.45 gm/cm³) to last soil depth (1.66 gm/cm³) because of clay content increment. Clay particle would be accumulated and finally flocculated in micropore which cohesion force between soil particle was quite so high. However, bulk density of both soil series were higher than general value (1.30 gm/cm³). This study as stated by Marshall and Holmes (1988) ; Jury *et al.* (1991).

Total porosity

With total porosity of both soil series, the results showed that they had a trend of decreasing when soil depth increased (Table 2). This is to say that Korat and Roi-et soil series decreased from 0.28, 0.37 at soil surface to 0.23, 0.33 at 95-100 cm. depth respectively because soil pore volume would be decreased when soil depth increased (Grable and Siemer, 1968). It could be noticed that total porosity of Korat soil series from 8 cm. to the last 100 cm. were almost similar about 0.24 which were definitely differented from soil surface (0.28). On contrast, total porosity of Roi-et soil series from soil sur-

face to 80 cm. depth were quite similar about   0.37 except at 95-100 cm. was 0.33.

Table 2   Average of bulk density (gm/cm^3) and total porosity of Korat and Roi-et soil series.

soil depth (cm.)	Korat soil series		Roi-et soil series	
	bulk density	total porosity	bulk density	total porosity
2-7	1.46	0.28	1.45	0.37
8-13	1.47	0.25	1.51	0.38
25-30	1.49	0.23	1.51	0.37
75-80	1.46	0.24	1.61	0.36
95-100	1.47	0.23	1.66	0.33
Average	1.47 ± 0.01	0.25 ± 0.02	1.55 ± 0.09	0.36 ± 0.02

Saturated hydraulic conductivity (K_{sat})

Average K_{sat} of Korat soil were higher than average K_{sat} of Roi-et soil series (Table 3). K_{sat} of both soil series would be trendency decrease when soil depth increased. It can obviously be noticed in K_{sat} of Roi-et soil series would decreased from soil surface (3.3 x10^{-4} cm./sec) to 100 cm. depth (1.0 x 10^{-5} cm./sec). This could be attributed to clay content would be increased in subsoil and also related into ρ_b increment. This results confirmed work reported by van Genuchten (1980) and Rose et al. (1965). The hypothesis of hydrology said that K_{sat} at any soil horizon is lower than 10 times K_{sat} of next horizon. They would be held that the imprevious layer happened in that horizon. (Taesombat, 1988; Buapan, 1995; Guyman, 1994). So, from this study, the imprevious layer of Korat and Roi-et soil series would be happened at about 100 and 75-80 cm. depth respectively. This study agrees with the work reported by Mallants et al. (1997).

Table 3   Saturated hydraulic conductivity (cm/sec) of Korat and Roi-et soil series.

depth (cm.)	saturated hydraulic conductivity (K_{sat}) (x 10^{-3} cm./sec.)	
	Korat soil series	Roi-et soil series
2-7	1.45 ± 0.63	0.33 ± 0.19
8-13	1.34 ± 0.58	0.20 ± 0.10
25-30	1.46 ± 0.91	0.14 ± 0.04
75-80	0.52 ± 0.30	0.02 ± 0.02
95-100	1.16 ± 0.30	0.01 ± 0.01

Infiltration rate (IR)

For infiltration rate of both soil series (Fig. 3-4), the results showed that IR of both soil series were more than 1 cm./min. at initial stage and then rapidly decreased later on at the final stage (20 min.) were quite constant. IR at constant rate (saturation state) of Korat and Roi-et soil series were about 2×10^{-3} and 2×10^{-4} cm./min. respectively. This event could have established IR at saturation state which were followed to K_{sat} values as reported by Hillel (1998). This study could indicate that IR of Roi-et soil series were lower than Korat soil series because of more clay content and ρ_b in Roi-et soil series. (Akratanakul, 1985 ; Burwell and Larson, 1969)
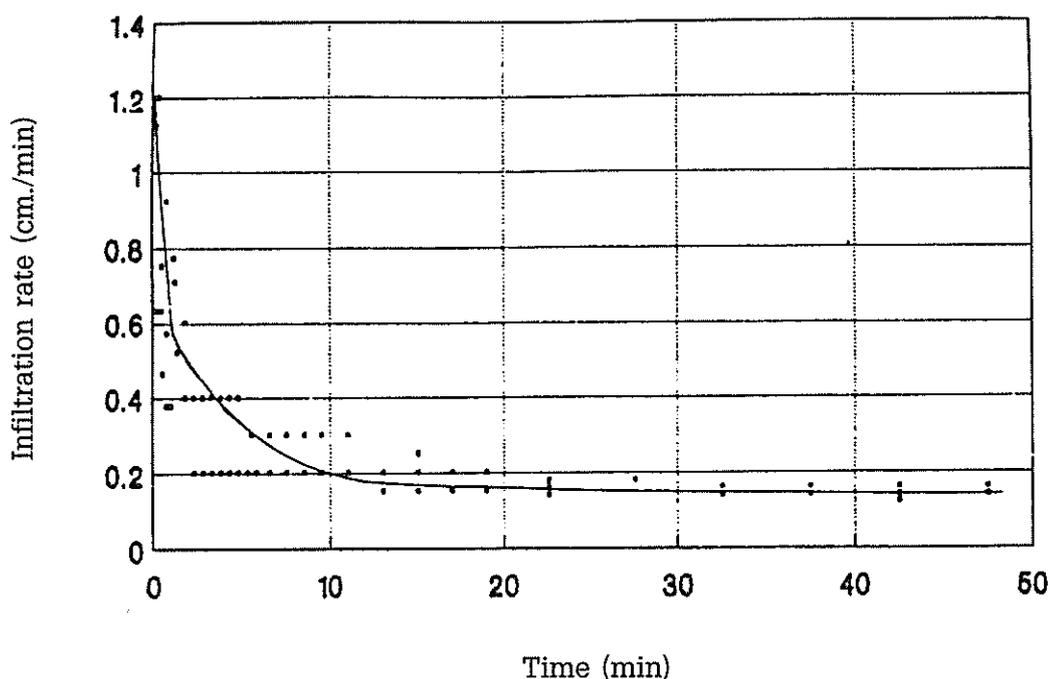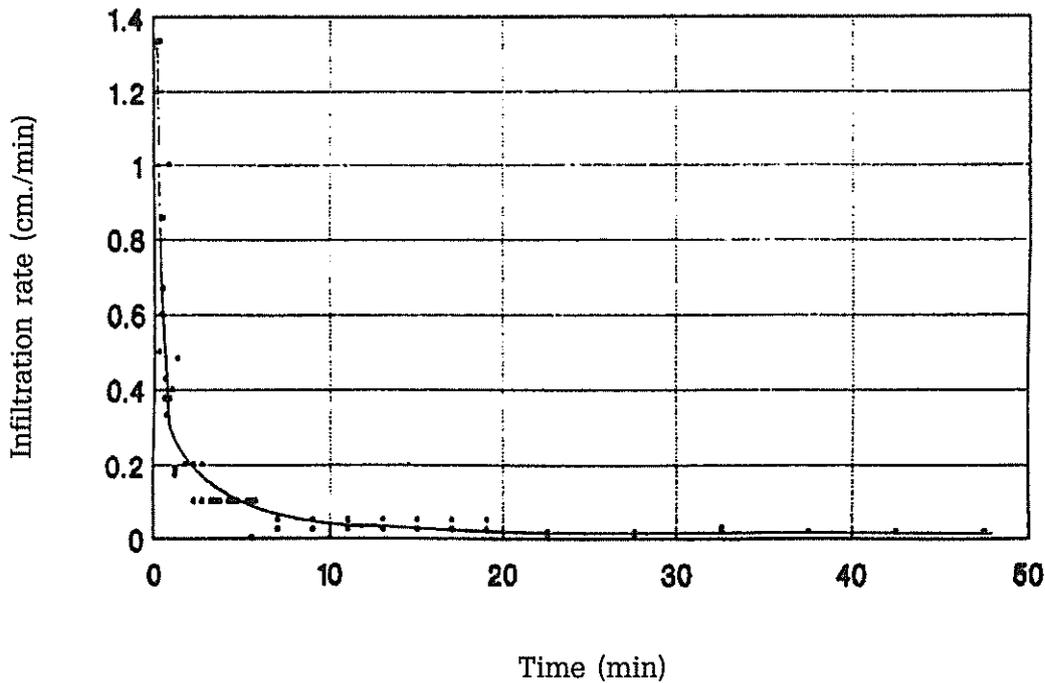

Figure 3 Infiltration rate of Korat soil series

Figure 4 Infiltration rate of Roi-et soil series.

Conclusion

Study on soil physical and hydraulic properties of Korat and Roi-et soil series showed that Roi-et soil series had more clay content, bulk density, total porosity but will have lower saturated hydraulic conductivity and infiltration rate. These values will effect on Roi-et soil series are poorly drainage and poorly aerated soil. So, Roi-et soil series are very suitable for paddy rice production whilst Korat soil series are appropriate for upland crop and orchard production due to well drainage and aerated soil.

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