Chapter 7

HUMUS COMPOSITION OF IRRI PADDY SOILS

SUMMARY

The composition of humus differed related to soil properties and management in wetland rice soils. The amount of each total humus, humic acid and fulvic acid was highest in uncultivated soil collected near the paddy soils. It was slightly less in rice soil which received rice straw after every crop, and considerably low where straw was removed after crops. Transformation of humic acid to fulvic acid, and the predominance of newly formed humic substances in 0.1 N NaOH extractable humic acid fraction were suggested in wetland rice soils compared with an uncultivated soil. The soil of IRRI experiment field (Maahas soil) contained a large proportion of 0.1 M $Na_4P_2O_7$ extractable humus in which humic acid fraction predominated. This fraction is assumed to be combined with metal ions and/or clay, and therefore more resistant to leaching and decomposition. Absorption of Pg pigment was observed in the $Na_4P_2O_7$ extracted humic acids of the 3 soils used in this study. Among the IRRI farm soils, that absorption was found only in the uncultivated soil and absent in wetland rice soils.

INTRODUCTION

It is well known that soil organic matter have important roles in agriculture as areservoir and a source of nutrients. Agricultural practices may alter the nature and composition of soil organic matter, and this change of soil organic matter counteracts the agricultural practices. Rice culture is no exception of this. Submerging, plowing and puddling soil accelerate the decomposition of organic matter, and crop residues change the quality and quantity of soil organic matter. However,very few researches have been done to clarify this subject. At the International Rice Research Institute, Soil Chemistry Department has been continuing a long term experiment on the effect of straw management in wetland rice culture for 21 crop seasons. I analyzed the humus composition of soils from this field as well as that of uncultivated field near the experiment farm to obtain preliminary knowledge on the effect of rice culture and straw management on humus composition. Humus composition of IRRI farm soils was also compared with that of other soils with different properties.

MATERIALS AND METHODS

Soil samples

Uncultivated soil. A soil sample was collected from an uncultivated field adjacent to IRRI experiment field. Wild grass belonging to legume covered the field.

The soil was separated by the depth of 10 cm, 20 cm and 30 cm. Soil samples were collected from 0-10 cm, 10-20 cm, and 20-30 cm layers.

Paddy soil. Paddy soil samples were collected from the plots for long term straw management experiment of Soil Chemistry Department, IRRI, while 21st crop was grown in 1982 wet season. The straw removed plot and the straw incorporated plot were chosen for comparison. Five sub-samples were collected from 0-15 cm layer between rice plants of each plot and mixed well. The straw management experiment was started in 1966. In the straw incorporated plot, the whole rice straw harvested was plowed into the field after each crop. Two crops were grown each year. This field has been grown to rice since 1960. It was previously grown to sugarcane. Humus compositions of the three paddy soil samples used in the main experiment were also analyzed. Carbon and nitrogen % of the soil samples were given in Table

Method of the analysis of
humus composition

After the soils were air dried, humus composition was analyzed by the method of Kumada et al. (1967).

RESULTS AND DISCUSSION

Humus composition of uncultivated and paddied Maahas clay

As shown in Table 1, the amount of each humus component and the total extractable humus content decreased with depth in the uncultivated Maahas soil. In 0.1 N NaOH extractable humus fractions, fulvic acid predominated, while in 0.1 M $Na_4P_2O_7$ extractable fractions humic acid predominated.

In the paddy soil from the plot where straw was removed after every crop season, the amounts of each humus component and total humus were considerably lower than those from the uncultivated soil. In the soil from the plot where rice straw was returned to soil after every crop, the amount of each extractable humus component was higher than that from the straw removed plot, however, it was still slightly less than that in the uncultivated soil.

In paddy soils, transformation of humic acid to fulvic acid is assumed. The fulvic acid extractable with 0.1 N NaOH is thought to be the most mobile humus component and susceptible to leaching or decomposition. This may cause the decrease in 0.1 N NaOH extractable humus in paddy soils in combination with the transformation of humic acid to fulvic acid. In paddy soils the amount and percentage of fulvic acid in the 0.1 M $Na_4P_2O_7$ extractable fraction were higher than those in the uncultivated soil. This may also suggest the transformation of humic acid to fulvic acid. Because the fulvic acid extractable with 0.1 M $Na_4P_2O_7$ is assumed to exist in combined form with metal ions and clay in soil, it is hardly leached out and therefore accumulates in the soil.

Spectrophotometric characteristics of humic and fulvic acids obtained from uncultivated and paddied Maahas clay

As shown in Table 2, humic acids extracted with 0.1 N NaOH from paddy soils had higher Δ log K and lower RF, in other words, they were lighter coloured, than those from the uncultivated soil. This suggests that old humic substances were decomposed and newly formed humic substances predominate in the 0.1 N NaOH extractable humic acid fraction in paddy soils.

Types of 0.1 N NaOH extractable humic acids were also different between the uncultivated soil and the paddy soil. It was B type in the uncultivated soil and Rp type in the paddy soil. Humic acid from the uncultivated soil was ranked to the group with higher degree of humification.

On the other hand, the colour intensity of the fulvic acid extracted with 0.1 N NaOH was higher in paddy soils than in the uncultivated soil as indicated by RF_{400} in Table 2. The more intense colour of the fulvic acids from paddy soils may also suggest the transformation of humic acid to fulvic acid in paddy soils.

Humic acids extracted by $Na_4P_2O_7$ from the uncultivated soil belonged to P_+ type, while those from the paddy soils belonged to B type. The plus mark of P_+ means that specific absorption of Pg pigment was recognized in the spectra of humic acid. The difference in the types of humic acids extracted by $Na_4P_2O_7$ was due to the higher Δ log K and slightly lower RF of paddy soil humic acids caused by the disappearance of Pg absorption. In spite of the difference in types between the uncultivated and paddy soils, old humic substances which was formed when the soil was under natural vegetation may still remain dominant in the 0.1 M $Na_4P_2O_7$ extractable humus fractions of the paddy soil, due to the complex forming capacity and the very condensed structure of organic matter in this fraction.

Absorption spectra of humic acids of the uncultivated soil and the paddy soil were compared in Figure **2.** Little difference was observed among the 3 layers of the uncultivated soil and between the straw plowed in and removed plots in their absorption spectra of humic acids as shown in Figs. 3 and 4.

However, the absorption spectrum of the 0.1 N NaOH humic acid from the paddy soil was more intensified in the absorption between 280 nm and 360 nm which is due to the lignin structure than that from the uncultivated soil.

In the absorption spectrum of the humic acid extracted with 0.1 M $Na_4P_2O_7$ from uncultivated soil, the absorption due to a Pg pigment which is produced by some kinds of fungi (Cenococcum graniforme etc.) were observed. However, in the absorption spectrum of the 0.1 M $Na_4P_2O_7$ humic acid from the paddy soil that specific absorption was almost disappeared probably due to leaching or decomposition.

Humic substances may play important roles in holding and transporting mineral nutrients in paddy soils. In Maahas soil which contain considerably large amounts of humus in both free and combined forms, humus may be one of the important factors of its fertility.

The change in humus composition of soil due to wetland rice culture was significant in both quality and quantity. From the spectrophotometric characteristics, it was suggested that humic substances were being transformed to the form specific to paddy soil during rice culture. Humic substances of paddy soils under different straw managements differed only in their amounts but not much in their spectorphotometric characteristics. Therefore, the change in humus composition during rice culture is thought to be an irreversible process even rice straw or other residues were returned to soil. However, decrease in amounts of each humus component was considerable when straw removal practice was repeated for many crop seasons, and return of rice straw to soil seemed indispensable to put a brake on the decrease of humus and soil fertility in paddy soil.

Humus composition of 3 paddy soil
samples used in the main experiment

Humus composition was very different between Luisiana soil and the other soils.

The main humus component in Luisiana soil was 0.1 N NaOH extractable fulvic acid. The ratio of humic acid was low in both 0.1 N NaOH extractable and 0.1 M $Na_4P_2O_7$ extractable fractions. The amount of 0.1 M $Na_4P_2O_7$ extractable fraction was low in Luisiana soil, reflecting the poor base content of the acidic soil.

In Maahas soil and Pila soil, 40-50% of the total humus are in the 0.1 M $Na_4P_2O_7$ extractable form, which is assumed to exist as complex with metal ions or clay. The 0.1 M $Na_4P_2O_7$ fraction was predominantly in the form of humic acid. The abundance of this fraction may be due to the high base content of these neutral and calcareous soils.

In the NaOH extractable fraction fulvic acid predominated in the 3 soils. However, the percentage of humic acid was higher in Maahas and Pila soil than in Luisiana soil.

The total amount of extracted humus increased in the order of Luisiana, Maahas and Pila. As the main humus fraction in Luisiana soil is fulvic acid, it is readily leached or decomposed.

Spectrophotometric characteristics of
3 paddy soil samples of the main experiment

As shown in Table 4, humic acids extracted by 0.1 N NaOH from the 3 soils all belonged to Rp type and those extracted by 0.1 M $Na_4P_2O_7$ belonged to B type. Humic acids extracted by 0.1 M $Na_4P_2O_7$ was colored darker and the inclination of the absorption curves was less steep.

No significant difference was observed in the spectrophotometric characteristics of 0.1 N NaOH extractable humic components of the three soils. Absorbance in the visible and ultraviolet range increased almost exponentially with decreasing wave length and the absorption spectra were featureless except a slight shoulder at 280 nm which indicates the contribution of lignin. (Fig. 4).

The absorption curve of 0.1 M $Na_4P_2O_7$ humic acid extracted from Luisiana soil had shoulders at 620 nm, 580 nm and 460 nm. These absorption shoulders are due to Pg pigments.

LITERATURE CITED

Kumada, K. O. Seto, Y. Ohsumi, and S. Ohta. 1967. Humus composition of mountain soils in central Japan with special reference to the distribution of P type humic acid. Soil Sci. Plant Nutr. 13:151-158.

Table 10. Analysis of carbon and nitrogen of the used soil samples (% of air dry soil).

	C	N	Moisture
Uncultivated Maahas soil			
Layer I (0-10 cm)	1.60	0.151	7.57
Layer II (10-20 cm)	1.44	0.137	6.95
Layer III (20-30 cm)	1.32	0.122	7.68
Maahas wetland rice soil (L3)			
Straw plowed in	2.03	0.165	9.04
Straw removed	1.58	0.124	8.83
Pila clay loam	2.48	0.204	6.63
Maahas clay	1.43	0.140	7.28
Luisiana clay	1.56	0.117	8.49

Table 11. Extracted amounts* of each humus component.

	0.1 NaOH extractable		0.1 M $Na_4P_2O_7$ extractable		Total extracted humus
	humic acid	fulvic acid	Humic acid	Fulvic acid	
Uncultivated Maahas clay					
0-10cm layer	5.07	7.94	7.83	1.65	22.5
10-20cm layer	4.19	7.59	7.73	1.45	21.0
20-30cm layer	3.43	7.04	6.56	1.08	18.1
Paddied Maahas clay					
straw plowed in	6.80	6.06	5.59	1.87	20.3
straw removed	3.82	4.55	4.85	1.50	14.7

*expressed as the consumed amount of 0.1 N $KMnO_4$ (ml)/g of air dried soil

Table 12. Spectrophotometric characteristics of humus components.

	0.1 N NaOH extraction				0.1 M $Na_4P_2O_7$ extraction			
	Δ log K	RF	Type	RF_{400}	Δ log K	RF	Type	RF_{400}
Uncultivated soil								
0 ~ 10 cm layer	0.734	43.4	B	19.3	0.549	58.1	P+	53.7
10 ~ 20 cm layer	0.733	43.9	B	17.7	0.550	61.5	P+	53.1
20 ~ 30 cm layer	0.740	40.9	B	17.0	0.556	67.3	P+	71.2
Paddy soil								
straw plowed in	0.940	20.1	Rp	27.3	0.657	56.3	B	62.8
straw removed	0.908	21.1	Rp	28.0	0.699	55.5	B	73.0

Δ log K : log K_{400} – log K_{600}

where K_{600} and K_{400} are absorption coefficients at 600 and 400 nm of humic acid solution in 0.1% NaOH

RF : K_{600}/(ml of 0.1 N $KMnO_4$ consumed by 30 ml of the humic acid solution used for determining K_{600}) x 1000

RF_{400} : K_{400}/(ml of 0.1 N $KMnO_4$ consumed by 30 ml of the fulvic acid solution used for determining K_{400}) x 1000

Humic acid is grouped into four types i.e., A, B, Rp, and P, according to RF and Δ log K as defined by Kumada et al (1967).

Diagram of the humic acid classification is shown in Figure 1.

Table 13. Extracted amounts of each humus component.

	0.1 N NaOH Extractable		$0.1\ M\ Na_4P_2O_7$ Extractable		
	Humic acid	Fulvic acid	Humic acid	Fulvic acid	Total extracted humus
Luisiana	2.32	10.7	0.52	1.74	15.2
Maahas H15	4.50	7.54	10.9	2.41	25.3
Pila	8.66	11.8	10.1	1.35	31.9
Maahas L3	6.80	6.06	5.59	1.87	20.3
	3.82	4.55	4.85	1.50	14.7

The amount of each humus component is expressed as the consumed ml of 0.1 N $KMnO_4$/g of air dried soil.

Table 14. Spectrophotometric characteristics of humus components.

	0.1 N NaOH extraction				0.1 M $Na_4P_2O_7$ extraction			
	Δ log K	RF	Type	RF_{400}	Δ log K	RF	Type	RF_{400}
Luisiana	0.904	20.9	Rp	23.0	0.661	48.1	B	44.6
Maahas H15	0.952	14.9	Rp	16.7	0.611	77.0	B	53.3
Pila	0.870	21.5	Rp	18.8	0.583	54.7	P^+	82.9
Maahas L3	0.940	20.1	Rp	27.3	0.657	56.3	P	62.9
	0.908	21.1	Rp	28.0	0.699	56.5	B	73.0

Δ log K : $\log K_{400} - \log K_{600}$

where K_{600} and K_{400} are absorption coefficients at 600 and 400 nm of humic acid solution in 0.1% NaOH.

RF : K_{600}/(ml of 0.1 N $KMnO_4$ consumed by 30 ml of the fulvic acid solution used for determining K_{600}) x 1000

RF_{400} : K_{400}/(ml of 0.1 N $KMnO_4$ consumed by 30 ml of the fulvic acid solution used for determining K_{400}) x 1000

Humic acid is grouped into four types i.e., A, B, Rp, and P, according to RF and Δ log K as defined by Kumada et al (1967).

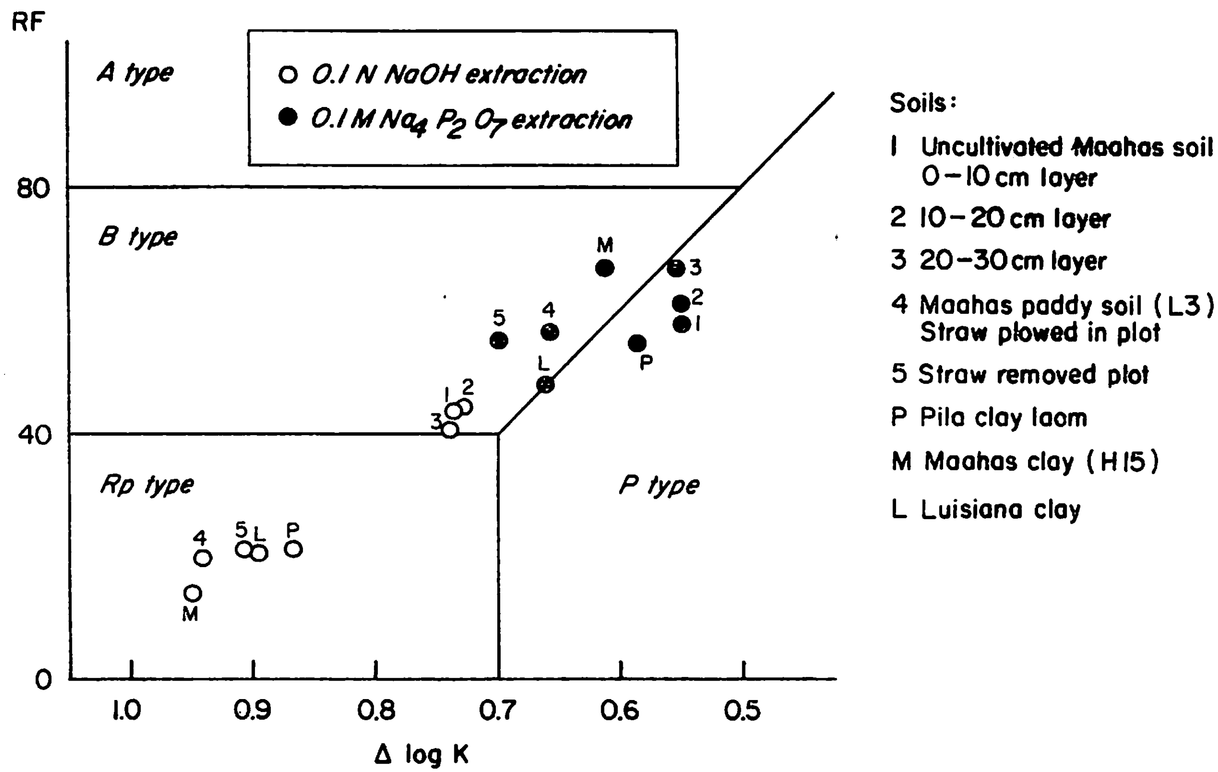

Fig. 21. Classification of humic acids

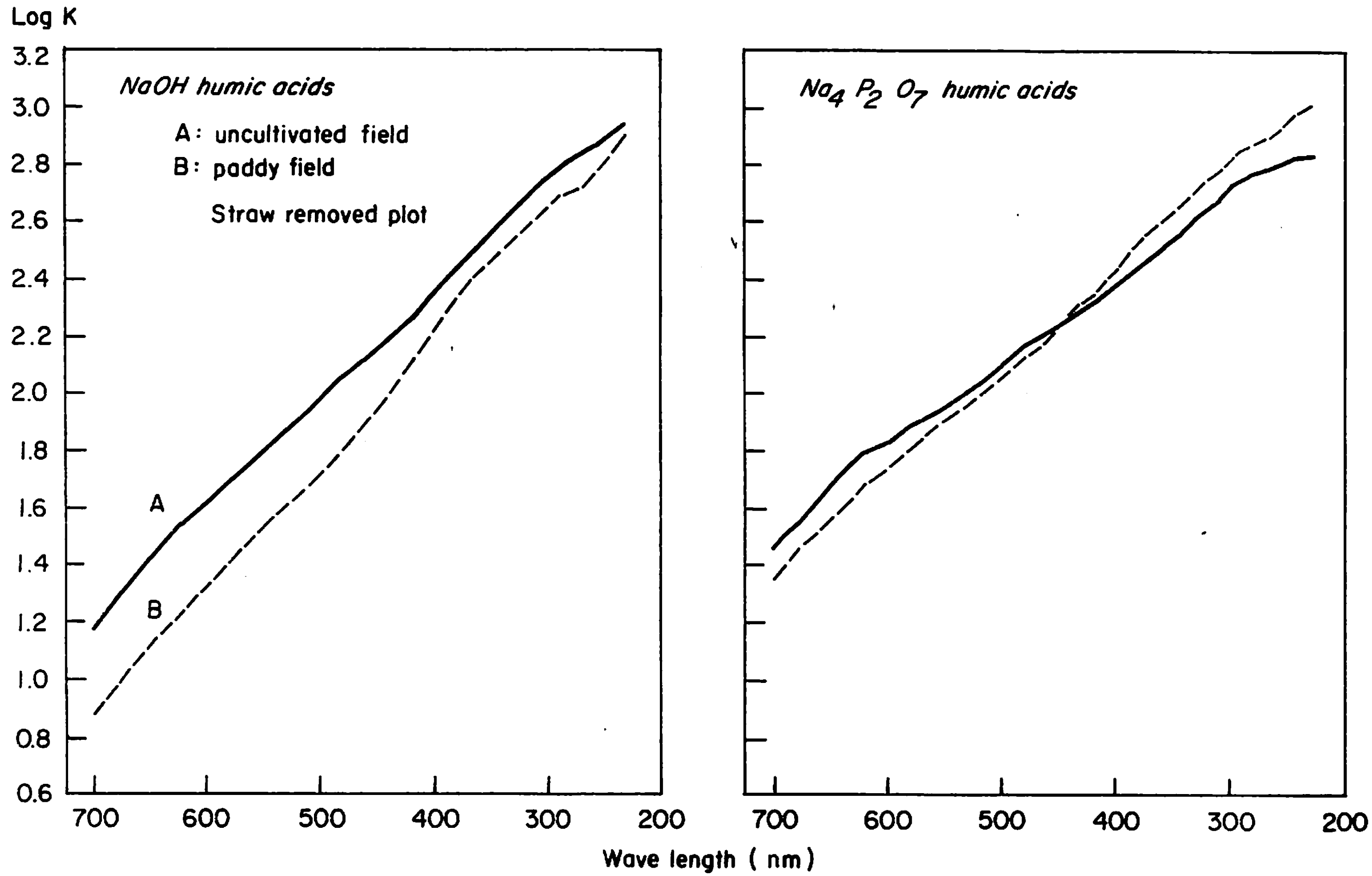

Fig. 22. Absorption spectra of humic acids in uncultivated and paddied Maahas soils

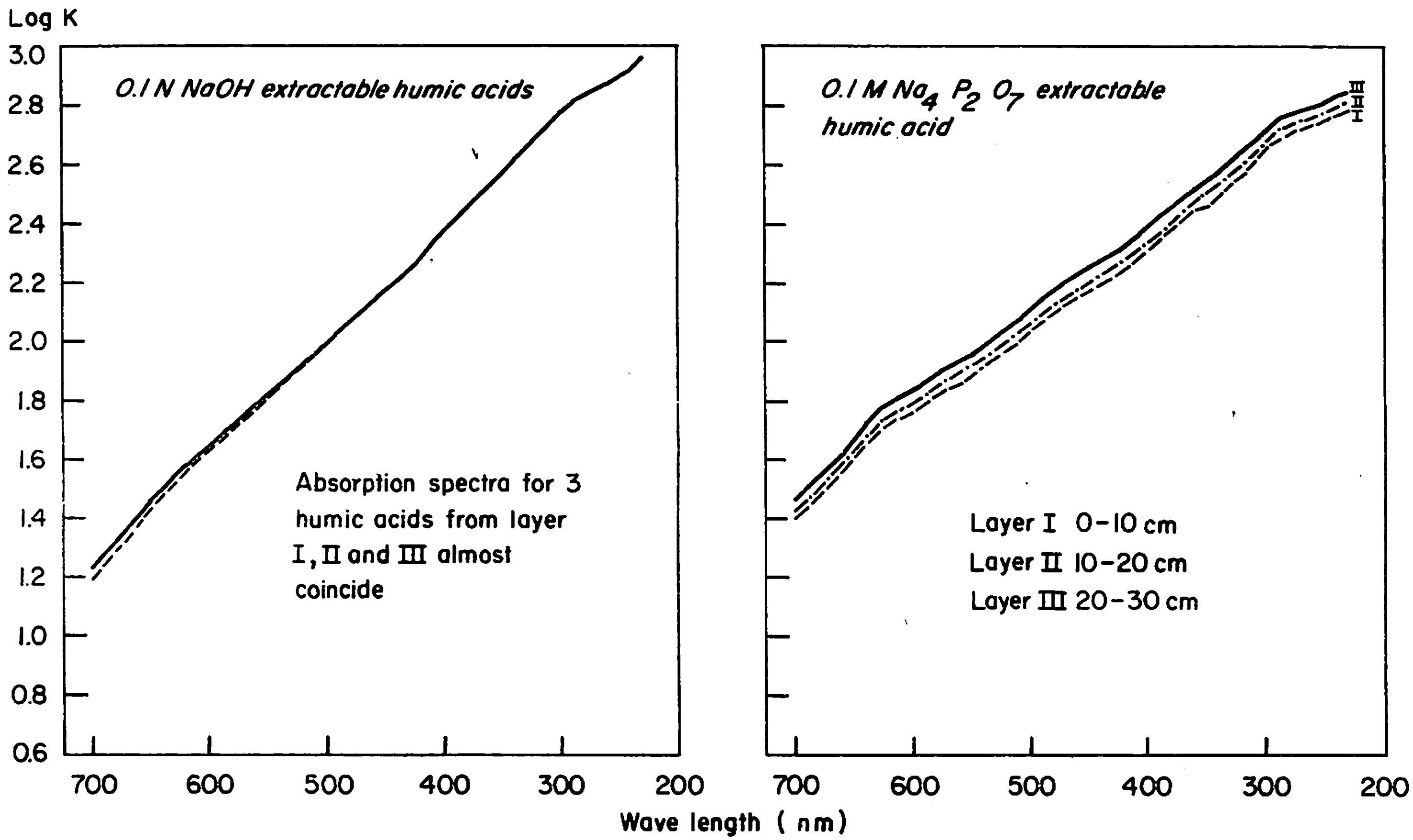

Fig. 23. Absorption spectra of humic acids in 3 layers of uncultivated Maahas soil

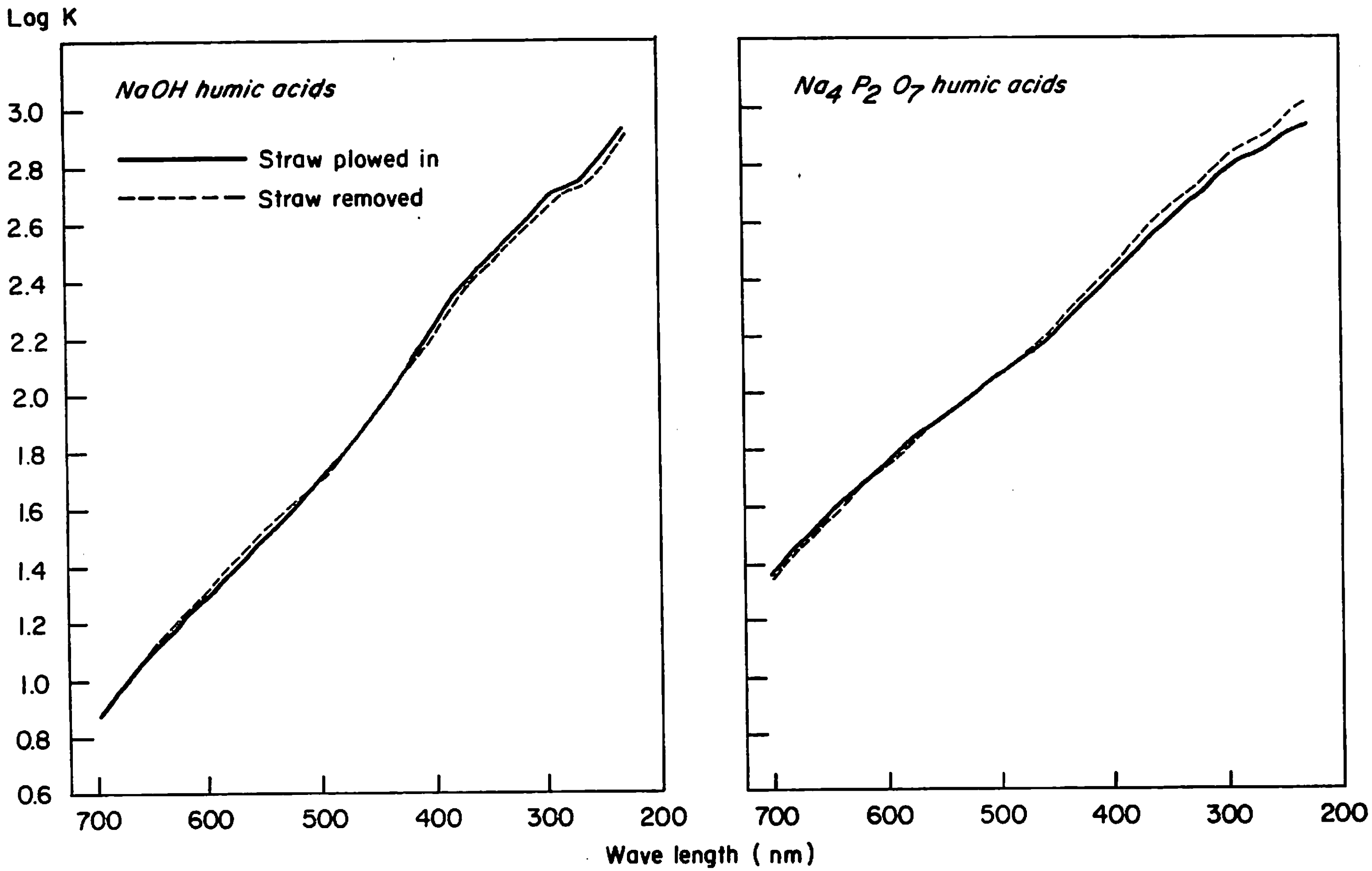

Fig. 24. Absorption spectra of humic acids in paddy soils continuously applied with rice straw and removed of rice straw

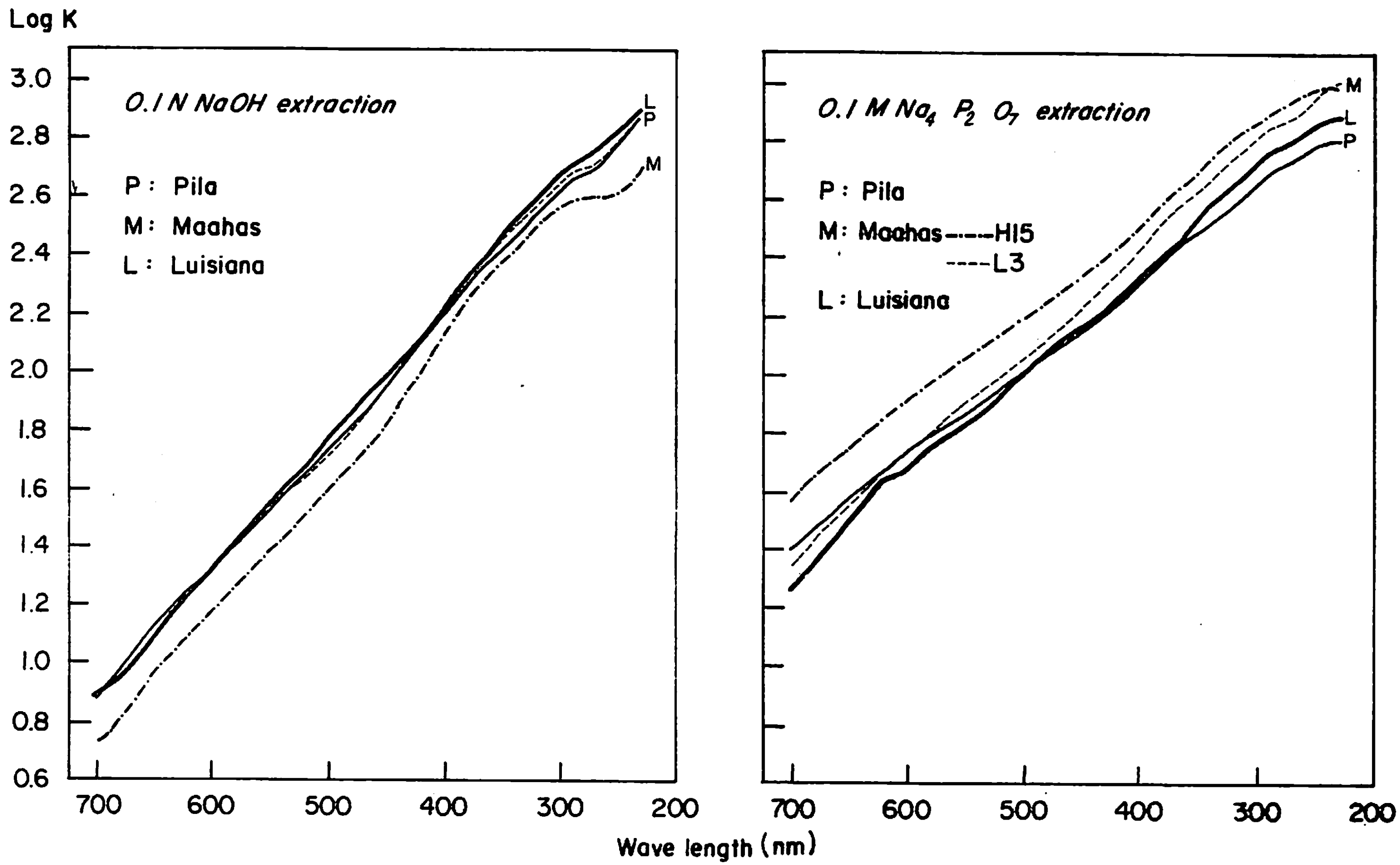

Fig. 25. Absorption spectra of humic acids in 3 paddy soils (Pila clay loam, Maahas clay and Luisiana clay)