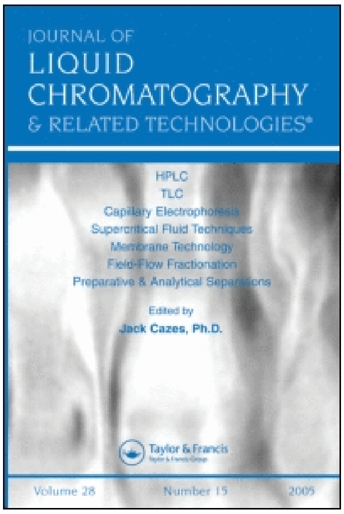

Journal of Liquid Chromatography & Related Technologies
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597273

Effect of Different Factors on the Movement of Some Amino Acids in Soils Using Thin-Layer Chromatography

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To cite this Article Kumari, K. , Singh, R. P. and Saxena, S. K.(1987) 'Effect of Different Factors on the Movement of Some Amino Acids in Soils Using Thin-Layer Chromatography', Journal of Liquid Chromatography & Related Technologies, 10: 7, 1299 — 1325
To link to this Article: DOI: 10.1080/01483918708066770
URL: http://dx.doi.org/10.1080/01483918708066770

JOURNAL OF LIQUID CHROMATOGRAPHY, 10(7), 1299-1325 (1987)

EFFECT OF DIFFERENT FACTORS ON THE MOVEMENT OF SOME AMINO ACIDS IN SOILS USING THIN-LAYER CHROMATOGRAPHY

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ABSTRACT

The influence of organic matter, $CaCO_3$, saline and alkaline salts, flyash, exchangeable cations and pH on the mobility of monocarboxylic, dicarboxylic, basic and aromatic amino acids has been studied using soil thin-layer chromatographic technique in two different type of soils. The mobility was expressed in terms of R_f, R_B and R_M values. The variation in R_f, R_B and R_M values of amino acids under different treatments have been reported and discussed on the basis of adsorption and leachability.

INTRODUCTION

Amino acids present in the soil as a breakdown of proteins are important sources of nitrogen to the plant in its nutrition. The distribution of the amino acids is affected by large number of factors. The literature on this aspect has been reviewed by Bremner (1). Several workers (2,3) have also studied the adsorption of some amino acids with clays. The soil being a complex system must be affecting the mobility of the amino acids but information on such soil factors affecting the mobility of various amino acids in soil and thus indirectly affecting their availability to plants is almost lacking.

Hence, in the present studies attempts have been made to determine the effect of commonly occuring salts in soil, organic matter, autoclaving, flyash, exchangeable ions and pH on the movement of monocarboxylic (alanine, glycine, isoleucine, leucine and valine), dicarboxylic (aspartic and glutamic), basic (histadine and lysine) and aromatic (phenylalanine and tryptophane) amino acids using soil thin-layer chromatography.

MATERIALS AND METHODS

The two different types of the surface soils (0-30 cm) viz. clay loam and silt loam used in the present studies, collected from Aligarh district were analysed for their mechanical composition by international pipette method, pH with Elico pH meter model LI-10, organic matter by Walkley and Black's method (4) and CEC by Jackson's method (5). The values are summarized in Table I.

The soils were ground and seived through a 100 mesh sieve to obtain samples with a small and nearly homogeneous particle size. Clean glass plates were coated with a water slurry of soil sample (0.5 mm thickness) with the help of TLC spreader. After air drying, two lines at 3 cm and 13 cm above the base were scribed on the plates to maintain the standard development distance of 10 cm. l-Alanine (ALA), l-aspartic (ASP), DL-glutamic (GLU), glycine (GLY), l-histadine (HIS), DL-isoleucine (ILE), l-leucine (LEU), l-lysine (LYS), DL-phenylalanine (PHE), l-tryptophane (TRP) and valine (VAL) of 0.5% concentration were applied as a spot on the TLC plates with the help of lambda pipette 3 cm above the bottom of the plates. A

TABLE I

Composition and Physico-chemical properties of Soils

Soil type	Mechanical composition %			pH	Organic matter	CEC in meq per 100 gm
	Sand	Silt	Clay			
1. Silt loam	30.5	59.1	7.6	8.4	0.304	9.00
2. Clay loam	22.20	45.48	32.32	8.6	1.144	26.00

2 cm wide strip of paper towel, moistened with distilled water was wrapped around the bottom of the plates. The loaded plates were then developed by ascending chromatography in a glass tank.

The organic matter (to the extent of 85%) was removed from the soils by treating the soil with 30% H_2O_2 (6). The soil was autoclaved to determine the effect of autoclaving.

In order to study the effect of different additives on the mobility of amino acids, $CaCO_3$ (5%), calcium sulphate, magnesium sulphate, sodium sulphate, sodium bicarbonate, sodium carbonate (1%, 3% and 5% each) and flyash (5% and 10%) were mixed in the soil samples.

The soil with hydrogen, calcium and sodium forms were prepared by Aldrich and Buchanan's method (7). The hydrogen saturated soil were used immediately after passing through the H-Dowex-50-W-X_8 cation exchange resin to avoid the movement of aluminium ions.

The pH of the developers was adjusted to 4,7 and 10 by adding, requisite amount of dil HCl and NaOH to distilled water in the studies dealing with the effect of pH on mobility.

In all these studies the developed plates were air dried at room temperature and sprayed with 1% ninhydrine (8) in distilled water followed by heating at 100 $\pm$ 5°C for 5 to 10 min. Pink spots indicated for ALA and GLU; dark gray for ASP; reddish yellow for GLY while violet spots for HIS, ILE, LEU, LYS, PHE, TRP and VAL.

The mobility of amino acids was expressed in terms of R_f (9), R_B (10) and R_M (11) values as $R_f = \frac{1}{10}\left(\frac{R_T + R_L}{2}\right)$ where R_T and R_L denotes the tailing and lateral fronts respectively,

$$R_B = \frac{\text{Distance moved by bottom of spot}}{\text{Distance travelled by developer}}$$

and $R_M = \log\left(\frac{1}{R_f} - 1\right)$

RESULTS AND DISCUSSION

When natural soils were used as an adsorbents and distilled water as eluent, the R_f, R_B and R_M values showed lateral movement of all the amino acids (Fig 1) except LYS (RB = 0) (which is not clearly visible in figure) in both the soils (Table II). The observations were in accordance with the increased tailings shown by amino acids by lower mobility (12). The movement of all the amino acids was lower in clay loam soil than silt loam soil which might partly be due to the higher CEC, clay and organic matter content in the former soil and partly by the release of sites for adsorption of amino acids. On the basis of R_f, R_B and R_M values the movement follows the order; for monocarboxylic amino acids ILE > LEU > VAL > ALA > GLY; for dicarboxylic amino acids GLU > ASP; basic amino acids HIS > LYS and for aromatic amino acids PHE > TRP.

The trend of the monocarboxylic and dicarboxylic amino acids can be explained on the basis of steric effect as the size of the molecule decrease the adsorption with the soils increases causing decrease in movement. In amongst the basic amino acid the movement of HIS is probably higher because it might be involved in the intramolecular H-bonding thereby decreasing its adsorption with the soils as compared to LYS. In aromatic amino acids decreased movement in TRP as compared to PHE could be attributed to the presence of two nitrogen which may have greater adsorption with soils. The above order of the amino acids are generally in accordance of the PI values. However, correlation of mobility with solubility shows a different trend. The mobility of monocarboxylic amino acids is inversely proportional to the solubility while that of others directly propositional to the solubility.

When organic matter was removed from soil (to the extent of 85%) the values of R_f, R_B of all the amino acids were reduced while

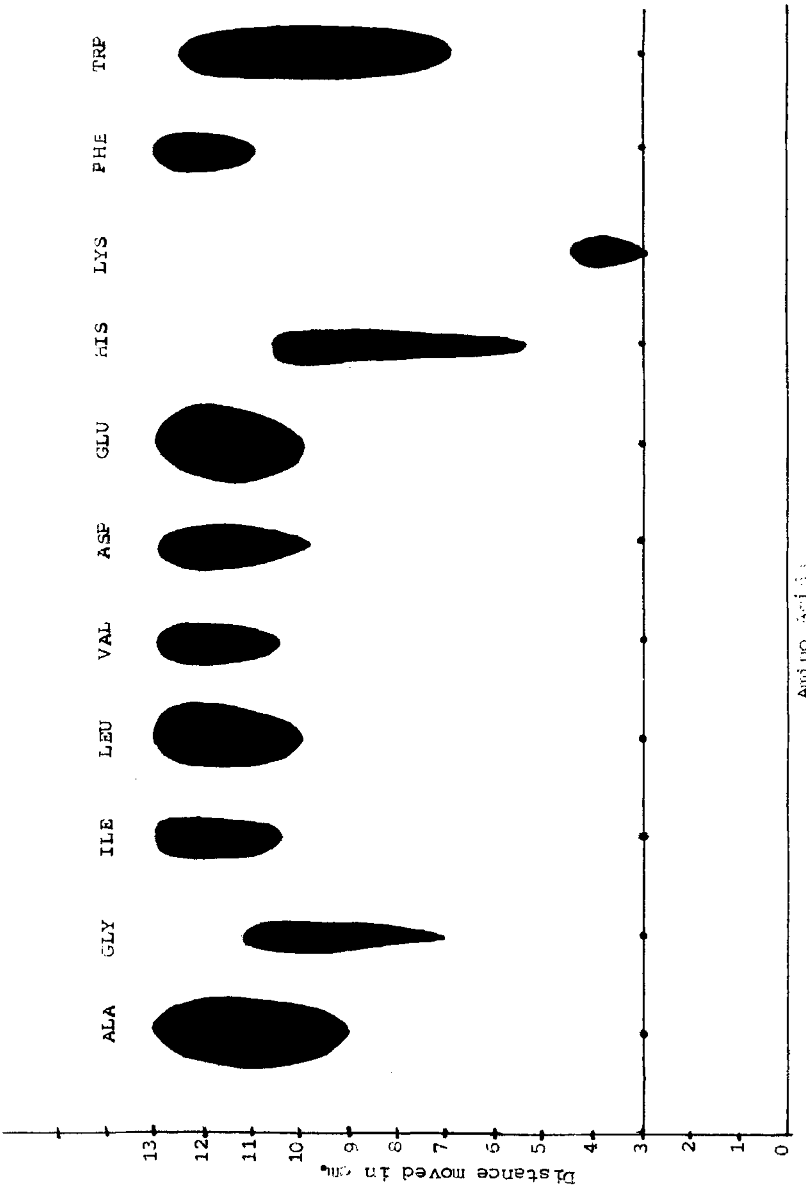

Fig. 1. Movement of amino acids in natural silt loam soil using distilled water as eluent.

TABLE II

Movement of amino acids in natural soils and soils without organic matter

(Movement expressed as R_f, R_B and R_M)

Amino Acids	Soils	Natural Soil			Soil without organic matter		
		R_f	R_B	R_M	R_f	R_B	R_M
A. Monocarboxylic Amino Acid:							
1. ALA	A	0.80	0.60	-0.60	0.68	0.45	-0.33
	B	0.67	0.56	-0.31	0.54	0.35	-0.07
2. GLY	A	0.61	0.40	-0.19	0.46	0.10	0.07
	B	0.45	0.20	0.09	0.48	0.30	0.03
3. ILE	A	0.88	0.75	-0.87	0.68	0.40	-0.33
	B	0.73	0.50	-0.43	0.78	0.57	-0.55
4. LEU	A	0.85	0.70	-0.75	0.61	0.27	-0.19
	B	0.70	0.35	-0.37	0.76	0.57	-0.50
5. VAL	A	0.88	0.75	-0.87	0.65	0.35	-0.27
	B	0.69	0.45	-0.35	0.78	0.78	-0.55
B. Dicarboxylic Amino Acid:							
6. ASP	A	0.85	0.70	-0.75	0.75	0.55	-0.48
	B	0.81	0.75	-0.63	0.61	0.43	-0.19

(continued)

(Table II continued)

Amino Acids	Soils	Natural soil			Soil without organic matter		
		R_f	R_B	R_M	R_f	R_B	R_M
7. GLU	A	0.85	0.70	-0.75	0.69	0.40	-0.35
	B	0.83	0.68	-0.69	0.70	0.53	-0.37
C. Basic Amino Acid:							
8. HIS	A	0.50	0.24	0.00	0.47	0.18	0.05
	B	0.40	0.23	0.18	0.23	0.00	0.52
9. LYS	A	0.07	0.00	1.12	0.05	0.00	1.28
	B	0.00	0.00	0.00	0.05	0.00	1.28
D. Aromatic Amino Acid:							
10. PHE	A	0.90	0.80	-0.95	0.60	0.25	-0.18
	B	0.63	0.40	-0.23	0.73	0.66	-0.43
11. TRP	A	0.67	0.39	-0.31	0.55	0.20	-0.09
	B	0.52	0.30	-0.03	0.61	0.41	-0.19

Abbreviation: A = Silt loam soil; B = Clay loam soil;
Other abbreviations are given in the text.

that of R_M increased in silt loam soil (Table II). This might be partly due to the fact that due to the removal of organic matter, the soil becomes highly dispersed resulting in slow penetration. However, in clay loam soil the movement of GLY, ILE, LEU, LYS, PHE and VAL increased while that of remaining decreased which could be due to the preferential adsorption of amino acids to the active soil sites (13) released by destruction of organic matter and the amino groups acting as cations to satisfy the negative charge on the clay in the absence of organic matter (14).

When autoclaved soils were used as an static phase and distilled water as eluent the movement of all the amino acids decreased except the basic amino acid in silt loam soil and GLY in clay loam soil (Table III).

Addition of 5% $CaCO_3$ to both the soils brought about decrease in the values of R_f, R_B of all the amino acids and increase in R_M values (Table IV). The adsorbent quality of $CaCO_3$ reduced the movement of all the amino acids as being highly adsorbed on the soil surfaces thereby reducing their upward leachability. These results are in the accordance with the work of Neerpass (15) and Singh et al. (16).

In order to study the effect of soil salinity or alkalinity both weak base and strong anionic salt viz. calcium sulphate, magnesium sulphate, sodium sulphate, sodium bicarbonate and sodium carbonate in the concentration of 1%, 3% and 5% were mixed with soils and these soils were used as an adsorbent and distilled water as eluent. The movement of all the amino acids was almost nil when both the soil were amended with sodium bicarbonate, and sodium carbonate. The marked decrease in movement of amino acids in alkaline salts amended soil might be due to the interaction of the acidic functionality of the amino acids (-COOH group). The movement

TABLE III

Movement of amino acids in autoclaved soils and Calcium Carbonate amended soils

(Movement expressed as R_f, R_B and R_M)

Amino Acids	Soils	Autoclaved Soil			5% $CaCO_3$		
		R_f	R_B	R_M	R_f	R_B	R_M
A. Monocarboxylic Amino Acid:							
1. ALA	A	0.76	0.58	-0.50	0.78	0.62	-0.55
	B	0.56	0.40	-0.10	0.56	0.37	-0.10
2. GLY	A	0.61	0.33	-0.19	0.56	0.30	-0.10
	B	0.50	0.30	0.00	0.39	0.16	0.19
3. ILE	A	0.85	0.70	-0.75	0.88	0.79	-0.87
	B	0.63	0.43	-0.23	0.64	0.43	0.25
4. LEU	A	0.84	0.68	-0.72	0.81	0.64	-0.63
	B	0.60	0.35	-0.18	0.63	0.36	-0.23
5. VAL	A	0.83	0.65	-0.69	0.89	0.78	-0.91
	B	0.61	0.40	-0.19	0.59	0.43	-0.16

B. Dicarboxylic Amino Acid:							
6. ASP	A	0.85	0.70	-0.75	0.81	0.66	-0.63
	B	0.63	0.45	-0.23	0.65	0.51	-0.27
7. GLU	A	0.85	0.70	-0.75	0.85	0.74	-0.75
	B	0.70	0.53	-0.37	0.71	0.55	-0.39
C. Basic Amino Acid:							
8. HIS	A	0.58	0.33	-0.14	0.49	0.23	0.02
	B	0.36	0.25	0.25	0.39	0.21	0.19
9. LYS	A	0.08	0.00	1.06	0.08	0.00	1.06
	B	0.00	0.00	0.00	0.00	0.00	0.00
D. Aromatic Amino Acid:							
10. PHE	A	0.81	0.65	-0.63	0.74	0.53	-0.45
	B	0.59	0.35	-0.16	0.59	0.37	-0.16
11. TRP	A	0.63	0.40	-0.23	0.56	0.28	-0.10
	B	0.46	0.25	0.07	0.30	0.07	0.37

Abbreviations are defined in Table II.

of all the monocarboxylic, dicarboxylic and aromatic amino acids decreased with increase in concentration of calcium sulphate and sodium sulphate in the adsorbent phase while that of basic amino acids increased in both the soils. The movement of GLY, basic and aromatic amino acids increased while that of others decreased with increase in concentration of magnesium sulphate in the soil phases (Table IV). A model of amino acid movement in 3% calcium sulphate amended silt loam soil is given in Fig 2.

The average movement of amino acids follows the order as

$Na_2SO_4 > CaSO_4 > MgSO_4$ for ALA, ASP and GLY

$CaSO_4 > Na_2SO_4 > MgSO_4$ for GLU, ILE, LEU and VAL

$Na_2SO_4 > MgSO_4 > CaSO_4$ for HIS and LYS in both the soils. The aromatic amino acids such as PHE and TRP have a different trend as

$Na_2SO_4 > CaSO_4 > MgSO_4$ in silt loam soil

$CaSO_4 > MgSO_4 > Na_2SO_4$ in clay loam soil

The movement of amino acids was more in neutral and saline salts amended soil than alkaline. The minimum the R_M values were observed in sodium sulphate and calcium sulphate (i.e. neutral and saline salts) showing maximum movement in both the soils. In a way similar results were obtained by Singh et al. (17) and Sharma et al. (18).

When silt loam soil was amended with 5% flyash (obtained from Thermal Power Station, Kasimpur, a cheapest waste product of industries using coal as fuel) the movement of ALA, HIS and TRP increased while that of ASP, GLU and PHE decreased and the remaining ones remained unaffected. In clay loam soil the R_f values of GLU, GLY, HIS, LEU, LYS and PHE increased while that of ALA, ASP, ILE, TRP and VAL decreased with the remaining unaffected (Table V). When the concentration of flyash (10%) was increased in soils the movement of all the amino acids in silt loam soil, decreased while these in clay loam soil, the movement of HIS, ILE, LEU, LYS and VAL

TABLE IV

Movement of amino acid in saline and alkaline salts amended soils

(Movement expressed as R_f, R_B and R_M)

Amino Acids	Soils	1%			3%			5%		
		R_f	R_B	R_M	R_f	R_B	R_M	R_f	R_B	R_M
a. Calcium Sulphate										
A. Monocarboxylic Amino Acid:										
1. ALA	A	0.74	0.52	-0.45	0.73	0.55	-0.43	0.70	0.50	-0.37
	B	0.70	0.40	-0.37	0.64	0.42	-0.25	0.58	0.40	-0.14
2. GLY	A	0.73	0.50	-0.43	0.68	0.45	-0.33	0.63	0.40	-0.23
	B	0.55	0.30	-0.09	0.53	0.30	-0.05	0.48	0.30	0.03
3. ILE	A	0.85	0.75	-0.75	0.83	0.61	-0.69	0.80	0.60	-0.60
	B	0.80	0.60	-0.60	0.73	0.50	-0.43	0.71	0.50	-0.39
4. LEU	A	0.88	0.75	-0.87	0.83	0.65	-0.69	0.73	0.45	-0.43
	B	0.79	0.58	-0.58	0.75	0.55	-0.48	0.68	0.35	-0.33
5. VAL	A	0.88	0.75	-0.87	0.83	0.65	-0.69	0.70	0.50	-0.37
	B	0.75	0.55	-0.48	0.73	0.50	-0.43	0.65	0.45	-0.27
B. Dicarboxylic Amino Acid:										
6. ASP	A	0.83	0.50	-0.69	0.75	0.55	-0.48	0.74	0.55	-0.45
	B	0.74	0.48	-0.45	0.63	0.35	-0.23	0.58	0.35	-0.14

(continued)

(Table IV continued)

Amino Acids	Soils	1%			3%			5%		
		R_f	R_B	R_M	R_f	R_B	R_M	R_f	R_B	R_M
7. GLU	A	0.90	0.80	-0.95	0.85	0.70	-0.75	0.72	0.45	-0.41
	B	0.84	0.68	-0.72	0.78	0.55	-0.55	0.70	0.50	-0.37
C. Basic Amino Acid:										
8. HIS	A	0.50	0.32	0.00	0.52	0.36	-0.03	0.60	0.50	-0.18
	B	0.35	0.20	0.27	0.45	0.30	0.09	0.48	0.25	0.03
9. LYS	A	0.13	0.00	0.83	0.13	0.00	0.83	0.13	0.00	0.83
	B	0.08	0.00	1.06	0.08	0.00	1.06	0.10	0.00	0.95
D. Aromatic Amino Acid:										
10. PHE	A	0.80	0.65	-0.60	0.75	0.60	-0.48	0.68	0.45	-0.33
	B	0.69	0.45	-0.35	0.68	0.45	-0.33	0.63	0.35	-0.23
11. TRP	A	0.68	0.50	-0.33	0.63	0.45	-0.23	0.58	0.35	-0.14
	B	0.53	0.25	-0.05	0.48	0.25	0.03	0.45	0.20	0.09
					b. Magnesium sulphate					
A. Monocarboxylic Amino Acid:										
1. ALA	A	0.73	0.57	-0.43	0.68	0.45	-0.33	0.65	0.40	-0.27
	B	0.56	0.39	-0.10	0.58	0.45	-0.14	0.60	0.40	-0.18

2. GLY	A	0.62	0.42	-0.21	0.67	0.38	-0.31	0.75	0.60	-0.48
	B	0.40	0.16	0.18	0.53	0.35	-0.05	0.54	0.17	-0.07
3. ILE	A	0.78	0.58	-0.55	0.69	0.60	-0.35	0.63	0.45	-0.23
	B	0.58	0.39	-0.14	0.63	0.38	-0.23	0.67	0.42	-0.31
4. LEU	A	0.76	0.60	-0.50	0.71	0.53	-0.39	0.67	0.38	-0.31
	B	0.58	0.44	-0.14	0.60	0.38	-0.18	0.62	0.38	-0.21
5. VAL	A	0.75	0.65	-0.48	0.68	0.51	-0.33	0.65	0.52	-0.27
	B	0.51	0.32	-0.02	0.59	0.42	-0.16	0.65	0.52	-0.27
B. Dicarboxylic Amino Acid:										
6. ASP	A	0.80	0.63	-0.60	0.75	0.60	-0.48	0.72	0.50	-0.41
	B	0.51	0.29	-0.02	0.54	0.40	-0.07	0.57	0.43	-0.12
7. GLU	A	0.79	0.61	-0.58	0.78	0.60	-0.55	0.76	0.61	-0.50
	B	0.43	0.26	0.12	0.50	0.30	0.00	0.66	0.32	0.29
C. Basic Amino Acid:										
8. HIS	A	0.59	0.46	-0.16	0.60	0.38	-0.18	0.69	0.61	-0.35
	B	0.48	0.25	0.03	0.57	0.25	-0.12	0.63	0.38	-0.23
9. LYS	A	0.10	0.00	0.95	0.15	0.00	0.75	0.26	0.00	0.45
	B	0.05	0.00	1.28	0.05	0.00	1.28	0.07	0.00	1.12
D. Aromatic Amino Acid:										
10. PHE	A	0.65	0.50	-0.27	0.67	0.45	-0.31	0.68	0.55	-0.33
	B	0.54	0.33	-0.07	0.56	0.37	-0.10	0.75	0.52	-0.48

(continued)

(Table IV continued)

Amino Acids	Soils	1%			3%			5%		
		R_f	R_B	R_M	R_f	R_B	R_M	R_f	R_B	R_M
11. TRP	A	0.54	0.32	-0.07	0.63	0.37	-0.23	0.68	0.46	-0.33
	B	0.44	0.27	0.10	0.50	0.30	0.00	0.51	0.30	-0.02
C. Sodium sulphate										
A. Monocarboxylic Amino Acid:										
1. ALA	A	0.83	0.65	-0.69	0.77	0.53	-0.52	0.68	0.50	-0.33
	B	0.73	0.53	-0.43	0.70	0.50	-0.37	0.68	0.47	-0.33
2. GLY	A	0.75	0.50	-0.48	0.73	0.50	-0.43	0.73	0.50	-0.43
	B	0.60	0.30	-0.180	0.55	0.20	-0.09	0.50	0.32	0.00
3. ILE	A	0.85	0.70	-0.75	0.75	0.50	-0.48	0.68	0.40	-0.33
	B	0.87	0.73	-0.83	0.66	0.43	0.29	0.60	0.40	-0.18
4. LEU	A	0.83	0.68	-0.69	0.73	0.45	-0.43	0.68	0.45	-0.33
	B	0.84	0.68	-0.72	0.59	0.35	-0.16	0.56	0.38	-0.10
5. VAL	A	0.80	0.65	-0.60	0.78	0.55	-0.55	0.68	0.35	-0.33
	B	0.77	0.53	-0.52	0.64	0.43	-0.25	0.61	0.37	-0.19

B. Dicarboxylic Amino Acid:										
6. ASP	A	0.83	0.65	-0.69	0.80	0.60	-0.60	0.73	0.50	-0.43
	B	0.73	0.50	-0.43	0.65	0.40	-0.27	0.63	0.40	-0.23
7. GLU	A	0.80	0.60	-0.60	0.75	0.55	-0.48	0.75	0.55	-0.48
	B	0.76	0.53	-0.50	0.75	0.50	-0.48	0.74	0.52	-0.45
C. Basic Amino Acid:										
8. HIS	A	0.63	0.40	-0.23	0.75	0.50	-0.48	0.75	0.60	-0.48
	B	0.53	0.35	-0.05	0.53	0.35	-0.05	0.67	0.40	-0.31
9. LYS	A	0.13	0.00	0.83	0.30	0.00	0.37	0.30	0.00	0.37
	B	0.08	0.00	1.06	0.08	0.00	1.06	0.10	0.00	0.95
D. Aromatic Amino Acid:										
10. PHE	A	0.78	0.61	-0.55	0.75	0.50	-0.48	0.73	0.45	-0.43
	B	0.61	0.36	-0.19	0.55	0.29	-0.09	0.50	0.32	0.00
11. TRP	A	0.73	0.45	-0.43	0.68	0.45	-0.33	0.68	0.35	-0.33
	B	0.46	0.23	0.07	0.41	0.19	0.16	0.41	0.20	0.16

Abbreviations are defined in Table II.

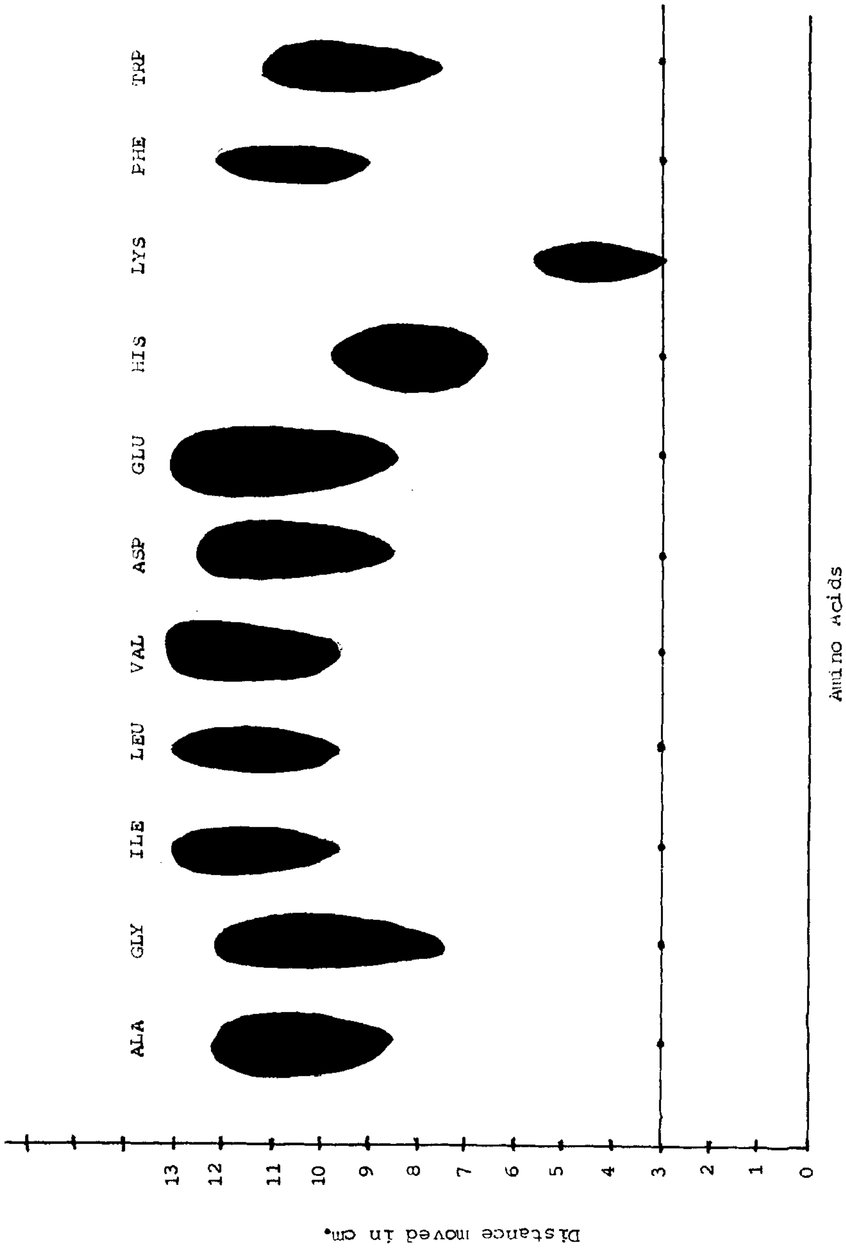

Fig. 2. Movement of amino acids in natural silt loam soil amended wity 3% calcium sulphate using distilled water as eluent.

TABLE V

Movement of amino acids in flyash amended soils

(Movement expressed as R_f, R_B and R_M)

Amino Acids	Soils	5% fly ash			10% fly ash		
		R_f	R_B	R_M	R_f	R_B	R_M
A. Monocarboxylic Amino Acid:							
1. ALA	A	0.84	0.68	-0.72	0.59	0.38	-0.16
	B	0.58	0.35	-0.14	0.60	0.38	-0.18
2. GLY	A	0.60	0.33	-0.18	0.44	0.18	0.10
	B	0.46	0.20	0.07	0.46	0.20	0.10
3. ILE	A	0.88	0.75	-0.87	0.76	0.53	-0.50
	B	0.66	0.40	-0.29	0.77	0.53	-0.50
4. LEU	A	0.84	0.68	-0.72	0.69	0.40	-0.35
	B	0.69	0.45	-0.58	0.73	0.48	-0.43
5. VAL	A	0.88	0.75	-0.87	0.73	0.45	-0.43
	B	0.66	0.43	-0.29	0.73	0.45	-0.43
B. Dicarboxylic Amino Acid:							
6. ASP	A	0.81	0.63	-0.63	0.79	0.63	-0.58
	B	0.73	0.55	-0.43	0.79	0.63	-0.58
7. GLU	A	0.81	0.63	-0.63	0.80	0.60	-0.60
	B	0.88	0.75	-0.87	0.80	0.60	-0.60

(continued)

(Table V continued)

Amino Acids	Soils	5% fly ash			10% fly ash		
		R_f	R_B	R_M	R_f	R_B	R_M
C. Basic Amino Acid:							
8. HIS	A	0.66	0.45	-0.29	0.46	0.25	0.07
	B	0.44	0.20	0.10	0.46	0.25	0.07
9. LYS	A	0.09	0.00	0.00	0.05	0.00	1.28
	B	0.00	0.00	0.00	0.05	0.00	1.28
D. Aromatic Amino Acid:							
10. PHE	A	0.83	0.65	-0.69	0.61	0.40	-0.19
	B	0.65	0.40	-0.27	0.61	0.40	-0.19
11. TRP	A	0.70	0.55	-0.37	0.48	0.25	0.035
	B	0.48	0.23	0.03	0.48	0.25	0.035

Abbreviations are defined in Table II.

TABLE VI

Effect of hydrogen, calcium and sodium soils on the movement of amino acids

(Movement expressed as R_f, R_B and R_M)

Amino Acids	Soils	H-soil			Ca-soil			Na-soil		
		R_f	R_B	R_M	R_f	R_B	R_M	R_f	R_B	R_M
A. Monocarboxylic Amino Acid:										
1. ALA	A	0.48	0.15	0.03	0.70	0.50	-0.37	0.73	0.45	-0.43
	B	0.39	0.15	0.19	0.54	0.40	-0.07	0.48	0.27	0.03
2. GLY	A	0.40	0.00	0.18	0.47	0.20	0.05	0.73	0.50	-0.43
	B	0.29	0.00	0.39	0.40	0.10	0.18	0.34	0.21	0.29
3. ILE	A	0.63	0.25	-0.23	0.73	0.50	-0.43	0.80	0.65	-0.60
	B	0.55	0.30	-0.09	0.63	0.40	-0.23	0.59	0.32	-0.16
4. LEU	A	0.60	0.20	-0.18	0.64	0.40	-0.25	0.68	0.45	-0.33
	B	0.33	0.00	0.31	0.48	0.30	0.03	0.36	0.21	0.25
5. VAL	A	0.60	0.20	-0.18	0.75	0.60	-0.48	0.78	0.60	-0.55
	B	0.50	0.30	0.00	0.68	0.50	-0.33	0.56	0.32	-0.10
B. Dicarboxylic Amino Acid:										
6. ASP	A	0.45	0.20	0.09	0.53	0.30	-0.05	0.78	0.55	-0.54
	B	0.39	0.15	0.19	0.55	0.35	-0.09	0.44	0.13	0.10

(continued)

(Table VI continued)

Amino Acids	Soils	H-soil			Ca-soil			Na-soil		
		R_f	R_B	R_M	R_f	R_B	R_M	R_f	R_B	R_M
7. GLU	A	0.50	0.00	0.00	0.65	0.45	-0.27	0.88	0.75	-0.87
	B	0.34	0.00	0.29	0.50	0.40	0.00	0.45	0.15	0.09
C. Basic Amino Acid:										
8. HIS	A	0.10	0.00	0.95	0.53	0.30	-0.05	0.65	0.45	-0.27
	B	0.00	0.00	0.00	0.40	0.20	0.18	0.20	0.00	0.60
9. LYS	A	0.07	0.00	1.12	0.10	0.00	0.95	0.10	0.00	0.95
	B	0.00	0.00	0.00	0.07	0.00	1.12	0.00	0.00	0.00
D. Aromatic Amino Acid:										
10. PHE	A	0.55	0.10	-0.09	0.60	0.25	-0.18	0.65	0.55	-0.27
	B	0.38	0.20	0.21	0.45	0.25	0.09	0.39	0.21	0.19
11. TRP	A	0.50	0.00	0.00	0.58	0.30	-0.14	0.64	0.40	-0.25
	B	0.20	0.00	0.60	0.40	0.20	0.18	0.25	0.14	0.48

Abbreviations are defined in Table II.

TABLE VII

Effect of pH on the movement of amino acids in soils using different pH leachates

(Movement expressed as R_f, R_B and R_M)

Amino Acids	Soils	4			7			10		
		R_f	R_B	R_M	R_f	R_B	R_M	R_f	R_B	R_M
A. Monocarboxylic Amino Acid:										
1. ALA	A	0.78	0.58	-0.60	0.80	0.60	-0.60	0.75	0.55	-0.48
	B	0.64	0.43	-0.25	0.67	0.56	-0.31	0.50	0.30	0.00
2. GLY	A	0.53	0.25	-0.05	0.61	0.40	-0.19	0.60	0.35	-0.18
	B	0.48	0.23	0.03	0.45	0.20	0.09	0.41	0.18	0.16
3. ILE	A	0.80	0.60	-0.60	0.88	0.75	-0.87	0.80	0.60	-0.60
	B	0.66	0.40	-0.29	0.73	0.50	-0.43	0.78	0.55	-0.55
4. LEU	A	0.80	0.60	-0.60	0.85	0.70	-0.75	0.81	0.62	-0.63
	B	0.63	0.35	-0.23	0.70	0.35	-0.37	0.75	0.50	-0.48
5. VAL	A	0.83	0.70	-0.87	0.88	0.75	-0.87	0.83	0.65	-0.69
	B	0.58	0.35	-0.14	0.69	0.45	-0.35	0.75	0.55	-0.48

(continued)

B. Dicarboxylic Amino Acid:										
6. ASP	A	0.03	0.65	-0.75	0.85	0.70	-0.75	0.79	0.63	-0.58
	B	0.70	0.50	-0.37	0.81	0.75	-0.63	0.61	0.39	-0.19
7. GLU	A	0.85	0.73	-0.75	0.85	0.70	-0.75	0.85	0.70	-0.75
	B	0.81	0.63	-0.63	0.83	0.68	-0.69	0.73	0.55	-0.43
C. Basic Amino Acid:										
8. HIS	A	0.66	0.43	-0.29	0.50	0.24	0.00	0.65	0.40	-0.27
	B	0.41	0.23	0.16	0.40	0.23	0.18	0.45	0.20	0.09
9. LYS	A	0.05	0.00	1.28	0.07	0.00	1.12	0.05	0.00	1.28
	B	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	1.28
D. Aromatic Amino Acid:										
10. PHE	A	0.78	0.55	-0.55	0.90	0.80	-0.95	0.81	0.63	-0.63
	B	0.53	0.28	-0.05	0.63	0.40	-0.23	0.74	0.50	-0.45
11. TRP	A	0.56	0.22	-0.10	0.67	0.39	-0.31	0.70	0.50	-0.37
	B	0.45	0.20	0.09	0.52	0.30	-0.03	0.49	0.23	0.02

Abbreviations are defined in Table II.

increased and that of ALA, ASP, GLU, PHE and TRP decreased. The decreased in the movement of amino acids with the addition of flyash might partly be due to the flyash acting as an adsorbent. The contents of flyash such as alumina, coesite, silica, amorphous carbon and small quantity of lime (19) are known for adsorbent quality.

The movement of all the amino acids studied was higher in Na-soil followed by Ca- and H-form in silt loam soil. However, in clay loam soil the maximum movement was in Ca-soil followed by Na- and H-soil. The minimum movement of all the amino acid was observed in both the H-saturated soils. Generally the movement of dicarboxylic, basic and aromatic amino acids follows the same order as in natural soil while that of monocarboxylic amino acid have different order. Dregne et al. (20), Singhal and Singh (21), Supak et al. (22), Singh et al. (23) and Sharma et al. (24) also observed higher adsorption of 2,4-D, demicron and aldicarb in H-saturated soils and lower movement of pesticides in H-saturated soils.

The effect of soil pH on the movement of amino acids through soils are summarized in Table VII. Generally in all the cases the R_f values of amino acids were lower both in acidic and alkaline ranges than in the neutral range except HIS at pH 4 and pH 10 in silt loam soil. However, in clay loam soil the movement of GLY and HIS increased at pH 4 and HIS, ILE, LEU and PHE at pH 10 while that of the remaining decreased. The movement of ALA, ASP and HIS was higher at pH 4 while that of the remaining at pH 10. Such a behaviour could be due to the differences in the adsorptive nature of the amino acids at different pH values understudy. In soil ammonium oxidation by microorganisms is inhibited at low pH. Similarly at higher soil pH levels the population of ammonia oxidising micro-organism decrease which being about poor conversion into mineral N. As a result of these phenomena the available amino acid concentration in soil increases which might result in more mobility (25).

Therefore, it appears that the movement and availability of different amino acids in soil varies with different types of soil and are governed by several factors.

ACKNOWLEDGEMENT

The financial assistance by the University Grants Commission, New Delhi (India) is gratefully acknowledged.

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