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Lysimeteric Study of Translocation of Nitrogen, Phosphorous and Some Herbicides in a Calcareous Soil

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Abstract: Today the cides are used worldwide. The effect of cides on soil and water contamination are well documented. One group of cides which are used in agriculture is herbicides for control of weeds in cultivated lands. The Atrazin, Alachlor, Butachlor and Eradican are used much more in cultivated area of Iran for control of weeds. The soil sample collected from the Marvdasht lands which is an intensive agriculture area. Transect of 0-100 cm of soil was transferred to a cylindrical lysimeter with 1 meter hight, 45 cm in diameter and an out let for drainage at the bottom and compacted to a bulk density of 1.5 g cm^{-3}. At first of summer Atrazin, Eradican, Alachlor and Butachlor were added to soil surface of each lysimeters at rates 3.5, 5, 2 and 3.5 kg ha^{-1} effective ingredient, respectively. At three of lysimeters maize (*Zea mays* L) was cultivated and the rest were bare. The lysimeters were irrigated according to 0.8, 1.0 and 1.2 times of field capacity (FC) at different intervals. Soil samples were collected from depth of 0-20, 30-40, 40-60, 60-80 and 80-100 cm at different dates with in 4 mounts and tested for herbicides, nitrogen and phosphorous residue. The tested soil in lysimeter is a calcareous soil with clayey texture. At the first of experiment 300 and 400 kg ha^{-1} diammonium phosphate and urea were added to lysimeters, respectively. The results of cultivated lysimeters show that atrazin was decreased with increasing time and depth of soil but not found in depth of more than 40 cm for 0.8 FC of irrigation regime, while the tested herbicides reached to 40-60 cm at 1.0 FC and 1.2 FC of irrigation regime, which is due to the amount of water used for irrigation. this trend for tested herbicides are the same in bare soils, but the detected amount of herbicides in bare soil is less than cultivated soils, which means the corn root may act as filter, where is reported in documents. After 84 days of experiments 75-95% of tested herbicides are degraded and or adsorbed to soil particles at different irrigation regime of tested bare and cultivated lysimeters. According to the result the nitrogen residue in soil layer showed an increase from top layer to middle layer and then decreased to soil bottom layer in each time of sampling and during the experiment. The nitrogen residue was decreased with increasing time and depth of soil. However the translocation of nitrogen in soil profile is not too much to reach ground water, this process may be due to heavy soil texture and denitrification. This result is similar for 0.08 FC, 1.0 FC and 1.2 FC of irrigation regime. The result of nitrogen residue in cultivated lysimeters is lesser than bare soil which is due to plant uptake. As results showed the amount of available phosphorous was decreased with increasing time and depth of soil in lysimeters and however, show excess phosphorous in tested soils, while, according to researcher findings 20 mg P kg^{-1} in soil of study area is adequate for optimum growth of most of plant species.

Key words:

INTRODUCTION

Atrazine, alachlor and metolachlor are the most heavily used herbicides in US, Canada [1, 2] and in south of Iran. According to Wauchope [3] herbicide losses from agricultural land ranged from 2-5% of applied amounts. Masse [4] and Southwick *et al*. [5] stated that atrazine and metolachlor concentrations in ground water, surface water and drainage effluent are considerable. According to Racker, *et al*. [6], the overall dissipation of a pesticide from soil results from a combination of loss mechanism such as microbial degradation, chemical hydrolysis, photolysis, volatility, leaching and surface run off. The degree to which each mechanism will contribute to the overall loss of pesticide is in turn dependent on the physicochemical properties of pesticide (e.g., water solubility, sorptive affinity), characteristics of the soil (e.g., pH, organic content, biomass, redox status),

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environmental conditions (e.g., temperatures, moisture) and management practices (e.g., application rate, formulation type). A signification reduction in herbicide and nitrate concentration in drainage effluent is reported by Liaght [7],who found significant difference between herbicide levels in grass covered and bare soil lysimeters and showed that denitrification was the predominat process for reducing nitrate levels. Liaghat [7] found that 99% of total applied atrazine, metoalchlor and metribuzin were trapped by soil filter and of the total applied nitrate more than 48% was dissipated by the soil filter. Atrazine is the most widely used herbicide and has been used as pre-and-post-emergent herbicide to control broad-leaf weed in the production of corn [8, 9]. Dehghani *et al.* [8] states that adsorption concentration of atrazine increases as the adsorption time increases. Increase in temperature by 10 degree reduced the half-life (15 days) of alachlor in soils [10]. Alachlor is an herbicide used on a number of crops to control annual grasses and many broad-leaved weeds [10]. Alachlor is high to moderately mobile in soil and mobilization decreases with an increase in organic carbon and clay content in soil. The transformation is primarily by biodegradation and very little by mineralization [10]. Walker *et al.* [11] demonstrated that alachlor degradation in temperate soils was markedly affected by temperature, moisture and adsorption. Sahid and Wei [12], showed that the half-life of alachlor decreased with increase in soil moisture. According to Korpraditskul *et al.* [13], the temperature is an important factor in the observed rate of degradation of atrazine. Noshadi, *et al.* [14] observed the reduction of atrazine in soil profile and present at most at depth of 50 cm below soil surface. Thelin and Gianessi [15] reported that in early 1990s, 411 ton y^{-1} active ingredient was applied to 1.7 million hectars in USA.

Microbial degradation and volatilization is the primary environmental pathway of EPTC in soil. Terrestrial field dissipation studies report soil half-life between 2-19 days for EPTC which have water solubility of 367 mg L^{-1}, low affinity for binding to soil and moderate potential to leach into ground water. EPTC is some what more persistent in anaerobic soils than in aerobic soils [16]. According USEPA [16], EPA reference dose of 0.025 mg kg^{-1} day^{-1} for EPTC is calculated which are called no-observed-adverse-effect level (NOAEL).

MATERIALS AND METHODS

Chemicals and physical properties of soil where measured in 2006. Soil texture by hydrometer method, electrical conductivity on saturated extract, pH on saturated paste by glass electerod pH meter, organic mater by wet oxidation, calcium carbonate equivalent by neutralizing with acid, total phosphorous by spectrophtometry, total-N by keldahle method [17] were determined. To evaluate the translocation and fate of herbicide, nitrogen and phosphorous in soil profile, a lysimeter with one meter length and 45 cm in diameter was constructed (Fig. 1). A transect of calcareous soil from Marvdasht, a highly intensive agricultural area, transferred to lysimiter and compacted to 1.5 g cm^{-3} bulk density. Physicochemical property of soil is presented in Table (1).

In three of lysimeter corn (*Zea mays* L) was cultivated at first of July 2007 and three lysimeter leaved bare. Atrazine, (2-choloro-4 ethylamino-6-isoproylamino-a-triazine), alachlor (2-chloro-2,6 – diethyl-N-(methoxymethyl)-acetanilide), butachlor (2-chloro-2,6-diethyl-N-l butoxymethyl)-acetanilide) and EPTC, eradican (5-ethyl-N,N, dipropythiocarbamate + N,N-diallyl-1,1-dichloroacetamide) were applied to soil surface at rate of 3.5, 5, 2 and 3.5 kg ha^{-1} active ingredient, respectively, urea and diammonium phosphate were applied to soil at rate of 400 and 300 kg ha^{-1}, respectively. Three irrigation regime as 0.8, 1.0 and 1.2 of field capacity (FC) were conducted to all treatments.

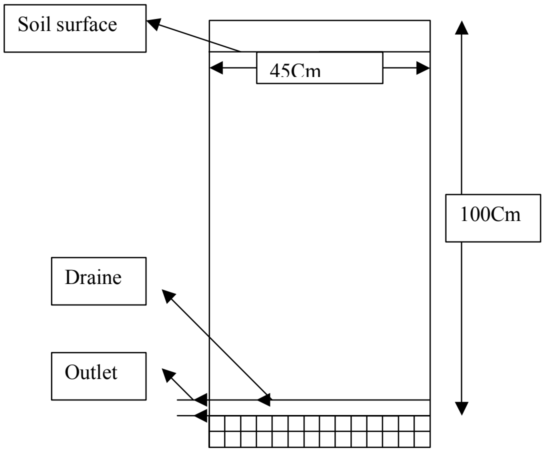

Fig. 1: Lysimeter

Table 1: Physicochemical properties of soil

Ava. K	Ava. P	Total N	CEC		EC	
ppm		%	Cmol kg^{-1}	pH	dS m^{-1}	Texture
220	63	0.042	16.95	7.22	2.21	Clay

At 4, 20 July, 6 and 27 Aug and 25 Sept. soil samples, were collected from depth of 0-20, 20-40, 40-60, 60-80 and 80-100 cm of soil column. Soil samples were tested for herbicides by gas chromatography.

RESULTS AND DISCUSSION

Result presented in Tables 2 and 3 and Figure 2-5 revealed that the amount of atrazin, alachlor, butachlor

Table 2: Atrazine (At.) and alachlor (Al.) residue in soil (mg kg^{-1})

		Cultivated Soil						Bare Soil					
		Irrigation Regime						Irrigation Regime					
Soil Depth (cm)	Date of Sampling (2007)	0.8FC		1.0 FC		1.2 FC		0.8FC		1.0 FC		1.2 FC	
		At.	Al.	At.	Al.	At.	Al.	At.	Al.	At.	Al.	At.	Al.
0-20	4 Jul.	9.85	3.72	9.2	3.41	9.94	3.42	9.9	3.82	9.25	3.45	10.2	3.42
20-40		7.11	0.75	6.03	0.78	5.02	0.76	7.15	0.68	6.14	0.68	5.12	0.66
40-60													
60-80													
0-20	20 Jul.	5.13	2.35	4.12	2.28	4.03	2.18	5.17	2.38	4.18	2.29	4.12	2.21
20-40		4.25	2.12	4.01	2.15	3.11	2.05	4.25	2.11	4.14	2.13	3.14	2.08
40-60													
60-80													
0-20	6 Aug.	2.86	1.58	2.65	1.45	2.65	1.49	2.92	1.62	2.67	1.48	2.61	1.52
20-40		2.38	0.4	2.32	0.42	2.42	0.45	2.32	0.41	2.28	0.42	2.31	0.45
40-60				1.76		1.96				1.78		1.98	
60-80													
0-20	27 Aug.	1.88	1.16	1.78	0.96	1.86	0.98	1.92	1.18	1.78	0.98	1.88	0.98
20-40		1.05	0.22	0.97	0.32	0.94	0.34	1.07	0.21	0.97	0.33	0.94	0.33
40-60				0.94	0.15	0.9	0.18			0.92	0.16	0.93	0.17
60-80													
0-20	25Sep.	1.83	0.96	0.77	0.84	0.82	0.52	1.85	0.97	0.79	0.85	0.91	0.56
20-40		1	0.24	0.71	0.29	0.8	0.31	0.98	0.23	0.73	0.28	0.85	0.32
40-60				0.62	0.18	0.64	0.17			0.64	0.18	0.66	0.19
60-80													

Table 3: Butachlor (Bt.) and Eradican (Er.) residue in soil (mg kg^{-1})

		Cultivated Soil						Bare Soil					
		Irrigation Regime						Irrigation Regime					
Soil depth (cm)	Date of sampling (2007)	0.8FC		1.0 FC		1.2 FC		0.8FC		1.0 FC		1.2 FC	
		Bt.	Er.	Bt.	Er.	Bt.	Er.	Bt.	Er.	Bt.	Er.	Bt.	Er.
0-20	4 Jul.	3.36	4.68	3.18	4.52	3.12	4.15	3.38	4.72	3.2	4.55	3.13	4.19
20-40		0.48	1.22	0.66	1.28	0.58	1.13	0.47	1.23	0.65	1.27	0.58	1.15
40-60													
60-80													
0-20	20 Jul.	2.68	3.39	2.21	3.36	2.14	3.27	2.71	3.42	2.23	3.41	2.16	3.27
20-40		1.85	2.18	2.11	2.72	2	2.65	1.88	2.18	2.13	2.78	2.01	2.67
40-60													
60-80													
0-20	6 Aug.	1.32	1.81	1.29	1.75	1.37	1.86	1.35	1.82	1.32	1.77	1.41	1.88
20-40		0.29	0.62	0.38	0.69	0.39	0.74	0.24	0.65	0.38	0.71	0.35	0.78
40-60													
60-80													
0-20	27 Aug.	0.92	1.02	0.96	0.98	0.78	0.82	0.98	1.11	0.98	0.99	0.82	0.86
20-40		0.28	0.41	0.32	0.45	0.31	0.53	0.27	0.4	0.31	0.46	0.35	0.57
40-60				0.11	0.12	0.15	0.15			0.12	0.09	0.14	0.12
60-80													
0-20	25Sep.	0.81	0.55	0.76	0.68	0.45	0.28	0.84	0.58	0.78	0.74	0.48	0.31
20-40		0.37	0.42	0.42	0.47	0.28	0.16	0.35	0.46	0.41	0.49	0.29	0.18
40-60				0.18	0.15	0.17	0.12			0.19	0.11	0.19	0.12
60-80													

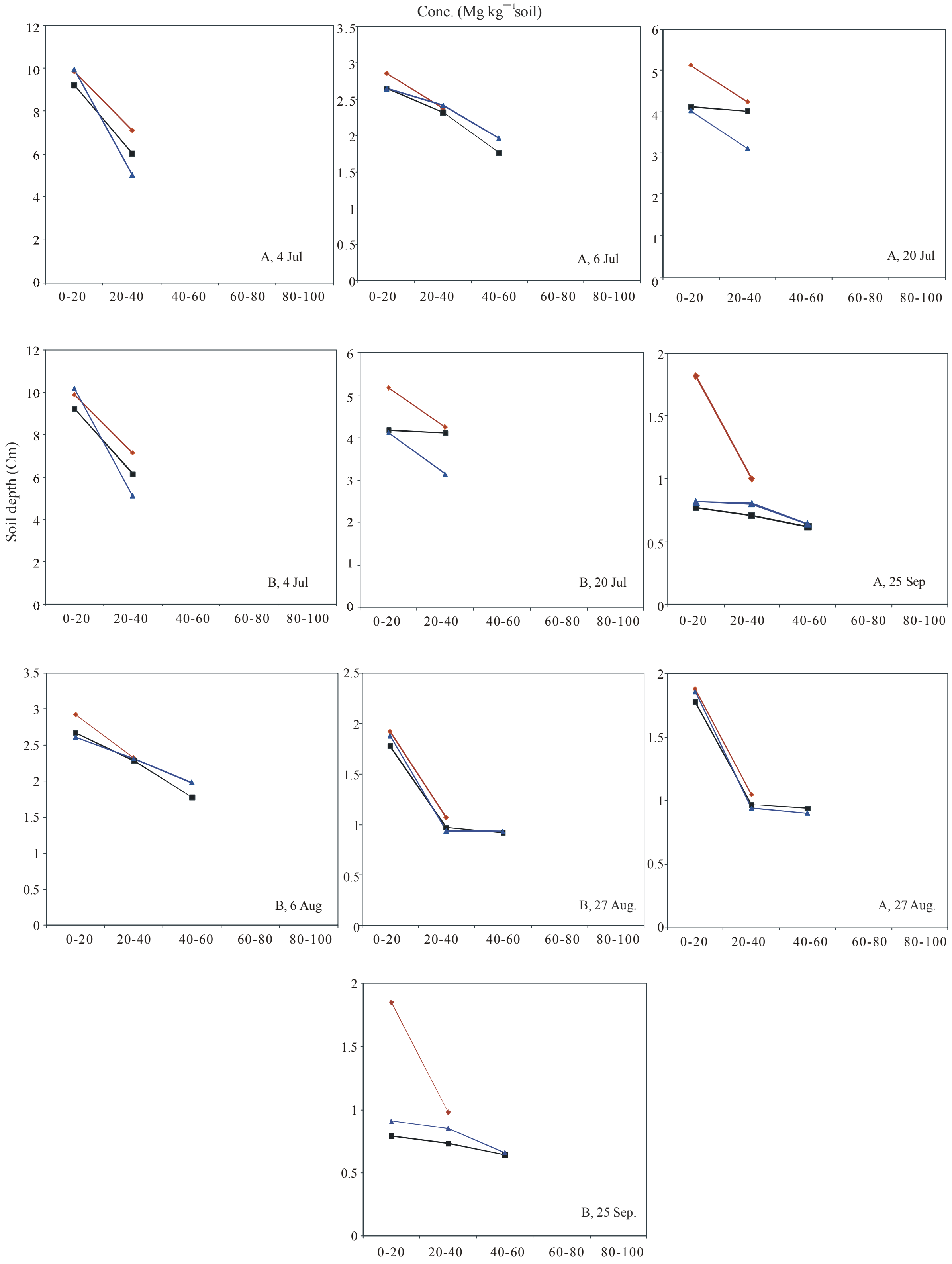

Fig. 2: The concentration (mg kg^{-1} soil) of atrazine residue in cultivated (A) and bare (B) soils

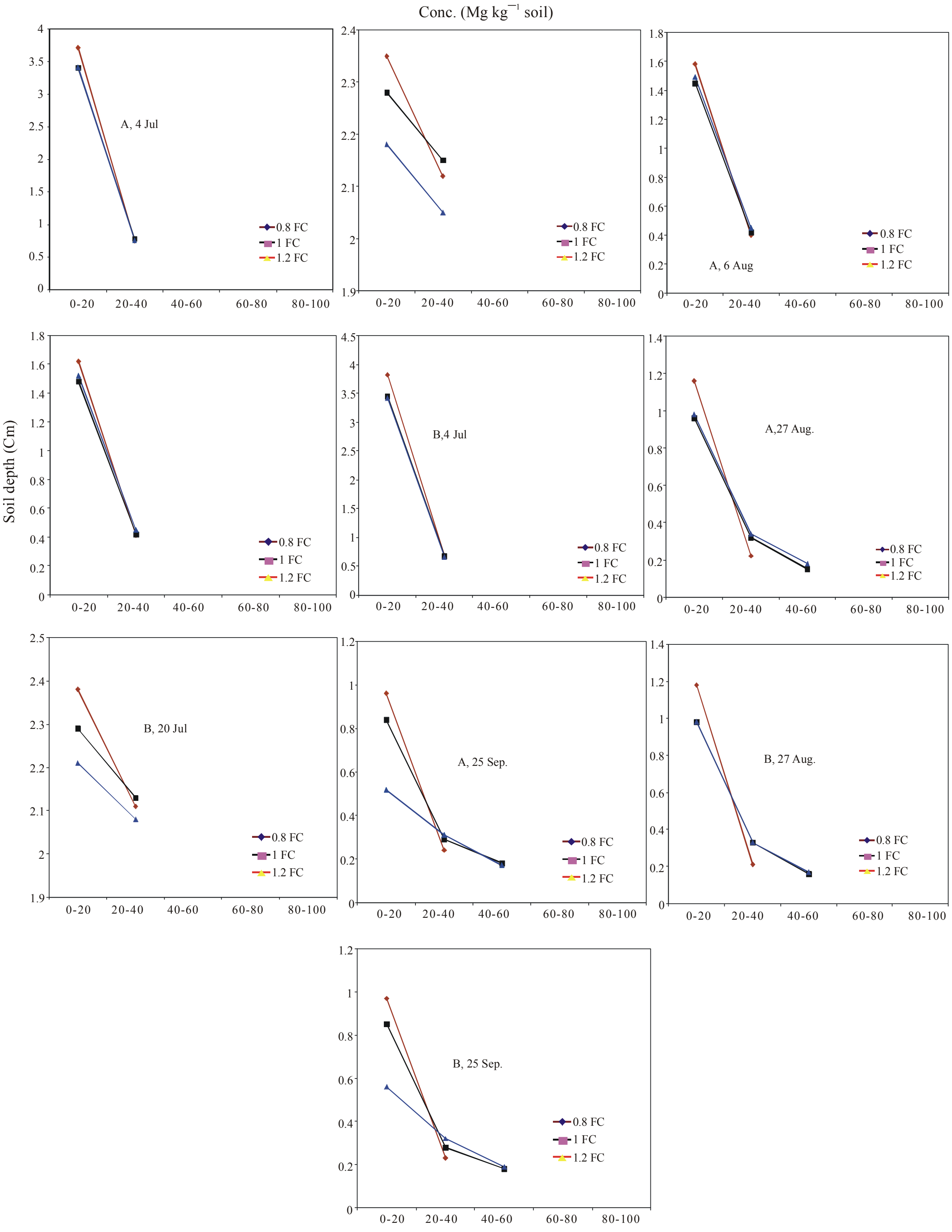

Fig. 3: The concentration (mg kg^{-1} soil) of alachlor residue in cultivated (A) and bare (B) soils.

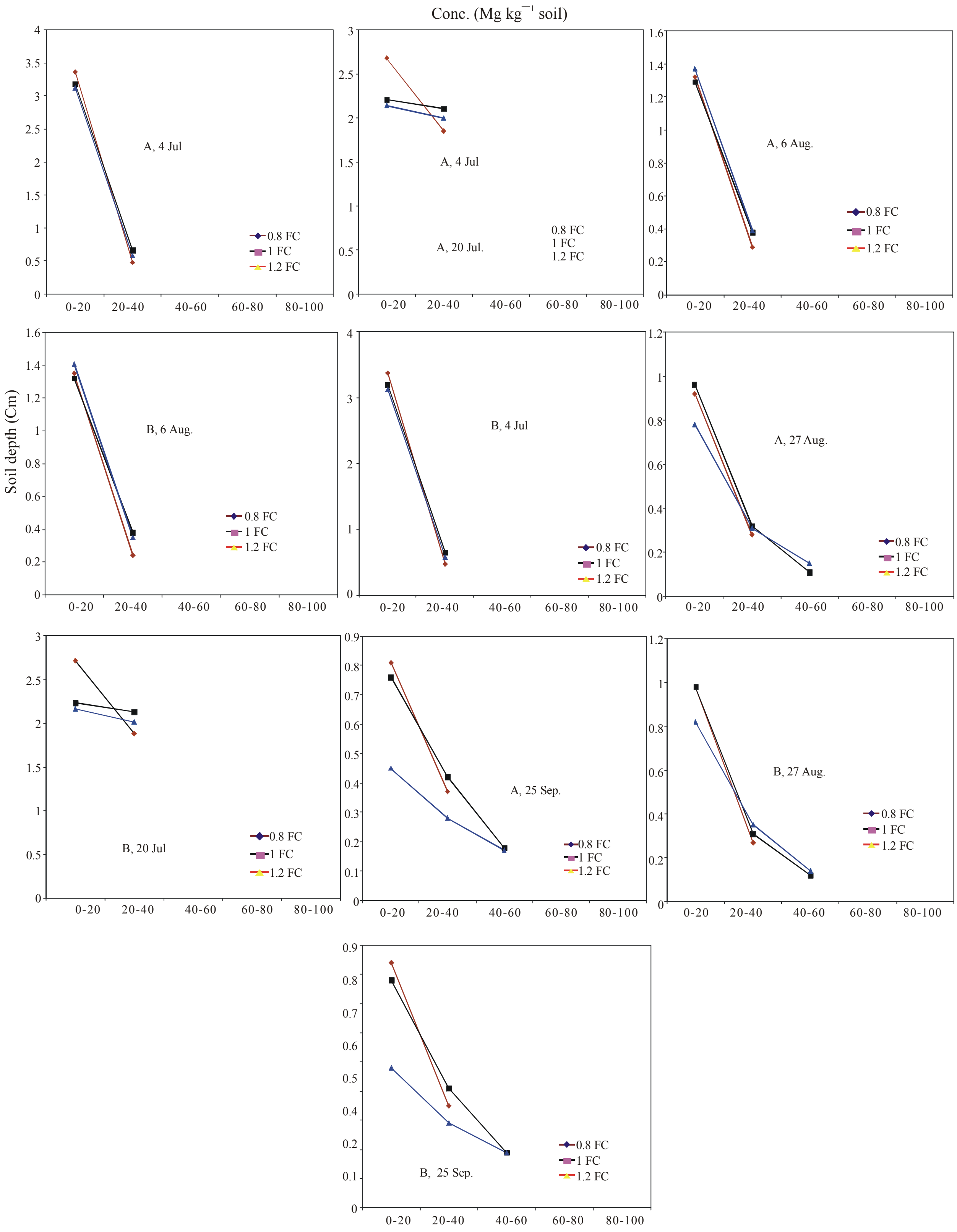

Fig. 4: The concentration (mg kg^{-1} soil) of butachlor residue in cultivated (A) and bare (B) soils.

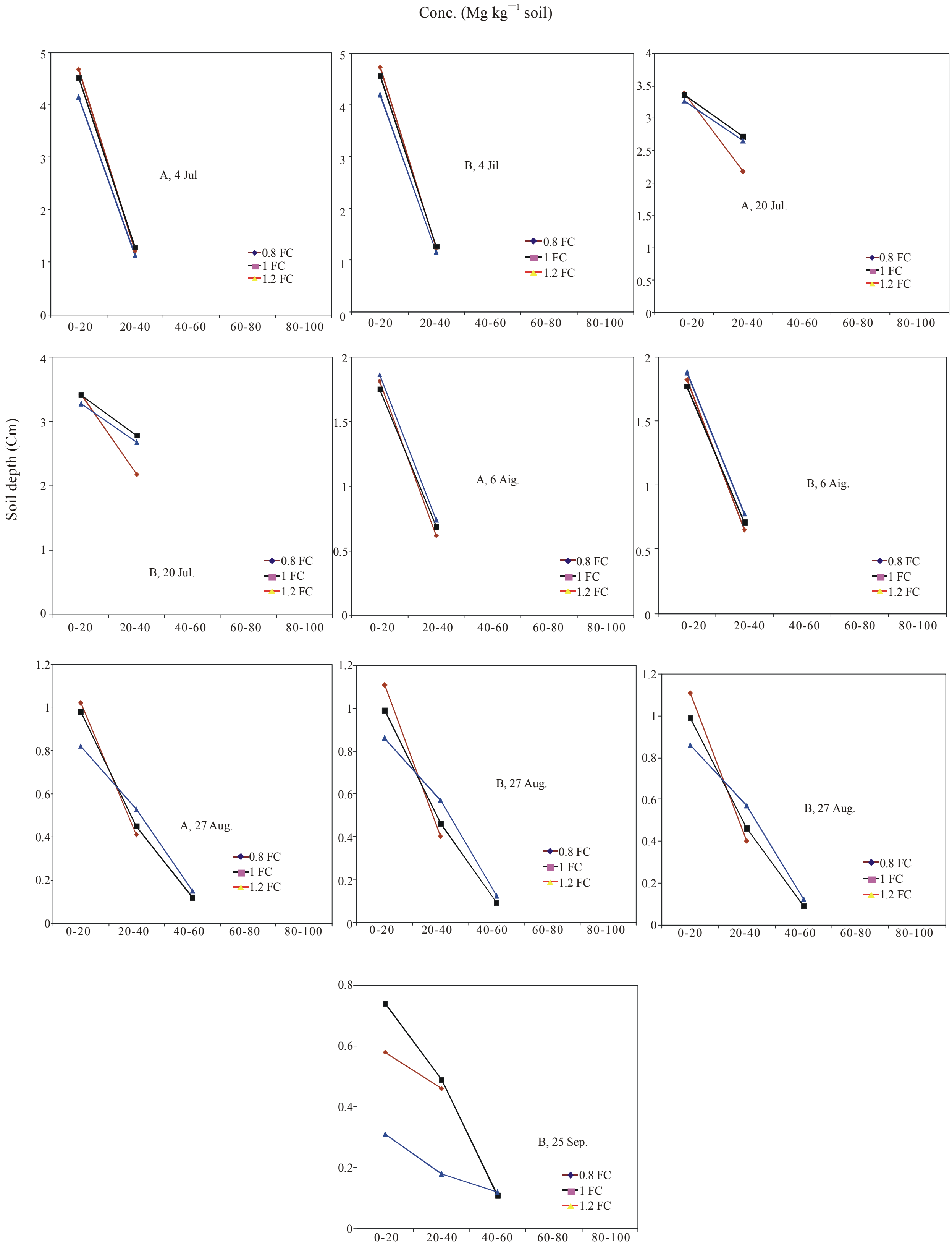

Fig. 5: The concentration (mg kg^{-1} soil) of eradican residue in cultivated (A) and bare (B) soils.

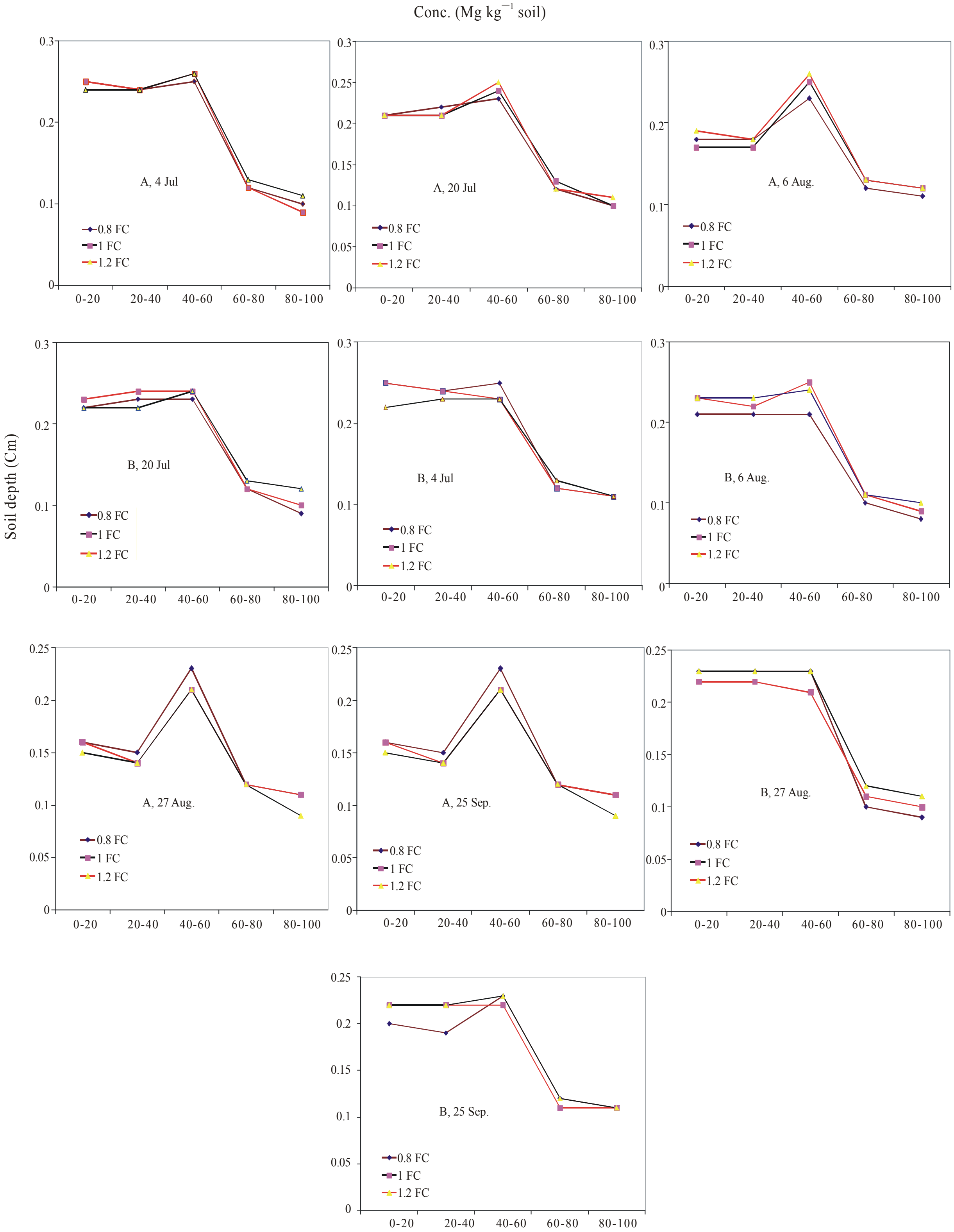

Fig. 6: The concentration of total nitrogen (%) residue in cultivated (A) and bare (B) soils

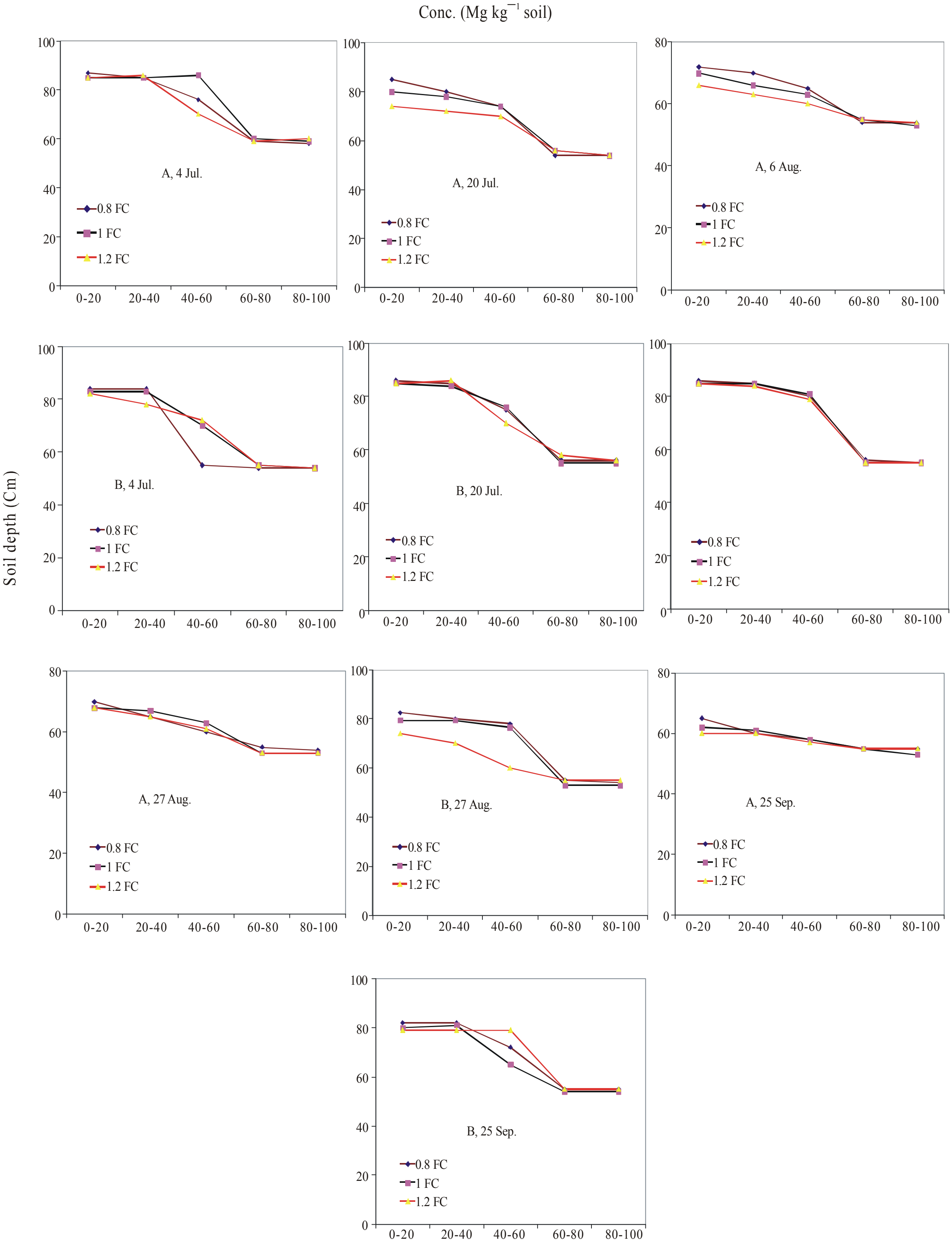

Fig. 7: The concentration of available phosphorous (mg kg^{-1} soil) residue in cultivated (A) and bare (B) soils

Table 4: Total nitrogen (TN, %) and Available phosphorous (AP, mg kg^{-1} soil) residue in soil

		Cultivated Soil						Bare Soil					
		Irrigation Regime						Irrigation Regime					
Soil depth (cm)	Date of sampling (2007)	0.8FC		1.0 FC		1.2 FC		0.8FC		1.0 FC		1.2 FC	
		TN	AP	TN	AP	TN	AP	TN	AP	TN	AP	TN	AP
0-20	4 Jul.	0.25	87	0.25	85	0.24	85	0.25	86	0.25	85	0.22	85
20-40		0.24	85	0.24	85	0.24	86	0.24	85	0.24	84	0.23	86
40-60		0.25	76	0.26	86	0.26	70	0.25	75	0.23	76	0.23	70
60-80		0.12	59	0.12	60	0.13	59	0.12	56	0.12	55	0.13	58
80-100		0.1	58	0.09	59	0.11	60	0.11	56	0.11	55	0.11	56
0-20	20 Jul.	0.21	85	0.21	80	0.21	74	0.22	86	0.23	85	0.22	85
20-40		0.22	80	0.21	78	0.21	72	0.23	85	0.24	85	0.22	84
40-60		0.23	74	0.24	74	0.25	70	0.23	80	0.24	81	0.24	79
60-80		0.12	54	0.13	56	0.12	56	0.12	56	0.12	55	0.13	55
80-100		0.1	54	0.1	54	0.11	54	0.09	55	0.1	55	0.12	55
0-20	6 Aug.	0.18	72	0.17	70	0.19	66	0.21	84	0.23	83	0.23	82
20-40		0.18	70	0.17	66	0.18	63	0.21	84	0.22	83	0.23	78
40-60		0.23	65	0.25	63	0.26	60	0.21	55	0.25	70	0.24	72
60-80		0.12	54	0.13	55	0.13	55	0.1	54	0.11	55	0.11	55
80-100		0.11	54	0.12	53	0.12	54	0.08	54	0.09	54	0.1	54
0-20	27 Aug.	0.16	70	0.16	68	0.15	68	0.23	82	0.22	79	0.23	74
20-40		0.15	65	0.14	67	0.14	65	0.23	80	0.22	79	0.23	70
40-60		0.23	60	0.21	63	0.21	61	0.23	78	0.21	76	0.23	60
60-80		0.12	55	0.12	53	0.12	53	0.1	55	0.11	53	0.12	55
80-100		0.11	54	0.11	53	0.09	53	0.09	54	0.1	53	0.11	55
0-20	25Sep.	0.16	65	0.15	62	0.17	60	0.2	82	0.22	80	0.22	79
20-40		0.16	60	0.14	61	0.16	60	0.19	82	0.22	81	0.22	79
40-60		0.23	58	0.22	58	0.23	57	0.23	72	0.22	65	0.23	79
60-80		0.12	55	0.13	55	0.14	55	0.12	55	0.11	54	0.12	55
80-100		0.11	55	0.12	53	0.11	55	0.11	55	0.11	54	0.11	55

and eradican was decreased with increasing depth of soil and decreased during the growth of plant. After 84 days of cultivation at 0.8 FC irrigation regime the amount of atrazine was decreased from 9.85 to 1.82 mg kg^{-1} soil and reached up to 40 cm soil depth and not more. This trend is similar for 1.0 FC and 1.2 FC irrigation regimes, but as the amount of irrigation water increased the concentration of atrazine and decreased in all depth of soil except for soil surface. Also it is pointed out that after 60 days of atrazine application it leached to depth of 40-60 cm at 1.0 and 1.2 FC but not in 0.8 FC irrigation regimes. This trends are similar for bare soil, but the concentration of atrazine in any time of soil sampling, soil depth and irrigation regimes is more than cultivated soil and it is well fitted with finding of Liaghat [7] which stated that the plant can filter the herbicides in soil. Liaghat [7] found that significant difference between herbicide levels in grass covered and bare soil lysimeters and showed that denitrification was the predominat process for reducing nitrate levels. Liaghat [7] showed that 99% of total applied atrazine, metoalchlor and metribuzin were trapped by soil filter and of the total applied nitrate more than 48% was dissipated by the soil filter.

The amount of atrazine (Table 2) was decreased from 9.85 to 1.00, 9.20 to 0.62 and 9.94 to 0.64 mg kg^{-1} soil after 84 days of application of atrazin for 0.8 FC 1.0 FC and 1.2 FC irrigation regimes, respectively.

The amount of alachlor was decreased from 3.72 to 0.24, 3.41 to 0.18 and 3.42 to 0.17 mg kg^{-1} soil after 84 days of application of alachlor (Table 2) for 0.8 FC, 1.0 FC and 1.2 FC irrigation regimes, respectively. The amount of butachlor (Table 3) was decreased from 3.36 to 0.37, 3.18

to 0.18 and 3.12 to 0.17 mg kg^{-1} soil after 84 days of application of butachlor for 0.8 FC, 1.0 FC and 1.2 FC irrigation regimes, respectively. The amount of eradican (Table 3) was decreased from 4.68 to 0.42, 4.52 to 0.15 and 4.15 to 0.12 mg kg^{-1} soil after 84 days of application of alachlor for 0.8 FC, 1.0 FC and 1.2 FC irrigation regimes, respectively. All herbicides tested were decreased with increasing depth and do not appeared in depth of more than 40 cm, after 84 days of experiment in 0.8 FC irrigation regime, but after 33 days all herbicide appeared at depth of 40 -60 cm and not more, at 1.0 FC and 1.2 FC irrigation regimes. It is pointed out that all herbicides were decreased with increasing amount of irrigation water at all depth and date of soil sampling. This finding is supported by Walker *et al* [11] and Sahid and Wei, [12]. The dissipation of pesticides due to increase in time and depth of sampling is well documented [7, 14]. The studied soil is heavy textured in nature and dissipation of herbicides may be due to adsorption of them to soil particles with increase in time [8]. The studies area is arid to semi arid and temperature increase from June to September which is one reason for reduction of concentration herbicides in soil, [10-13]. Finally it is concluded that dissipation of herbicides in soil is due to temperature, clay and moisture content of soil [6], time of adsorption [8], physicochemical properties of herbicides [6] and soil cover by plant [7]. According to the result (Table 4, Figures 6) the nitrogen residue in soil layers shows an increase from top layer to middle layer and then decreased to soil bottom layer in each time of sampling and during the experiment. The nitrogen residue was decreased with increasing time and depth of soil. However the translocation of nitrogen in soil profile is not too much to reach ground water, this process may be due to heavy soil texture and denitrification [7]. This result is the same for 0.08 FC, 1.0 FC and 1.2 FC of irrigation regime. The result of nitrogen residue in cultivated lysimeters is lesser than bare soil which is due to plant uptake. As results showed (Table 4, Figures 7) the amount of available phosphorous was decreased with increasing time and depth of soil in lysimeters, however, showed excess phosphorous in tested soils, while, Karimian [18] 20 mg kg^{-1} P in soil of study area is adequate for optimum growth of most of plant species.

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