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Effect of Shifting Cultivation on Distribution of Nutrient Elements and Carbohydrates Within Water-Stable Aggregates in Northern Iran

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Abstract: This study attempts to evaluate the nutrient element and carbohydrate distribution within Water-Stable Aggregates (WSA) of two natural ecosystems, native forest and pasturelands, under different land uses. Soil samples were collected from depths of (0-20) cm in Typic Haploxeroll soils. The overall pattern indicated that Mean Weight Diameter (MWD) and WSA were greater in the pasture and forest soils compared with the adjacent cultivated soils and aggregates of >1.0 mm size were dominant in the uncultivated soils, whereas the cultivated soils comprised aggregates of the size ≤0.5 mm. Distribution of organic carbon, nitrogen, phosphorus and carbohydrates within the WSA showed preferential enrichment of these parameters in the macroaggregate fraction (4.75-1.0 mm) for the uncultivated soils and microaggregate fraction (>0.25 mm) for the cultivated soils. Average distribution of total exchangeable bases within WSA showed that cultivation of forest pastureland soils significantly led to reduce in these nutrient in the 4.75-2.0 mm fraction and increase in concentration of these cations in <0.25 mm fraction. Since smaller aggregates are preferentially removed by erosion, this study emphasizes the need for sustainable soil management practices that they will minimize nutrient loss when forest or pastures lands are converted to cropland.

Key words: Land use change, natural ecosystems, water-stable aggregate, mean weight diameter, Alborz mountains range

INTRODUCTION

Soil Organic Matter (SOM) is an important source of inorganic nutrients for plant production in natural and managed ecosystems. The conversion of forests and pasturelands into croplands (shifting cultivation) known to deteriorate soil properties, especially reduce Soil Organic Carbon (SOC) and changes in distribution and stability of soil aggregates (Ross, 1993; Singh and Singh, 1996). Loss of SOM with cultivation is connected to the destruction of macroaggregates, as a result, soil becomes more susceptible to erosion since macroaggregates are disturbed (Six *et al*., 2000). Initial and rapid of nutrient and SOC decay occur mainly due to plant uptake and organic matter oxidation (Ross, 1993). Soil carbohydrates, which represent from 5 to 25% of SOM (Stevenson, 1994), constitute a significant part of the labile pool of SOM and are most affected by land use changes (Guggenberger *et al*., 1995; Spaccini *et al*., 2001). Due to the temporary biological stability of carbohydrates (Insam, 1996), their long-lasting role in improving soil physical properties may not be assumed in all soil conditions (Piccolo *et al*., 1996; Degens and Sparling, 1996) and large emphasis had been given to the action of polymeric carbohydrates in stabilizing soil structure (Tisdall, 1996). The effect of cultivation on the nutrient and microbial characteristics of soil are observed in the C and N-enriched small macroaggregate fractions (2.00-0.25 mm) (Degens and Sparling, 1996). Degens and Sparling (1996) reported that SOM, polysaccharides, polyuronides and phenols were associated with the >0.25 mm Water-Stable Aggregates (WSA). Christensen (1992) observed that whereas the C/N, C/P and N/P ratios of water-stable macroaggregates were smaller than those of microaggregates, the microaggregates contained less SOM associated with silt plus clay than the macroaggregates. Mbagwu and Piccolo (1990) with working on some North Central Italian soils reported that, in terms of total contents, C, N and P are preferentially concentrated in the macroaggregates. They further noted a similarity in the dynamics of C and N in the amended and control plots, while P distribution is not uniform within the aggregated irrespective of the types of amendments added. Generally, most studies on physico-chemical properties (Jaiyeoba, 2003; Bewket and Stroosnijder, 2003; Nyakatawa *et al*., 2001;

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Paz-Gonazalez *et al*., 2000) with respect to management practices concentrated on whole soil (<2 mm) analysis, while a proper understanding of nutrient dynamics requires an evaluation of the location of these nutrients within aggregates. On the other hands, their location gives an indication of their potential accessibility for microbial degradation and on their storage and loss by erosion when forest or pastureland converted to cropland (Adesodun *et al*., 2007).

Rapid population growth in north Iran requires additional farmlands for food production. One way to expand the cropland is clear cutting the forests and converting pasturelands to the croplands (shifting cultivation). This results in destruction of natural ecosystems and reduction of the current or future capacity of soil to produce. It can be because of erosion, decline in fertility, changes in aeration and moisture content, salinization or change in soil flora or fauna (Balesdent *et al*., 1998). Since different aggregate fractions are selectively removed during erosion, the aim of this study was to evaluate the distribution of C, N, P, cations and carbohydrates within different WSA of soils under different land use i.e., uncultivated and cultivated forest and pastureland soils in the Alborz mountains range of the North of Iran.

MATERIALS AND METHODS

Description of the study area: The study was conducted in the southeast Sari city, Mazandaran province; in the Alborz mountain range (35°15'-36°10' latitude and 53°35'-53°30' longitude; asl 1900 m) of the northern regions of Iran. The prevailing climate of study area is a typical Mediterranean climate with the large term mean annual temperature and precipitation of 18°C and 620 mm, respectively (Soil Survey Staff, 1999). Soil moisture and temperature regimes are determined as xeric and thermic, respectively. Most of precipitation falls during the winter and spring (November-May) and dominant soils in the study are Typic Haploxerolls (Soil Survey Staff, 1999). The physiographic units of the study area are dominantly as a hilly type and on average, the soil depth is 55 to 60 cm with a slope ranges from 10 to 15%. No salinity and drainage problems exists and carbonate calcium equivalent, electrical conductivity are 22% and 1.01 dS m^{-1}, respectively, while general slope aspect of soils is similar.

Concurrently, increasing population and the absent of new land for cultivation have transformed former virgin pastureland and forest (natural ecosystem) to rainfed land and vegetable land, in fact, increased the intensity of cultivation. Dominant tree species in the forests are *Acer persicum*, *A. pojark*, *Pinus nigra*, *P. brutia* and plant cover of the pastureland because of overgrazing ranges for 80 to 60%. Dominant grass species could be mentioned as Agropyrom intermedium (Host), *P. beauv*, *Hurdeum bulbosum* L., *Festuca ovina*. Some pasturelands and forest soils have been converted to wheat (*Triticum aestivum* L.) growth fields since 1988. Some bulk soil physical and chemical properties of these two natural resources i.e., native forest and pastureland are shown in Table 1.

Soil sampling: Soil samples were collected in September 2006 and the sampling design involved selection of four sites from each four ecosystem i.e., four uncultivated and their adjacent cultivated forests and pasturelands. All of the sites located on the same physiographical units and the same slope aspect under each land use. These sites were either adjacent to one another or divided into a country roads, maximum distance separating the sites was 1100 m. At each sampling location, three sub samples were taken at least 15 m apart and were mixed, i.e., from each site one soil composite sample was taken for depth of 0-20 cm. Because the main objective of the study was to assess the changes in soil properties, resulting from surface perturbations samples were taken only at depth of 0-20 cm (the approximate plow layer). This added up 20 soil samples for each land-use and 80 soil samples for all land-use investigated in the study. After air drying the samples for 1 week, soil samples were sieved through 4.75 mm sieve size for aggregate fractionation.

Soil aggregate size fractionation and stability: In this procedure, 50 g of the <4.75 mm aggregates were placed on the topmost of a nest of sieve of diameters 2.0, 1.0, 0.5 and 0.25 mm. The samples were left immersed in the water for 10 min and then sieved by moving the sieve 3 cm vertically 50 times during a period of 2.0 min. The mass resultant aggregates on each sieve were dried at 105°C for 24 h, weighted and stored for analysis of carbohydrates, C, N, P and cations. The percent water-stable aggregates (%WSA) on each of the following size ranges: 4.75-2.0, 2.0-1.0, 1.0-0.05, 0.5-0.25 and <0.25 mm were then determined (Cambardella and Elliott, 1993). Thus,

$$\text{WSA (\%)} = ((M_{a+s} - M_s)/(M_t - M_s)) \times 100$$

Where:

M_{a+s} = Mass of the resistant aggregates plus sand (g)

M_s = Mass of the sand fraction alone (g)

M_t = Total mass of the sieved soil (g)

Table 1: Main characteristics (means±SD) of bulk soil chemical and physical of two natural ecosystems

Soil[a]	Sand ($g\ kg^{-1}$)	Silt ($g\ kg^{-1}$)	Clay ($g\ kg^{-1}$)	pH (1:1 H_2O)	OC ($g\ kg^{-1}$)	TN ($g\ kg^{-1}$)	Bulk density ($g\ cm^{-3}$)
Forest	21.3±0.2	38.9±0.2	39.8±0.1	7.42±0.1	38.90±0.2	3.62±0.2	1.28±0.1
Pastureland	20.6±0.3	40.8±0.2	38.6±0.2	7.72±0.1	41.27±0.4	3.81±0.1	1.21±0.1

[a]: Values are means of triplicate soil samples(<2 mm)

The model of Van Bavel (1950) as modified by Kemper and Rosenau (1986) used to determine the mean weight diameter (MWD) of wet-stable aggregates. Thus,

$$MWD = \sum_{i=1}^{n} X_i W_i$$

Where:

X_i = Mean diameter of each size fraction (mm)

W_i = Proportion of the total mass in the corresponding size fraction after deducting the weight of stones (upon dispersion and passing through the same sieve) as indicated above

The higher values of MWD indicate the dominance of the less erodible and large aggregates of the soil (Piccolo and Mbagwu, 1999).

Chemical properties: Organic Carbon (OC) was determined by the Walkley and Black (1934) as modified by Allison (1965) dichromate oxidation procedure. Total Nitrogen (TN) was determined with the Kjeldahl method (McGill and Figueiredo, 1993). Available phosphorus (P) was measured by the Olsen method (Olsen *et al*., 1954). The content of acid-hydrolysable in water-stable aggregates was determined using the phenol-sulphuric acid procedure. The monosaccharide content in the hydrolysates was measured colorimetrically as glucose equivalents (Piccolo *et al*., 1996). All measurements were expressed as glucose concentration in g kg^{-1} of water-stable aggregates. Exchangeable bases were determined by ammonium acetate replacement procedure as described by Thomas (1982) and Ca, Mg, K and Na were measured (Page, 1992).

Each variable of four sites in each land use were averaged at the (0-20) cm depth to perform statistical analysis. Analysis of variance was performed using SAS software. Means were compared by Least Significant Difference (LSD) at $p<0.05$ or $p<0.001$ level.

RESULTS AND DISCUSSION

Aggregate size distribution and stability: The distribution and stability of water stable aggregates (WSA) showed that in uncultivated (forest and pasture) soils, the macroaggregates fractions (>0.25 mm) decreased significantly with cultivation (Table 2). In the forest and pasture soils, most soils was found in 0.25-4.75 mm size macroaggregates and to a lesser extent in microaggregates (<0.25 mm). In the forest soils, cultivation decreased the WSA proportion of 4.75-2.0 mm fraction in depth 0-20 cm by 5 times, while the decrease was 1.3 times for 2.0-1.0 mm aggregate fraction. The effect of cultivation on pasture soils followed the pattern observed with forest soils; showing 4.5 times deceases for 4.75-2.00 mm fraction and 1.9 times decease for 2.0-1.0 mm fraction.

However, in the cultivated (cropland) soil, a significantly large proportion of the soil was retained as microaggregate and small macroaggregates (<0.25) (Table 2). Since small aggregates size (<1.2 mm) was found to be a useful indicator of soil degradation (Whalen and Chang, 2002), tillage in the cultivated soils of two natural ecosystems disintegrated the large aggregates into smaller aggregates, resulting in higher proportion of small aggregates (<0.25 mm) in this soils. This could be attributed to the breakdown of aggregates by tillage, differences between the four-land use types in annual organic matter input that gives cementing agents and the enmeshing effects of roots and associated micro and macro organisms. In addition, these results could have been due to the former being largely depend on live and decaying plant root, fungal hyphae and especially costs of earthworms and termites that would have been rapidly destroyed by tillage. These results confirm earlier observations that macroaggregates are dynamic in nature and the size distribution of macroaggregates affected by the change in land use and management (Beare *et al*., 1994; Puget *et al*., 1995; Spaccini *et al*., 2001; Ashagrie *et al*., 2007). A greater shift in water stable aggregates from large macroaggregates with cultivation also induced significant reduction in MWD. The MWD values indicated that cultivation reduced the aggregate stability of soils of the forest area by 1.6 times, whereas tillage operation led to 3.14 reductions in the stability of soils of pastureland area (Table 2). The greater reduction of MWD values observed with soils of pastureland over soils of forest area could be attributed to dominance of grasses that rapidly removed from surface larger after cultivation. The reduction in the proportion in the macroaggregate fraction (>0.25 mm) following cultivation was also reported (Haynes, 1999; Spaccini *et al*., 2001; Adesodun *et al*., 2007). As with findings of Haynes (1999) in pasture soil and Spaccini *et al*. (2001) in forest soil, the >2 and 1-2 mm classes of the forest were 13 and 4 times, respectively.

Table 2: Aggregate size distribution (WSA%) and stability (MWD) (means±SD) of soils of the two natural ecosystems and their adjacent cultivated ecosystem

	Aggregate sizes (mm)^{A}					
Ecosystems	4.75-2.00	2.00-1.00	1.00-0.50	0.50-0.25	< 0.25	MWD (mm)^{B}
Forest	28.2±4.4^{a}	20.7±2.2^{a}	14.8±2.4^{b}	19.2±2.4^{a}	17.1±2.3^{b}	3.62±0.1^{A}
Pastureland	23.4±1.2^{a}	23.9±1.1^{a}	22.2±2.4^{a}	20.4±0.8^{ab}	10.1±2.9^{b}	3.55±0.1^{A}
Forest (cultivated)	5.7±1.2^{c}	15.8±1.8^{b}	16.2±3.2^{b}	32.2±2.4^{a}	30.1±3.1^{a}	2.20±0.1^{B}

^{A}: Values (aggregate sizes) with different letter(s) in rows indicate significant differences (p<0.05), ^{B}: Values (MWD) with different letter(s) in column indicate significant differences (p<0.05)

Table 3: Distribution of carbohydrates (g kg^{-1}) (means±SD) in aggregates size fractions of two natural ecosystems and their adjacent cultivated ecosystems

	Aggregate sizes (mm)^{A}					
Ecosystems	4.75-2.00	2.00-1.00	1.00-0.50	0.50-0.25	< 0.25	Bulk soil^{B}
Forest (uncultivated)	11.3±0.2^{a}	8.43±0.4^{ab}	8.7±0.6^{ab}	7.84±0.7^{ab}	4.07±0.3^{c}	40.34±0.7^{A}
Forest (cultivated)	4.6±1.1^{b}	5.80±0.8^{b}	6.2±0.6^{b}	5.20±0.5^{b}	10.80±0.3^{a}	32.60±0.6^{C}
Pastureland (uncultivated)	13.2±1.7^{a}	11.30±1.1^{a}	8.1±0.3^{b}	7.80±0.2^{b}	6.20±0.3^{c}	46.60±0.3^{A}
Pastureland (cultivated)	7.2±0.3^{b}	5.10±0.5^{b}	6.4±0.4^{b}	6.90±0.3^{b}	13.10±1.1^{a}	38.70±0.5^{B}

^{A}: Values with different letters in rows indicate significant differences (p<0.05), ^{B}: Values (<2 mm) with different letters in column indicate significant differences (p<0.05)

Table 4: Carbon (C), nitrogen (N) and available phosphorus (P) content (g kg^{-1} aggregate) (means±SD) in aggregate sizes of two natural ecosystems and their adjacent cultivated ecosystem

Aggregate	Natural forest			Cultivated forest			Natural pastureland			Cultivated pastureland		
sizes (mm)	C	N	P	C	N	P	C	N	P	C	N	P
4.75-2.00	47.1±1.20^{a}	4.6±0.4^{a}	43.1±2.1^{a}	22.1±1.2^{b}	2.5±0.4^{a}	19.3±10.1^{a}	51.2±14.1^{a}	5.2±1.1^{a}	45.1±9.20^{a}	20.1±2.3^{c}	2.46±0.3^{c}	18.2±2.1^{c}
2.00-1.00	42.3±4.10^{a}	3.8±1.7^{a}	30.2±9.1^{a}	20.2±1.5^{b}	2.4±1.1^{a}	18.2±3.10^{a}	36.6±5.20^{a}	3.4±0.7^{a}	32.3±14.1^{a}	21.0±1.5^{bc}	2.50±0.4^{c}	15.3±1.7^{c}
1.00-0.50	40.9±14.2^{a}	3.6±0.4^{a}	22.8±2.1^{a}	19.8±1.4^{b}	2.3±0.8^{a}	17.2±11.2^{a}	39.1±3.40^{a}	3.4±0.9^{a}	28.8±3.40^{a}	19.2±1.7^{c}	2.30±0.3^{c}	15.3±1.2^{c}
0.50-0.25	36.3±3.50^{a}	3.6±0.9^{a}	22.8±3.1^{a}	24.2±2.3^{ab}	2.8±0.4^{a}	31.3±9.20^{a}	37.7±6.40^{a}	3.9±1.1^{a}	23.1±4.20^{a}	28.2±2.1^{b}	3.23±0.1^{b}	29.2±0.9^{b}
<0.25	28.7±6.10^{a}	2.8±1.1^{a}	21.4±2.1^{a}	39.2±2.1^{a}	3.6±1.2^{a}	34.3±3.50^{a}	33.3±12.2^{a}	3.3±1.8^{a}	20.4±11.2^{a}	38.1±2.7^{a}	4.06±1.1^{a}	32.3±2.4^{a}

Means within a column that are the same letter(s) are not significant at (p<0.05)

Carbohydrate distribution in the WSA: Soils under cultivation had lower carbohydrate than the adjacent soils under forests and pastureland in whole <2 mm soil samples (Table 3). Cultivation caused 23.6 and 20.6% decreases in total carbohydrates content for forest and pastureland soils, respectively. The results of carbohydrates distribution within the WSA for two natural ecosystem (Table 3) shows that soil carbohydrates content decreased with decreasing wet-aggregate sizes, while cultivation in both led to increase in carbohydrates concentrations with decrease in the WSA.

Also results indicated a poor correlation (R^2 = 0.52) between carbohydrates content and aggregate stability (as defined MWD) that supports other findings (Spaccini *et al*., 2001, 2004) suggesting that polysaccharides can not be always considered as persistent structural stabilizers because of their rapid degradation by microbial activities (Insam, 1996; Piccolo and Mbagwu, 1999; Spaccini *et al*., 2004). In cultivated soils with lower physical quality, a general and significant increase in carbohydrates was found in microaggregates (<0.25 mm). This could be attributed to the presence of a high content of humified organic matter in microaggregates that controls the biological stabilization of carbohydrates (Spaccini *et al*., 2004). But the high aggregate stability of the uncultivated soils because of favorable condition provided a relatively high carbohydrates content in larger aggregate size (>0.25 mm), where the products deriving from initial decomposition of plant residues in both natural ecosystem tend to accommodate (Guggenberger *et al*., 1995).

Carbon, nitrogen and phosphorus concentration of aggregate fractions: Data on Organic Carbon (OC), nitrogen (N) and available phosphorus (P) content (g kg^{-1} aggregate) of the different aggregates size fractions are reported in Table 4. In the soils under native forest and pastureland, none of the parameters show significant differences among that. In contrast, in the cultivated soils in both natural ecosystems, OC and nitrogen content were significantly different among the different size fractions and appeared to decreases as sizes increased from 0.50 to 4.75 mm diameter (Table 4). The OC, N and P contents associated with each macroaggregate size in the two natural ecosystem, were two-to-three-fold higher than the corresponding values in the cultivated soil, although the differences generally were not statistically significant. The aggregate fraction >4.75 mm had least value of OC in the two cultivated soils. This could be attributed partly to the redistribution and/or transfer of OC from the large aggregates to smaller ones either in the process of biodegradation or by mechanical disruption of the large macroaggregates (Dormaar, 1983; Christensen, 1992; Ashagrie *et al*., 2007). The available phosphorus (P) distribution within the WSA for the forest and pasture soils followed the trend observed with OC and TN, but in cultivated soils increased available P with decrease aggregate size fraction. This trend shows significant increase ($p<0.05$) in distribution of available P in smaller aggregate with cultivation. The distribution pattern of P showing preferential enrichment of the smaller aggregates than the larger aggregates in both two cultivated soil, contradicts the observation of Adesodun *et al*. (2005) and Mbagwu and Piccolo (1990). Cultivation in this study indicated higher accumulation of C, N and P in the WSA of the both uncultivated soils. This could be attributed to this fact that cultivation leads to exposure of more surface area to microbial attack, oxidation, burning effect of temperature and preferential removal of the smaller aggregates by erosion.

The relationship between WSA, OC, N and P contents was not significant, suggesting that other factors such as inorganic soil constituents (Tisdall, 1996), the arrangement of the organic compound other than the absolute organic matter quality (Dormaar, 1983), might have participated in the binding of the soil particles in to WSA and the relative importance of each varies in differing situations (Haynes, 1999).

Distribution of exchangeable cations in the WSA: Figure 1 and 2 show the results of exchangeable cations distribution such as Ca^{2+}, Mg^{2+}, K^{+}, Na^{+} within WSA for two natural ecosystems after cultivation. Cultivation of these two uncultivated soils generally let to reduction in the concentration of the total exchangeable cations such as Ca^{2+}, Mg^{2+}, K^{+}, Na^{+} in the macroaggregate fractions (0.25 to 4.75 mm) and increase in concentration of these cations in the <0.25 mm fraction.

In uncultivated forest soils (Fig. 1), the concentration of Ca^{2+}, for example, ranged from 4.4 cmol kg^{-1} for the macroaggregate fraction (4.75-2.00 mm) to 2.7 cmol kg^{-1} for the microaggregate fraction (<0.25 mm). The range for uncultivated pastureland soils (Fig. 2) was 4.6 cmol kg^{-1} (4.75-2.00 mm fraction) to 3.1 cmol kg^{-1} for the microaggregate fraction. As a result, the effect of cultivation on pastureland soils followed approximately the pattern observed with forest soils. The observed differences in the Ca^{2+} and Mg^{2+} contents, that are very important for flocculating of particles, in macroaggregates and microaggregates fraction, for both uncultivated and cultivated forest and pastureland, were significant ($p<0.05$), expert 6.2 cmol kg^{-1} (uncultivated forest) and 5.4 cmol kg^{-1} (cultivated pastureland) that were similar.

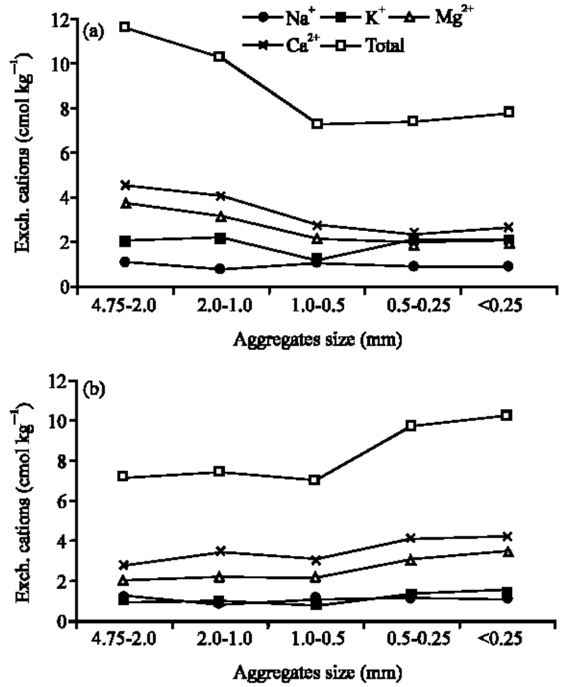

Fig. 1: Exchangeable cations distribution in water-stable aggregates (WSA) of the forest soils. (a) uncultivated and (b) cultivated

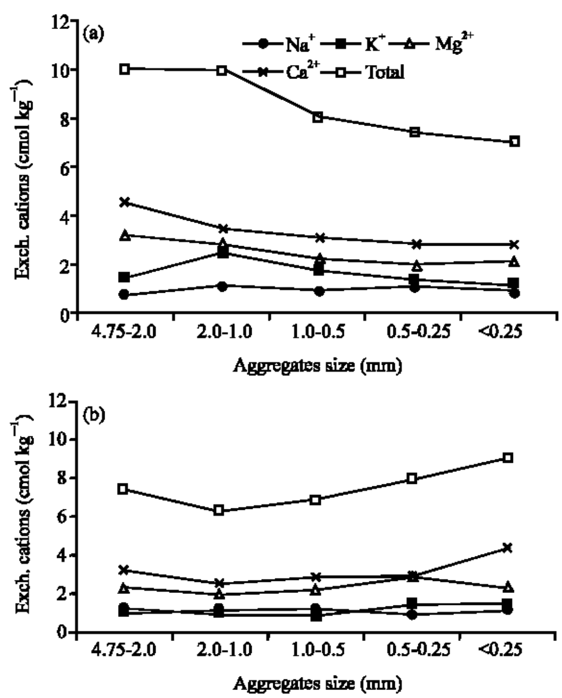

Fig. 2: Exchangeable cations distribution in water-stable aggregates (WSA) of the pastureland soils. (a) uncultivated and (b) cultivated

The general trend showed that in uncultivated soils in both natural ecosystem, the 4.75-2.00 mm fraction and microaggregates (<0.25 mm) were preferentially enriched with total exchangeable bases (as Ca^{2+}, Mg^{2+}, K^+ and Na^+), whereas cultivation led to redistribution of these nutrient element showing increases in the concentration of the elements of the elements with decreases in aggregate sizes. Results also indicated that divalent cations (Ca^{2+} and Mg^{2+}) were higher in macroaggregate fractions than monovalent cations are more tightly held at the exchange complexes with macroaggregates than the monovalent cations (Adesodun *et al*., 2007). Researchers in the literature (Nyakatawa *et al*., 2001; Jaiyeoba, 2003) reported the effect of soil chemical properties with respect to management practices concentrated on whole soil (i.e., <2.00 pre-sieved soil) but this study characterized the nutrient distribution within both macroaggregates (>0.25 mm) and microaggregates (<0.25 mm) fractions.

CONCLUSION

The degradation of the highland soils with the restricted depth by shifting cultivation seriously impaired soil properties and especially result in reduction of the proportion water-stable macroaggregates and overall aggregates stability and an increase in the proportion of microaggregates. The effect of cultivation on amount of macroaggregates was most evident in the >1 mm size aggregates. In uncultivated soils, more structurally stable soil carbohydrates, elemental C, N and P were more evenly distributed in the size-aggregates, whereas they preferentially accumulated into the macroaggregates (>0.25 mm) and in cultivated soil in the <0.25 mm fractions. When carbohydrates are stored in the microaggregate fractions they are protected from microbial degradation as a result of physical and chemical (such as hydrophobic interaction) processes. As a results, cultivation induced redistribution of OC, N, available phosphorus and other nutrient element (Ca^{2+}, Mg^{2+}, K^+ and Na^+) to the smaller aggregates. Since smaller particles or aggregates are preferentially removed by erosion and reinstate the degraded lands in the study region of the North of Iran.

REFERENCES

Adesodun, J.K., J.S.C. Mbagwu and N. Oti, 2005. Distribution of carbon, nitrogen and phosphorus in water-stable aggregates of an organic waste amended Ultisol in Southern Nigeria. Bioresour. Technol., 96: 509-516.

Adesodun, J.K., E.F. Adeyemi and C.O. Oyegoke, 2007. Distribution of nutrient elements within water stable aggregates of two tropical agro-ecological soils under different land uses. Soil Till. Res., 92: 190-197.

Allison, L.E., 1965. Organic Carbon. In: Methods of Soil Analysis, Black, C.A. *et al*. (Eds.). Part 2. American Society of Agronomy, Monograph No. 9. Madison, Wisconsin, pp: 1367-1378.

Ashagrie, Y., W. Zech, G. Guggenberger and T. Mamo, 2007. Soil aggregation and total and particulate organic matter following conversion of native forests to continuous cultivation in Ethiopia. Soil Till. Res., 94: 101-108.

Balesdent, J., E. Besnard, E. Arrouays and C. Chenu, 1998. The dynamics of carbon in particle size fractions of soil in a forest cultivated sequence. Plant Soil, 201: 49-57.

Beare, M.H., P.F. Hendrix and D.C. Coleman, 1994. Water-stable aggregates and organic fractions in conventional and no-tillage soils. Soil Sci. Soc. Am. J., 58: 777-786.

Bewket, W. and L. Stroosnijder, 2003. Effects of agroecological land use succession on soil properties in Chemoga watershed, Blue Nile basin, Ethiopia. Geoderma, 111: 85-98.

Cambardella, C.A. and E.T. Elliott, 1993. Carbon and nitrogen distribution in aggregates from cultivated and nature grassland soils. Soil Sci. Soc. Am. J., 57: 1071-1076.

Christensen, B.T., 1992. Physical fractionation of soil organic matter in primary particles and density separates. Adv. Soil Sci., 20: 1-76.

Degens, B. and G. Sparling, 1996. Changes in aggregation do not correspond to changes in labile organic C fractions in soil amended with ^{14}C-glucose. Soil Biol. Biochem., 28: 453-462.

Dormaar, J.F., 1983. Chemical properties of soil and water stable aggregates after sixty-seven years of cropping to spring wheat. Plant Soil, 75: 51-61.

Guggenberger, G., W. Zech and R.J. Thomas, 1995. Lignin and carbohydrate alteration in particle-size separates of an oxisol under tropical pastures following native savanna. Soil Biol. Biochem., 27: 1629-1638.

Haynes, R.J., 1999. Labile organic matter fractions and aggregate stability under short-term, grass-based leys. Soil Biol. Biochem., 31: 1821-1830.

Insam, H., 1996. Microorganism and Humus in Soils. In: Humic Substances in Terrestrial Ecosystems, Piccolo, A. (Ed.). Elsevier, Amsterdam, pp: 265-292.

Jaiyeoba, I.A., 2003. Changes in soil properties due to continuous cultivation in Nigerian semiarid Savannah. Soil Till. Res., 70: 91-98.

Kemper, W.D. and R.C. Rosenau, 1986. Aggregate Stability and Size Distribution. In: Methods of Soil Analysis, Klute, A. (Ed.). Part 1. Physical and Mineralogical Methods, 2nd Edn. Agronomy Monographs, 9. ASA-SSA, Madison, WI, pp: 425-442.

Mbagwu, J.S.C. and A. Piccolo, 1990. Carbon, nitrogen and phosphorus concentration in aggregates of organic waste-amended soils. Biol. Wastes, 31: 97-111.

McGill, W.B. and C.T. Figueiredo, 1993. Total Nitrogen. In: Soil Sampling and Methods of Analysis, Carter, M.R. (Ed.). Canadian Society of Soil Science/Lewis Publishers, pp: 201-211.

Nyakatawa, E.Z., K.C. Reddy and K.R Sistani, 2001. Tillage, cover cropping and poultry litter effects on selected soil chemical properties. Soil Till. Res., 58: 69-79.

Olsen, S.R., C.W. Col, F.S. Watanabe and L.A. Dean, 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. US Department of Agriculture, Circular, pp: 939.

Page, A.L., 1992. Methods of Soil Analysis. ASA and SSSA Publishers, Madison, WI., pp: 321.

Paz-Gonazalez, A., S.R. Vieira and M.T. Taboada, 2000. The effects of cultivation on the spatial variation of selected properties of an umbric horizon. Geoderma, 97: 273-292.

Piccolo, A., A. Zena and P. Conte, 1996. A comparison of acid hydrolysis for the determination of carbohydrates in soils. Commun. Soil Sci. Plant Anal., 27: 2909-2915.

Piccolo, A. and J.S.C. Mbagwu, 1999. Role of hydrophobic components of soil organic matter on soil aggregate stability. Soil Sci. Soc. Am. J., 63: 1801-1810.

Puget, P., C. Chenu and J. Balesdent, 1995. Total and young organic matter distributions in aggregates of silty cultivated soils. Eur. J. Soil Sci., 46: 449-459.

Ross, S.M., 1993. Organic matter in tropical soils: Current conditions, concerns and prospects for conservation. Prog. Phys. Geogr., 17: 265-305.

Singh, S. and J.S. Singh, 1996. Water-stable aggregates and associated organic matter in forest, savanna and cropland soils of a seasonally dry tropical region. India Biol. Fert. Soils, 22: 76-82.

Six, J., K. Paustian, E.T. Elliott and C. Combrink, 2000. Soil structure and organic matter: I. Distribution of aggregate-size classes and aggregate-associated carbon. Soil Sci. Soc. Am. J., 64: 681-689.

Soil Survey Staff, 1999. Soil Taxonomy. A Basic System of Soil Classification for Making and Interpreting Soil Surveys. 2nd Edn. USDA, Washington DC., pp: 871.

Spaccini, R., A. Zena, C.A. Igwe, J.S.C. Mbagwu and A. Piccolo, 2001. Carbohydrates in water-stable aggregates and particle size fractions of forested and cultivated soils in two contrasting tropical ecosystems. Biogeochemistry, 53: 1-22.

Spaccini, R., J.S.C. Mbagwu, C.A. Igwe, P. Conte and A. Piccolo, 2004. Carbohydrates and aggregation in lowland soils of Nigeria as influenced by organic inputs. Soil Till. Res., 75: 161-172.

Stevenson, F.J., 1994. Humus Chemistry: Genesis, Composition, Reactions. 2nd Edn. Wiley, New York.

Thomas, G.W., 1982. Exchangeable Cations. Methods of Soil Analysis. In: Chemical and Microbiological Properties, Page, A.L., R.H. Miller and D.R. Keeney (Eds.). Part 2. 2nd Edn. Agronomy Monograph 9, ASA and SSSA, Madison, WI., pp: 159-165.

Tisdall, J.M., 1996. Formation of Soil Aggregates and Accumulation of Soil Organic Matter. In: Structure and Organic Matter Storage in Agricultural Soils, Carter, M.R. and B.A. Stewart (Eds.). Advances in Soil Science. CRC, Lewis Publisher, Boca Raton, pp: 16-57.

Van Bavel, C.H.M., 1950. Mean-weight diameter of soil aggregates as a statistical index of aggregation. Soil Sci. Soc. Am. Proc., 14: 20-23.

Walkley, A. and C.A. Black, 1934. An examination of the Degtjareff method of determining soil organic matter and a proposed modification of the chronic acid titration method. Soil Sci., 37: 29-38.

Whalen, J.K. and C. Chang, 2002. Macroaggregate characteristics in cultivated soils after 25 annual manure applications. Soil Sci. Soc. Am. J., 66: 1637-1647.