Biological Forum – An International Journal **7**(2): 869-874(2015)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Improvement of Soil Physicochemical Characteristics Using Legume Crops

Abdollah Javanmard
Department of Agronomy and Plant Breeding,
Faculty of Agriculture, Maragheh University, Maragheh, Iran

(Corresponding author: Abdollah Javanmard)
(Received 12 August, 2015, Accepted 09 October, 2015)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The use of legume crops as a green manure is considered an important agronomic technique in cropping systems to improve soil quality and crop production. We conducted a field experiment to evaluate the impact of legume crops Grasspea (*Lathyrus sativus*), Vetch (*Vicia villosa* L), Berseem clover (*Trifolium alexandrinum*), Sainfoin (*Onobrychis sativus*), Maragheh Vetch (*Vicia dasycarpa*) and Control treatment (without green manure) on the organic carbon (OC), calcium carbonate equivalent (CCE), bulk density, moisture percentage and electrical conductivity of soil extract. This study was carried out at the Research Farm of Maragheh University, Maragheh, Iran in 2013. Legume crops were sown at the beginning of May and ploughed three months later. Soil samples were taken in autumn before wheat sowing (September). Result showed that the green manure application have significant effects on the organic carbon (OC), calcium carbonate equivalent (CCE), bulk density, moisture percentage and electrical conductivity of soil extract. The highest organic carbon was obtained with the application of grasspea treatment. The bulk density content was significantly higher in control soil than in legume crop treatments, while the electrical conductivity of soil behaved in the opposite way. Significantly higher calcium carbonate equivalent was observed in the vetch, and berseem clover crops than control. Also the highest value of moisture content was observed with vetch application. Therefore, cultivation of legume crops for so-called green manure can be useful management practice for enhancing soil properties.

Keywords: Berseem clover, Bulk density, Electrical conductivity, Green manure, Organic carbon.

INTRODUCTION

Leguminous green manure is a standard management tool in cropping systems, because it provides nitrogen (N) to subsequent crops. While the practice of applying leguminous green manures is declining in the modern cropping system due to the availability of synthetic fertilizers and the cost and time required producing a green manure crop, they remain extensively used in low-input cropping systems in tropical and subtropical areas (Peng Chen *et al.,* 2014). The increasing costs of synthetic fertilizers and the deterioration of soil properties, in the absence of legumes, have prompted many farmers to reconsider leguminous green manure (Crews and Peoples, 2004).

Also, long-term agricultural practices and technologies, such as monocultures, the excess use of inorganic fertilizers and pesticides along with a simultaneous decrease in organic manure amendments applied to the soil, agricultural heavy machinery, and inadequate practices of soil management, can significantly affect soil quality by worsening the physical, chemical and biological properties of the soil (Piotrowska and Wilczewski, 2012). Consequently, the loss of organic matter content followed by a decrease in the sustainability of soil can be expected in the long term (Valarini *et al.,* 2002). An increasing concern for the sustainability of soil quality has led to the development of a set of management practices that reduce the potentially negative impact of agricultural activities. In this regard, proper organic matter management appears to be the most important (Piotrowska and Wilczewski, 2012).

The application of green manures to soil is considered a good management practice in any agricultural production system because can increase cropping system sustainability by reducing soil erosion and ameliorating soil physical properties (Smith *et al.,* 1987), by increasing soil organic matter and fertility levels (Power, 1990), by increasing nutrient retention (Dinnes *et al.,* 2002), and by reducing global warming potential (Robertson *et al.,* 2000). Leguminous and non-leguminous plants are used in the production of green manures. Leguminous plants form symbiotic associations with Rhizobium bacteria in order to fix N_2. This fact causes that the green manures, which their principal component are leguminous plant debris, supply to the soil important amounts of N in relation to the green manures obtained from non-leguminous plants. However, the influence of this organic matter on soil properties depends upon amount, type, size and dominant component of the added organic materials (Tejada *et al.,* 2008).

Some results concerning the positive influence of legume crops on the physical and chemical properties of soil (Eichler-Löbermann *et al.,* 2008) and the yields of the subsequent crops (Kosteckas and Marcinkevičiene 2009; Wilczewski, 2004) have been published. Legume crops make it possible to use fertilizer compounds unemployed by the previous crop and limit their leaching into the ground water (Berntsen *et al.,* 2006). Some researchers have been devoted to the role of legume and catch crops in the reduction of nitrogen losses from the cropping system by adsorbing it from the soil and transferring to the following crop (Constantin *et al.,* 2010), which is of special importance in temperate climates with high precipitation during autumn and winter. Physical and chemical properties, however, generally respond to management practices slowly, and therefore there is a need for a long-term study on the influence of certain management practices in order to observe possible changes (García *et al.,* 2000). That is why they may be useful as early indicators of biological changes in soil (Masciandaro *et al.,* 2004). In order to protect the desired agricultural productivity and sustainability, application of organic materials has been recommended as one major remedial measure and is the most practical option for increasing organic inputs in monoculture systems. Furthermore, green manure increased the amount of soil water stable aggregates and improved soil structure. There have been many studies conducted worldwide to investigate the effects of various agricultural practices on soil physical properties (Li *et al.* 2003; Pinheiro *et al.* 2004). For example, in a 27 yr experiment, Nie *et al.* (2010) showed that long-term combined application of pig manure and rice straw with chemical fertilizer significantly reduced soil bulk density and soil particle density, enhanced soil porosity and water holding capacity, promoted the formation of 5-0.5 mm water stable aggregates and increased soil aggregate stability. The objective was to evaluate the effects of green manure on soil physicochemical properties.

MATERIALS AND METHODS

The field assay was conducted in 2013 growing season at the University of Maragheh (37°24' lat. N; 46°16' E long. E, 1477 m above sea level) located in east Azerbaijan province of Iran. The annual temperature averages 13.2°C and the annual rainfall averages 309 mm.

Experiment was arranged based randomized complete block design (RCBD) with four replications. Experimental green manure Treatments were included: Grasspea (*Lathyrus sativus*), Vetch (*Vicia villosa* L.), Berseem clover (*Trifolium alexandrium*), Sanfoin (*Onobrychis sativa*), maragheh vetch (*Vicia dasycarpa*) and control treatment. For determining the physicochemical properties of the soil, before planting, samples were gathered from the depth of (0-30 cm) for each plot (Table 1). Planting date has started on May. Each plot consisted six rows of 3 m long and 20 cm apart. During blooming stage, legumes were returned to the depth of 30 cm of the soil. Soil samples were air-dried separately and they were passed sieve through a 20-mesh screen. Measured traits were: organic carbon, calcium carbonate equivalent (CCE), bulk density, moisture weight percentage, electrical conductivity of soil extract (Ec). Organic carbon was determined by method of Walkley and Black (1934). The calcium carbonate equivalent was determined by titrimetric method of Erich and Ohno (1992). Bulk density and Moisture weight percentage was determined cylinder method (Margesin and Schinner, 2005). Electrical conductivity of soil extract was determined by the methods which are outlined by USDA (1954). The analysis of variance of the data was carried out by using SPSS soft-ware. Means were compared by Duncan's multiple range test at P≤0.05.

Table 1: Soil characteristics of the experimental site.

pH	EC (dS/m)	OC	CCE	Total N	Clay	Silt	Sand
		(%)					
8.4	0.42	0.42	9.75	0.12	37.6	36.9	25.5

OC: Organic Carbon, CCE: Calcium carbonate equivalent, EC: Electrical conductivity.

RESULT AND DISCUSSION

A. Organic carbon

The results of the present study showed that soil organic carbon (SOC) in plots subjected to the planting green manure treatments was significantly higher than control treatment. The highest rate of organic carbon content was in grasspea (4.68%) and the least amount was in the control treatment (0.76%) (Fig. 1). By returning the grasspea into the soil, 607.81 g.m^{-2} dry matter added to the soil.

Hwang *et al.,* (2015) concluded that the total organic concentration increased with increasing total biomass application level. As green manure is an organic material, incorporation of green plant material obviously, increased the accumulation of soil organic matter during the growth period of rice and wheat. Biederbeck (1993) compared the effect of two types of grasspea, chickpea and lentil as green manure, and detected that grasspea and chickpea produce high biomass.

Introduced them as suitable green manure because they have a great potential in producing high amount of biomass. Returning green manure in order to increase soil organic carbon and organic matter soil fertility is a microbiological processes that occurs as a result of plant nutrients releasing (Talger *et al,* 2009). Soil Organic carbon has been considered the key factor influencing the quality of soil for a long time. Soil organic matter is a source, and a sink for plant nutrients in soils and it is important in maintaining soil silt, aiding infiltration of air and water, promoting water retention and reducing erosion (Gregorich *et al.,* 1994). Zhang *et al* (2007) showed that by adding Amelioration organic manure or green manure cropping significantly increased organic C storage in soil. Hati *et al* (2006) reported, that Addition of organic matter through FYM and higher crop growth and biomass addition due to leaf shedding and root biomass addition under NPK + FYM might have contributed to higher soil organic carbon content. Tisdall and Oades (1982) found that organic

C helps in the formation of aggregates in two main aspects. First, organic carbon acts as a nucleus surrounded by the clay that forms the aggregate. Second, organic carbon connects particles of different sizes through physical binding to form aggregates.

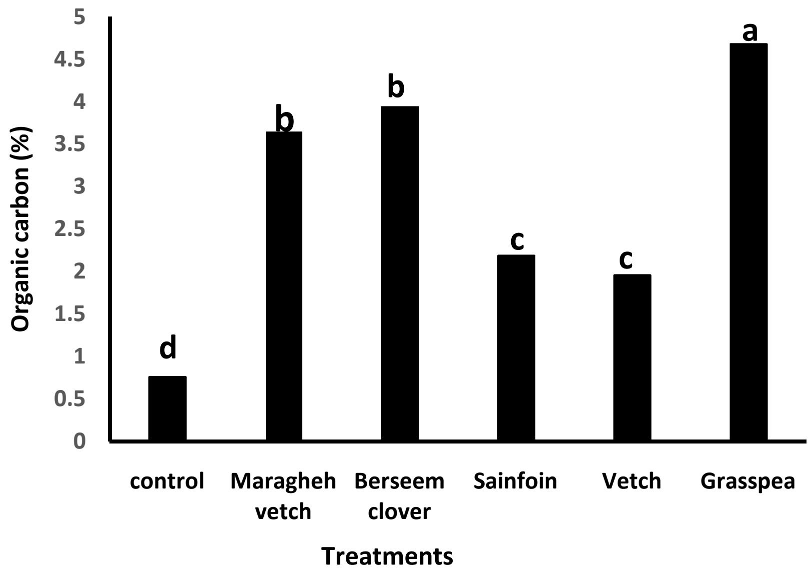

Fig. 1. Amount of soil organic carbon under influence of different plants as green manure. Dissimilar letters indicate significant differences at the 5% level according to Duncan's test.

B. Calcium carbonate equivalent (CCE)

Between different plants as green manure, there was significant difference in soil Calcium carbonate equivalent at the rate of 1% level probability. The highest rate in CCE content was in Berseem clover and the lowest amount in CCE was in control (Fig. 2). Green Manure plants have the potential in increasing of soil pH. Increasing of soil pH causes an increase in soil alkaline. Consequently it prepares a good medium for plant growth. Excess of lime in the soil is dangerous for the plants and it assumes as a harmful condition in agriculture. As a result, excess lime rates forbids the plant to absorb some nutrient like Fe and Cu. Qin (1998) showed that increasing Ca concentration in the nutrient solution and liming had beneficial effect on plant growth under Al stress and alleviated Al toxicity of plants. Thus, liming is the usual method for ameliorating Al toxicity in the acidic soil. However, it has been discovered that liming may also cause negative effects on plant growth and soil properties (Ahmad and Tan, 1986).

Application of organic materials increases pH of soil solution. Wong *et al.* (1998), who found that the increased soil pH was directly proportional to the base caution (Ca, Mg and K) concentrations of the added organic material. Application of lime, organic matter, chemical fertilization and planting of tree and green manure crops are common measures for amelioration of degraded red soils (Li, 1983).

C. Bulk density

The soil bulk density and soil density are important indicators of soil physical properties and the constraining factors that affect soil fertility and crop productivity. Statistical analysis showed that the differences between green manures and control treatment was significant. The soil bulk density in all green manure treatments was significantly reduced compared with fallow treatment. The highest Bulk density content observed in Control treatment (1.65 $g.m^{-3}$) and the lowest amount was in grasspea (1.12 $g.m^{-3}$) (Fig. 3).

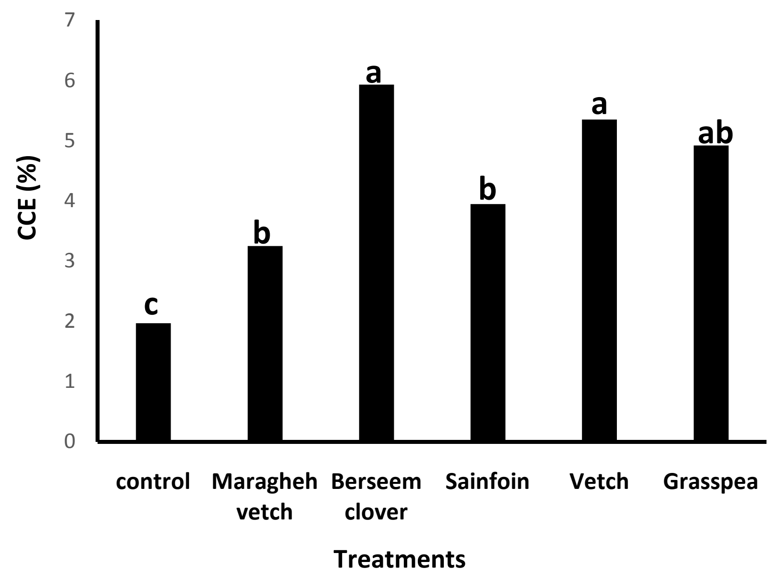

Fig. 2. Amount of soil CCE under influence of different plants as green manure.
Dissimilar letters indicate significant differences at the 5% level according to Duncan's test.

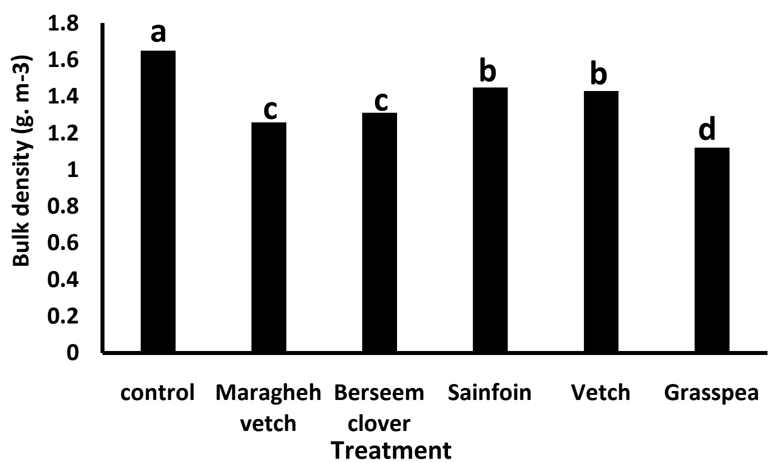

Fig. 3. Amount of soil bulk density under different plants as green manure.
Dissimilar letters indicate significant differences at the 5% level according to Duncan's test.

There were no significant differences between Maragheh vetch with berseem clover and vetch with sainfoin treatments. Yang *et al.* (2005) reported that planting alfalfa could reduce soil bulk density and enhance porosity. Liu *et al.* (2006) showed that application of green manure could reduce soil bulk density and pH, as well as increase soil organic matter and soil microbes in a tobacco field. These results support the reduced bulk density observed in response to increased organic inputs observed by Albaladejo *et al.* (2008). They suggested that this may have been due to a dilution effect of the dense mineral fraction of the soil caused by the increase in organic matter in the plow layer soil, and the increase in porosity due to the improvement in soil structure (Haynes and Naidu 1998). Incorporation of green manure increased total pore space, which in turn decreased bulk density of soil. Similar findings were reported by Joshi *et al* (1994). The bulk density values increased with the passage of time at all soil depths irrespective of treatments. The decrease in the bulk density might be due to higher soil organic carbon content of soil in addition, bulk density improves aggregation and increases root growth. Decreasing the bulk density could be the decreasing some soil minerals in the soil because of increasing organic matters. The results of this experiment are the same with the result of the experiments of Yang *et al* (2012).

D. Moisture weight percentage

Statistical analysis showed that the differences between green manure treatments and control were significant ($P<0.05$), but the differences between the five green manure treatments were not significant (Fig. 4). Moisture content was the lowest in Control treatment (15.67), and the highest amount of Moisture Weight percentage was in grasspea (21.29). Decreasing the bulk density due to using green manure, and increasing the organic matter the soil improve the soil aggregation. Consequently, it increase the soil porosity and Moisture Weight percentage. By increasing the soil porosity water penetrates into the soil better. Consequently, increasing moisture percentage, the rate of available water for the rotating crops will increase. Improvement in soil aggregation by the application of crop residues and organic manure increases porosity, hydraulic conductivity, infiltration rate, water-storage capacity. However, it decreases bulk density and penetration resistance (Prasad and Sinha, 2000). Incorporation of organic matter either in the form of crop residues or farmyard manures has been shown to improve soil structure and water retention capacity (Bhagat and Verma, 1991); increase infiltration rate (Acharya *et al.*, 1988) and decrease bulk density (Khaleel *et al.,* 1981). The increase in water stable aggregation from increases crop yields and organic matter returns (Haynes and Naidu, 1998).

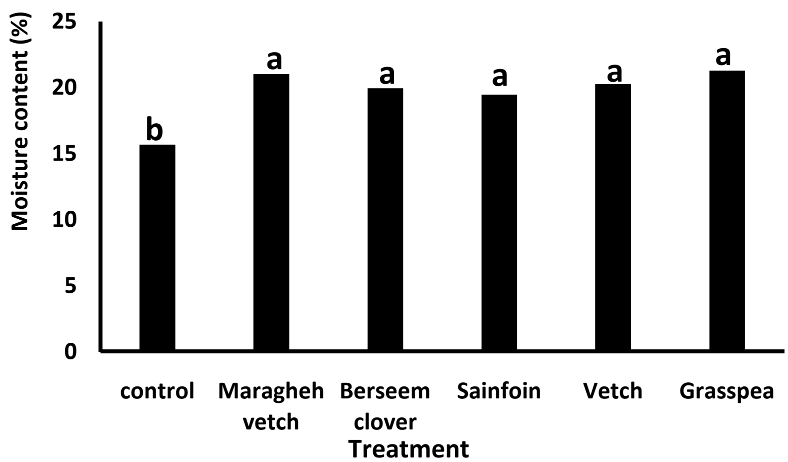

Fig. 4. The amount of soil moisture content under different plants as green manure. Dissimilar letters indicate significant differences at the 5% level according to Duncan's test.

REFERENCES

Berntsen J, Olsen JE, Petersen BM, Hansen EM. (2006). Long-term fate of nitrogen uptake in catch crops. *European Journal of Agronomy*, **25**, 383-390.

Chen CP, Cheng CH, Huang YH, Chen CT, Chao-Ming LCM, Menyailo OV, Fan LJ, Yang YW. Converting leguminous green manure into biochar: changes in chemical composition and C and N mineralization. *Geoderma*, **232**: 581-588.

Constantin J, Mary B, Laurent F, Aubrion G, Fontaine A, Kerveillant P, Beaudoin N. (2010). Effects of catch crops, no till and reduced nitrogen fertilization on nitrogen leaching and balance in three long-term experiments. *Agriculture, Ecosystems and Environment*, **135**, 268-278.

Crews TE, Peoples MB. (2004). Legume versus fertilizer sources of nitrogen: ecological tradeoffs and human needs. *Agric. Ecosyst. Eviron.* **102**, 279-297.

Dinnes DL, Karlen DL, Jaynes DB, Kaspar TC, Hatfield JL, Colvin TS, Cambardella CA. (2002) Nitrogen management strategies to reduce nitrate leaching in tile-drainded Midwestern soil. *Agron. J.* **94**, 153-171.

Eichler-Löbermann B, Köhne S, Kowalski B, Schnug E. (2008). Effect of catch cropping on phosphorus bioavailability in comparison to organic and inorganic fertilization. *Journal of Plant Nutrition*, **31**, 659-676.

Garcia C, Hernandez T, Pascual JA, Moreno JL, Ros M. (2000). Microbial activity in soils of SE Spain exposed to degradation and desertification processes. Strategies for their rehabilitation. In: Garcia, C., Hernandez, M.T. (Eds.), Research and Perspectives of Soil Enzymology in Spain. CEBAS-CSIC, Spain, pp. 93-143.

Hwang HY, Kim GW, Lee YB, Kim PJ, Sang Yoon SY. (2015). Improvement of the value of green manure via mixed hairy vetch and barley cultivation in temperate paddy soil. *Field Crops Research,* **183**: 138-146.

Jensen ES, Peoples MB, Boddey RM, Gresshoff PM, Hauggaard-Nielsen H, Alves BJR, Morrison MJ. (2011). Legumes for mitigation of climate change and provision of feedstock for biofuel and biorefineries. A review. Agronomy Sust. Devel. Doi: 10.1007/s13593-011-0056-7.

Kosteckas R, Marcinkevičiene A. (2009). The integrated evaluation of the influence of catch crops and manure on spring barley agrocenosis in organic farming. *Agronomy Research,* **1**: 355-362.

Masciandaro G, Ceccanti B, Benedicto S, Lee HC, Cook F (2004). Enzyme activity and C and N pools in soil following application of mulches. *Can. J. Soil Sci.* **84**, 19-30. 2004.

Monokrousos N, Papatheodorou EM, Diaamantopoulod JD, Stamou GP. (2006). Soil quality variables in organically and conventionally cultivated field sites. *Soil Biology and Biochemistry,* **38**, 1282-1289.

Nie J, Zheng SX, Yang ZP, Liao YL, Xiao J. (2010). Long-term effects of chemical fertilizer, pig manure and rice straw on physical properties of a reddish paddy soil. *Scientia Agricultura Sinica,* **7**: 1404-1413.

Liu GS, Luo ZB, Wang Y, Li HL, Wang GF, Ma JM. (2006). Effect of green manure application on soil properties and soil microbial biomass in tobacco field. *Journal of Soil and Water Conservation*, **20**(1): 95-98.

Li ZP, Lin XX, Cheng LL. (2003). Effect of fertilizer application on physical properties of infertile red soils. Soil, 2, 112-117.

Pinheiro EFM, Pereira MG, Anjos LH. (2004). Aggregate distribution and soil organic matter under different tillage systems for vegetable crops in a Red Latosol from Brazil. *Soil Tillage Research*, 77: 79-84.

Piotrowska A, Wilczewski E. (2012). Effects of catch crops cultivated for green manure and mineral nitrogen fertilization on soil enzyme activities and chemical properties. *Geoderma,* **189**: 72-80.

Power JF. (1990). Use of green manures in the Great Plains. In: Havlin, J.L., Jacobsen, J.S. (Eds.), Proceedings of the Great Plains Soil Fertility Conference, Denver, CO. 6-7 March. Kansas State University, Manhattan, KS, pp. 1-18.

Robertson GP, Paul EA, Harwood RR. (2000). Greenhouse gases in intensive agriculture: contributions of individual gases to the radioactive forcing of the atmosphere. *Science,* **289**, 1922-1925.

Reginald EM, Pramod KC, Dhyan S, Ashok KP. (2007). Soil quality response to long-term nutrient and crop management on a semi-arid incepotisol. *Agriculture, Ecosystems and Environment,* **118**, 130-142.

Tejada JL, Gonzalez AM, Garcı´a-Martı´nez JP. (2008). Effects of different green manures on soil biological properties and maize yield. *Bioresource Technology,* **99**: 1758-1767.

Tisdall JM, Oades JM. (1982). Organic matter and water stable aggregates in soil. *European Journal of Soil Science*, **33**, 141-163.

Valarini PJ, Cruz Díaz Alvarez M, Gascó JM, Guerrero F, Tokeshi H. (2002). Integrated evaluation of soil quality after the incorporation of organic matter and microorganisms. *Brazilian Journal of Microbiology,* **33**, 35-40.

Wang GL, Duan JN, Jia NF, Liao JP. (2006). Effects of long term fertilization on soil physical and chemical property in Loess hilly area. *Journal of Soil and Water Conservation,* **20**: 82-85.

Wilczewski E. (2004). Effect of fertilization methods on the biomass productivity of nonpapilionaceous plants grown as stubble intercrops. *Acta Scientiarum Polonorum Agricultura* **3**(1), 139-148.

Yang CX, Li GH, Li CL. (2005). Economical green manure mulches earth surface in Xishuangbanna rubber plantation. *Chinese Agricultural Science Bulletin*, **21**: 280-283.

Yang YH, Jiang PA, EK A, YQ Z. (2005). Effects of planting Medicago sativa on soil fertility. *Arid land Geography,* **28**, 248-251.

Yang Zeng-ping XU, Ming-gang ZH, Jun N, Ju-sheng G, Yu-lin L, XIE J. (2012). Effects of Long-Term Winter Planted Green Manure on Physical Properties of Reddish Paddy Soil Under a Double-Rice Cropping System. *Journal of Integrative Agriculture,* **11**(4): 655-664.

Zhang MK, Fang LP. (2007). Effect of tillage, fertilizer and green manure cropping on soil quality at an abandoned brick making site. *Soil & Tillage Research* **93**: 87-93.