BIHAREAN BIOLOGIST 11 (1): 48-52
Article No.: e161401

http://biozoojournals.ro/bihbiol/index.html

Effect of animal manure on decreasing chemical fertilzer use in degraded farm fields in semiarid region of Central Turkey

Gökhan BÜYÜK[1,*], Cladio ZUCCA[2] and Erhan AKÇA[3]

1. Adiyaman University, Kahta Vocational School, Kahta, Adıyaman, Turkey.
2. University of Sassari, Dept. of Agricultural Sciences (Dipartimento di Agraria), Viale Italia 39, 07100 Sassari, Italy.
3. Adiyaman University, Technical Sciences Vocational School, Adıyaman, Turkey.
* Corresponding author, G. Büyük, E-mail: gbuyuk@adiyaman.edu.tr

Received: 23. February 2016 / Accepted: 18. June 2016 / Available online: 23. June 2016 / Printed: June 2017

Abstract. Intensive agriculture in dry lands when coupled with wind erosion causesdegradation of soils' physical and chemical qualities that limits achieving desired yield. Karapınar, located in Central Anatolia (CA) of Turkey experienced severe wind erosion in 1960s which affected 145000ha arable land. The mitigation studies undertaken from 1960s to 1990s successfully suppressed wind erosion effectsinKarapınar. However, private farm soils are still threaten by wind erosion due to improper land use such as excess irrigation, over use of fertilizers, tillage and unsuitable crop pattern that all degrades soils physical and chemical qualities. The soil organic carbon is the major soil component lost due to ignorance of organic matter supply to cultivated fields inCA although it is traditionally the center of small ruminant production with its wide grazing lands. The current number of small ruminants exceeds 500.000 heads in the study area and manures generally sold to other regions of the country. The urgent necessity for providing carbon to eroded soils which have shallow A-horizons (<15cm) in the site can be met by local livestock activities.But farmers are not aware of animal manures efficiency or replacement with chemical fertilizers. Thus, an experiment was conducted at three 0.5 haplots for demonstrating the efficiency of animal manure for cereal production. The cattle manure was applied at a rate of 20 t ha^{-1} to two plots (Akçaşehir and Karapınar) and control (Ereğli). As all soils are deficient in Zn content, 50 $kgha^{-1}$ $ZnSO_4.7H_2O$ was provided to all plots. Conventional cropping was undertaken at Ereğli experimental field by application of 350$kgha^{-1}$ urea, 160 $kgha^{-1}$ TSP (Triple Super Phosphate). Results revealed that manure application successfully substituted wheat's nutrition requirement in CAalsoincreased soil organic matter even not at desired level (>3%).The outcomes of the study is shared to farmers via Karapınar Agricultural Chamber and Turkey's largest NGO namely TEMA (The Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitats) for capacity building.

Key words: manure, organic matter, Central Anatolia, degradation.

Introduction

Today's agricultural practices focus on achieving maximum yield rather than increasing soil quality by high input of agro-chemicals and intensive tillage (Kobayashi 2005). Decreased soil quality by excess tillage triggers wind erosion in arid lands. For combating and mitigating negative effects of wind erosion in arid farm lands, soils organic carbon should be supplied to fields for sustaining soils production capacity (Sommer et al. 2013). The major source for supplying organic matter to soils in CA can be animal manure, already available as much as 200.000.000 kg/year (from more than 500.000 head sheep in the area (Mevka 2014). Several studies revealed the positive effects of manure on soils and crops quality by increasing available plant macronutrients N, P, and K (Masto et al. 2007), water holding capacity, cation exchange potential, pH buffering and dense root development, increasing plants resistance to abiotic conditions (Martin & Sauerborn 2013).

Rates of manure application to soil depend on several factors, including the type of crop, availability and chemical composition of manure along with soil parameters. However, excess application rates can adverse the positive effects on soils and plants by increasing salinity due to chloride content of animal manure (Diacono & Montemurro 2010). Animal manure applied at no-till conditions revealed enhanced yield production in soybean, black oat and Italian ryegrass rotation (Costa et al. 2014).

Agricultural practices dates back to 9000 years BP in Anatolia (Akça & Kapur 2014). The extensive use of soils for centuries where production is limited by dry climate and poor soil quality due to carbonate rich lacustrine parent material (Kalaycı et al. 2011). Thus, for intensive cultivations soils demand external nutrient inputs particularly for N, P and Zn (Fig. 1). For supplying plant nutrients N-P-K fertilizers are excessively applied and particularly overuse of nitrogen fertilisers increased decomposition of organic material. Therefore N and P nutrition are not crucial as in the case of organic material. At rainfed conditions the average cereals (wheat and barley) yield varies from 2,5 to 3 t ha^{-1} in Central Anatolia however increases up to 5.86 to 6.02 t ha^{-1} at irrigated fields with high chemical fertilizer input (Öztürk et al. 2008). So, enhancing soil with cattle manure for meeting the demand of depleted micronutrients and organic material are crucial for the sustainable maintenance of soils for food security and economy of farmers in CA.

Decreasing soil quality can only be maintained by application of organic and mineral additives that were up taken by plants (Maillard & Angers 2014). And particularly in CA agricultural monoculture dominated practices decreased organic matter and available plant nutrients (Mayes et al. 2014).

Soil nutrient status in cultivated lands is widely controlled by external inputs of soil conditioners and fertilizers (Davis 2007) mostly containing macronutrients of nitrogen, phosphorus and potassium so nutrient balance is negatively changed for micronutrients such as Zn, Fe and Mn. Moreover, for increasing yield amount from a unit area, stakeholders with small farms (app.6 hectares for Turkey, Uzundumlu 2012) tend to use high nitrogen bearing agrochemicals which also decrease organic matter of soils (Chievenge et al. 2011) by inducing decomposition rate of organic matter. Although animal manures positive effects on soil aggregation is well-known (Alliaume et al. 2013) its application in

CA, a major agricultural zone of Turkey covering 55.000km² greater than several countries such as Netherlands and Denmark (http://data.worldbank.org/country), is limited (Işık et al. 2000). Thus, this study is one of the pioneering trials at private eroded lands that set assessment ofreal life responses of animal manure application. The study based on the use of cattle manure at three private fields located in CA of Turkey. The experiment was set up for determination of animal manure on physical, chemical and nutrition properties of experimental fields and compared with conventional cultivation (plant nutrients are provided by chemical fertilizers) for revealing animal manure efficiency in semi-arid conditions.

Material and Methods

Study area

Experiments were conducted in 2011-2013 during the harvest period (July) at 3 plots 0.5 ha area located in Karapınar, Akçaşehir and Ereğli (CA, Turkey) (Fig. 1). Sites have similar geographical conditions that are characterized by continental climate with 350mmmean annual precipitation and elevation of 1000m in Karapınar and Akçaşehir, and 1050m in Ereğli.

Figure 1. Locations of the experimental fields.

Prior to 1970s the majority of the agricultural management was based on rain fed conditions in CA was, and after harvest in July, farm fields were highly vulnerable to wind erosion. Following the introduction of irrigation in late 1970s from ground well increased the period of land cover along with yield. The lacustrine parent material rich in carbonate in CA lead to the formation of mainly Calcisols/Inceptisols and Cambisols/Inceptisols (Akça & Kapur 2014). Soils of the experimental fields were classified as Haplic Calcisol Aric according to IUSS Working Group WRB (2014) and TypicCalcixerept according to Soil Survey Staff (2014) which have developed on flat lands with high pH (>7.8) and medium texture (silty loam, loamy clay) with low organic matter.

The experimentalsoilsare classified into Land capability class of III due to their high susceptibility to wind erosion (Soil Conservation Service 1961). This may be seen atrelatively shallow surface horizons (Ap) of experimental fields which less than 15cm. The low organic matter and Zn along with shallow A-horizon revealeda degraded land affected by wind erosion. Wind erosion has been a long standing issue in Konya plain and effecting majority of the soils (Kuzucuoğlu et. al. 1996). The magnitude of erosion is increased at bare cultivated lands following harvest in July, soils are prone to severe wind erosion during the drought periods namely August and September in Konya Plain.

Experiment was undertaken with Genotype 1252 (220kgha^{-1} seeded), a widely cultivated wheat in CA for pasta production due to its high yielding characteristics (Atılgan & Aşkın 2008). Sprinkle irrigation was established to all plots, and four irrigation treatments were applied during the cultivation period.

Treatments

The cattle manure utilized in the experiment was matured for 6 months prior to application, and was free of bedding material and weeds (Table 1). As animal manure is primarily used for enhancing soil organic matter, nitrogen, potassium and phosphorous content (Sommer et al. 2013) other nutrients such as iron, zinc and magnesium that are generally found at lower amounts were neglected in this study. The manure was applied at a rate of 20tha^{-1} to two plots (Akçaşehir and Karapınar) and Ereğli plot was the control. The Central Anatolian soils are deficient in Zn content (Kalaycı et al. 2011), thus 50 kgha^{-1} $ZnSO_4.7H_2O$ was provided to all plots for eliminating Zn related growing problems. Conventional cropping was undertaken at Ereğli experimental field by application of 350kgha^{-1} urea, 160kgha^{-1} TSP during growing season.

Table 1. Chemical properties of animal manure used for the treatments.

Total N	P	K	Organic Matter	Zn	Fe	Cu	Mn	EC	pH
kg ton^{-1}			%	mg kg^{-1}				dS/m	
16	2.62	15	68	42	45	25	112	1.2	6.8

Soil and plant analysis

Soil samples (from 0-20 and 20-50cm) were collected from random points of each experimental plotbefore sowing in September 2011,and following harvesting in August 2012, 2013. Also soil samples were collected from private fields adjacent to experimental plots. Soils pH, electrical conductivity (EC), exchangeable cation, organic matter (OM), macro and micronutrients were determined using the methods employed routinely outlined by Sparks (1996) (Table 2). The nutrient contents of N (Kjeldahl), K, P_2O_5, of manure were determined according to the guidelines described by Reuter and Robinson (1997). Leaf samples were collected according to Bergman (1988) from youngest matured leaves during flag leaf foliation both from experimental plots and adjacent farm fields which are cultivated conventionally. The second soil samplings were undertaken following harvest in July 2012 and 2013 for the evaluation of animal manure effects on soils physical and chemical properties. Yield was calculated with average harvested grain from each plots of experimental fields and provided as kg/ha. Private fields soil and plant nutrient analyses under conventional management also provided in the study for comparing manure treatments.

Fields were selected from various locations with similar soil and ecological conditions. However, experiments in each field was established with 3 replicates and data averages of each replicates were evaluated. The data were analyzed according to coincidence blocks

Table 2. Some physical and chemical properties of the experimental soils before sowing.

Location	Karaman		Karapınar		Ereğli	
Depth (cm)	0-20	20-50	0-20	20-50	0-20	20-50
pH	7.9	8.1	7.8	7.9	7.9	8.0
EC (dS/m)	0.04	0.05	0.06	0.06	0.09	0.1
CEC (me 100g^{-1})	28.7	28.5	14.2	12.7	26.3	27.5
$CaCO_3$ (%)	28.5	29.6	31.4	32.8	28.4	32.8
P_2O_5 (kg ha^{-1})	68	68	101	97	12.2	9.6
Zn (mg kg^{-1})	0.9	0.7	0.8	0.7	0.9	0.65
Fe (mg kg^{-1})	4.8	4.7	5.0	4.8	5.0	4.5
Mn (mg kg^{-1})	3.0	2.8	3.0	2.9	2.9	2.8
Cu (mg kg^{-1})	0.8	0.8	0.7	0.7	0.8	0.75
Total N (%)	0.4	0.2	0.2	0.1	0.3	0.2
Organic Matter (%)	1.1	0.8	0.9	0.7	1.2	0.9
Texture	Loamy clay	Loamy clay	Loam	Loam	Silty clay loam	Silty clay loam

design, using thrice reported variance analysis and MRD (Most Reliable Difference) tests with the (MSTAT-C, 1988) software.

Results and Discussions

No nutrient deficiency symptoms have been observed at animal manure applied plots in Karapınar and Akçaşehir (Fig. 2). This is also supported by the plant leaf analyses of Karapınar and Akçaşehir which were within sufficient levels (Barker & Pilbeam 2006) (Fig. 3). However, the major and micronutrients were relatively low at Ereğliplot (Fig. 4). Manure application increased plots K content (Fig. 2). K status in Central Anatolian soils is becoming a critical issue due to extensive maize cropping with the introduction of irrigated agriculture. Maize is known to consume high amounts of K than wheat (Büyük et. al. 2010). Therefore animal manure application is also necessary for keeping soils K level above deficiency levels, although no symptom or data is obtained for its deficiency in experimental soils and plants.

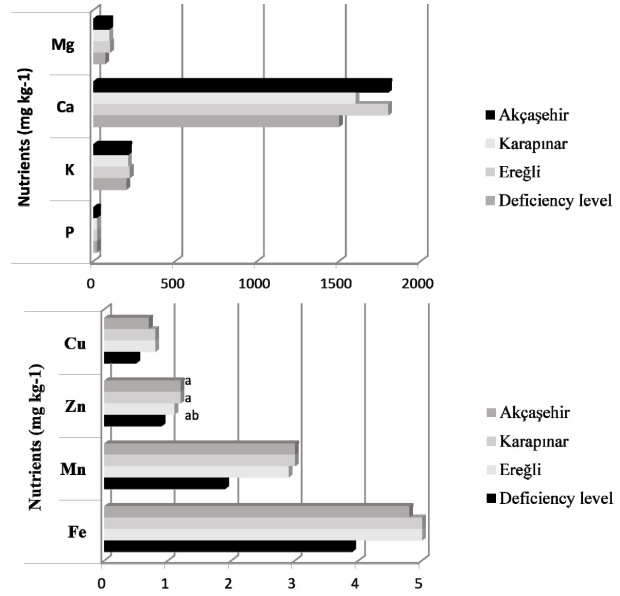

Figure 2. Experimental fields' soils plant nutrient levels following treatments.

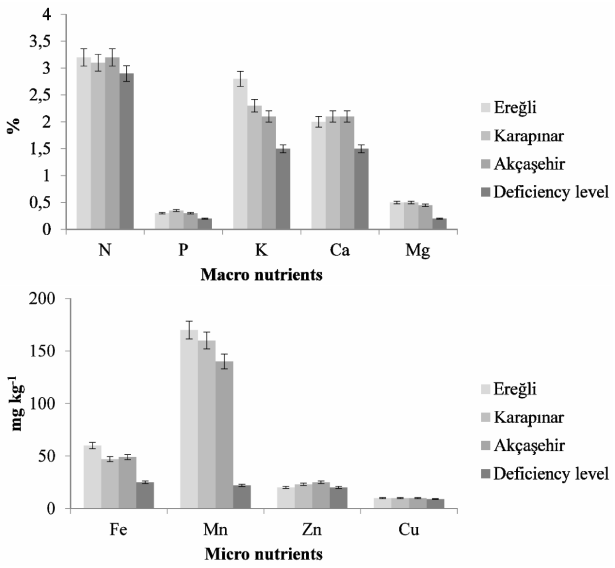

Figure 3. Experimental plots crop leaves plant nutrient contents following treatments.

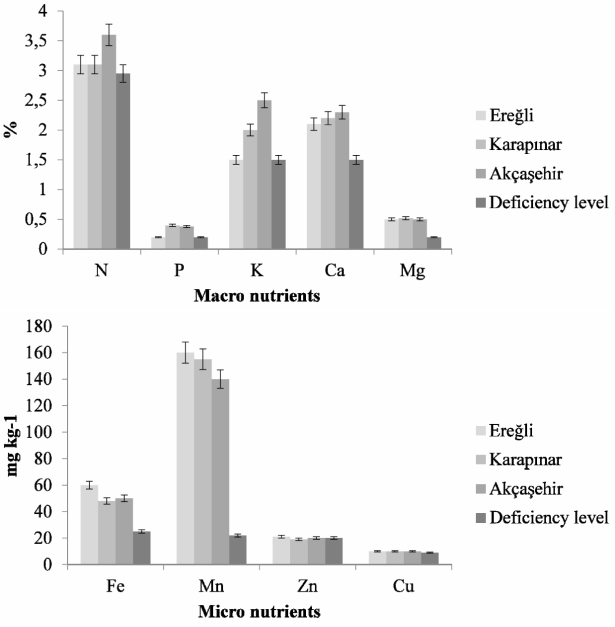

Figure 4. Plant nutrition content of the private farm soils adjacent to experimental plots (no treatment) during study.

Soils of experimental sites along with private farm fields' soils were re-analyzed for their nutrient contents following harvest (Fig. 2, 4). A significant change was observed in Zn levels at manure and Zn-applied soils which increased from 0.9ppm to 1.2ppm.Zinc concentration is determined to be affected by manure and fertilizer application at 0.05 significance level. Other than Zn and Cu, the nutrient levels of soils are above deficiency level in manure applied plots (Fig. 3, 4) However, Zn should be always monitored due to its common deficiency in Konya Plain particularly cereals Zn uptake is not sufficient (Kalaycı et al. 2011) (Table 2).

Other nutrients such as P, K, Mg, Cu, Mn and Fe were in sufficient range following harvest (Fig. 2 and 3) which revealed that the amount used by plant was most probably provided by manuring or manure-increased solubility of said nutrients (Uzoma et al. 2011). However, organic matter increase in two years of experiment was not statistically significant and less than 1% at all plots, which revealed the necessity of continuous manure application or other organic matter sources to the soils. The yields from experimental plots in Karapınar, Akçaşehir and Ereğli were 6.4, 6.8 and 6.3tha^{-1} respectively (Fig. 6). The private fields' yields were varied from 6.15 t ha^{-1} to 7.0 t ha^{-1}.

Soils pH, EC and calcium carbonate did not reveal any change following animal manure application. Thus, yield level of experimental plots were quite similar to conventionally managed private fields productivity which showed the efficiency of animal manure for substituting chemical fertilizers for wheat production except zinc, which should be given as chemical fertilizer due to high deficiency levels in Central Anatolian soils. Wheat yield found to be affected

from animal manure at 0.05 significance level.

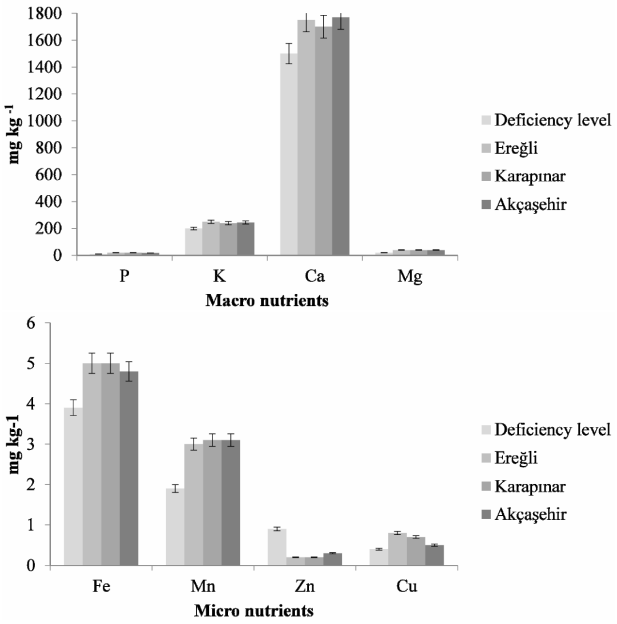

Figure 5. Plant nutrition content of the private farmscrops leaves' adjacent to experimental plots during study.

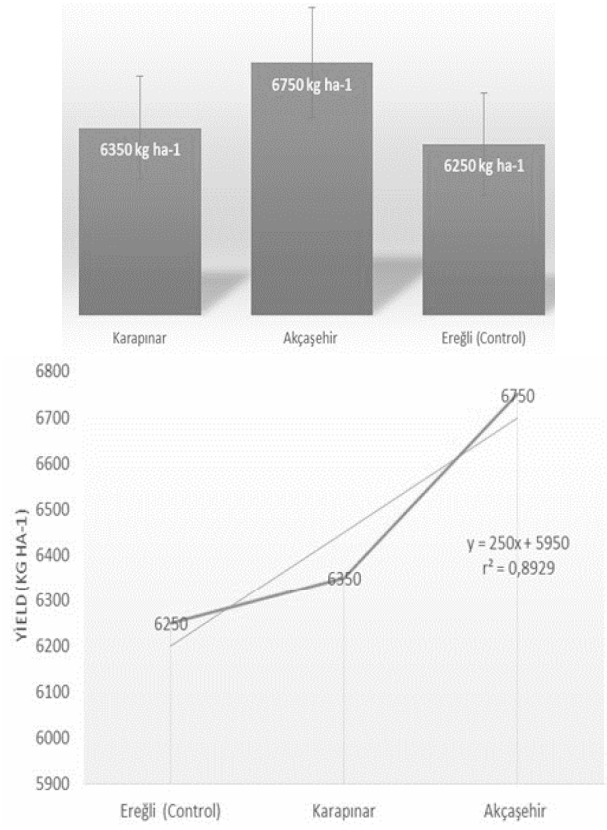

Figure 6. Wheat yields at experimental fields following treatments.

Conclusion

The increasing demand of chemical fertilizer based plant nutrients in conventional agriculture decreases both soil quality and net profits from yields as price of agrochemicals are in increasing trend. Thus, management of crop nutrition via local natural sources particularly at areas with high livestock population as in Central Anatolia of Turkey is crucial for food security. The experiment with irrigated areas set with animal manure revealed no difference between yield output and nutrient levels compared to chemical fertilizer applied plots. The20tha^{-1} animal manure application at experimental soils provided sufficient growth for wheat production at irrigated conditions. So, this rate of application cereals N and P requirements are most probably met by animal manure instead of chemical fertilizers. Moreover, animal manure's other favorable effects, although not measured in the study, on soil quality aeration, water holding capacity, resistance to erosional effects are another positive outputs of increasing soils organic matter content. However, annual animal manure application at high amounts can create secondary salinization due to its chloride content particularly at areas with low rainfall such as Konya Plain. So, following manure application soil salinity should be monitored for preventing secondary salinity.

Acknowledgements. Authors wishes to express their profound thanks to Dr. SelimKapurfor his invaluable critics. This study is funded via CROP-MAL Project of TEMA Foundation and MITSUI Environmental Fund.

References

Akça, E., Kapur, S. (2014): The Anatolian Soil Concept of the Past and Today. The Soil Underfoot: Infinite Possibilities for a Finite Resource, Taylor and Francis.

Alliaume F, Rossing, W.A.H., García, M., Giller, K.E., Dogliotti, S. (2013): Changes in soil quality and plant available water capacity following systems re-design on commercial vegetable farms. European Journal of Agronomy, 46: 10-19.

Atılgan, G.N., Aşkın, A. (2008): Genetic variation for grain yield and quality in durum wheat released in Turkey from 1991 to 2002. The International Symposium of "From Seed to Pasta: The Durum Wheat Chain". Bologna, Italy.

Barker, A. V., Pilbeam, D.J. (2006): Handbook of Plant Nutrition. Taylor and Francis. 613p.

Bergmann, W. (1988):Ernahrungsstörungen bei kulturpflanzen. pp.373-382. VEB Gustav Eisher Verlag, Jena.

Chivenge, P., Vanlauwe, B., Gentile, R., Six, J. (2011): Organic resource quality influences short-term aggregate dynamics and soil organic carbon and nitrogen accumulation. Soil Biology and Biochemistry 43(3): 657-666.

Costa, S.E.V.G.A., Souza, E.D.,Anghinoni, I., Carvalho, P.C.F., Martins, A.P., Kunrath, T.R., Cecagno, D., Balerini, F. (2014): Impact of an integrated no-till crop–livestock system on phosphorus distribution, availability and stock. Agriculture, Ecosystems & Environment 190: 43-51.

Davis, A.S. 2007. Nitrogen Fertilizer and Crop Residue Effects on Seed Mortality and Germination of Eight Annual Weed Species. Weed Science 55(2): 123-128.

Diacono, M., Montemurro, F. (2010): Long-term effects of organic amendments on soil fertility. A review Agronomy for Sustainable Development 30: 401–422.

IUSS Working Group WRB. (2014): World Reference Base for Soil Resources 2014. International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. FAO, Rome.

Işık, Y., Altınel, B., Bilgin, N., Deniz, Y., Öğretir, K., Akın, A. Halitligil (2000): Effect of Nitrogen Fertilization on Yield and Nitrogen and Water Use Efficiencies of Winter Wheat (Durum and Bread) Varieties Grown Under Conditions Found in Central Anatolia. Biology and Fertility of Soils 31: 175-182.

Kalaycı, M., Arısoy, Z., Çekiç, C., Kaya, Y., Savaslı, E., Tezel, M., Önder, O., Yazıcı, A., Çakmak, İ. (2011): The effects of soil and foliar applications of zinc on grain zinc concentrations of wheat and maize. Proceedings of the Third International Zinc Symposium, Hyderabad, India: pp.10-14.

Kobayashi, K. (2005): Japanese Water Management Systems from an Economic Perspective: The Agricultural sector. OECD Workshop on Agriculture and Water: Sustainability, Markets and Policies 14-18 November, 2005. Adelaide, South Australia.

Kuzucuoğlu, C., Parish, R., Karabıyıkoğlu, M. (1998): The dune systems of the Konya Plain (Turkey): their relation to environmental changes in Central Anatolia during the Late Pleistocene and Holocene. Geological Journal 34(12): 175-198.

Maillard, É., Angers, D.A. (2014): Animal manure application and soil organic carbon stocks: a meta‐analysis. Global Change Biology 20(2): 666-679.

Martin, K., Sauerborn, J. (2013): Crops and their Environment. pp. 103-185. In. Agroecology. Springer.

Masto R.E., Chhonkar, P.K., Singh, D.K., Patra, A.K. (2007): Soil quality response to long-term nutrient and crop management on a semi-arid Inceptisol. Agriculture, Ecosystems & Environment 118 (1–4): 130–142.

Mayes, M., Marin-Spiotta, E., Szymanski, L., Akif Erdoğan, M., Özdoğan, M., Clayton, M. (2014): Soil type mediates effects of land use on soil carbon and nitrogen in the Konya. Geoderma 232–234: 517–527.

MEVKA. (2014): Karapınar Province Report. Mevlena Developmnet Agency. <http://www.mevka.org.tr/Content/ViewArticle/karapinar_ilce_raporu?articleID=ZX0CLro3UXc%3D> accessed 10 09 2014.

Öztürk, Ö., Topal, A., Akınerdem, F., Akgün, N. (2008): Effects of sowing and harvesting dates on yield and some quality characteristics of crops in sugar beet/cereal rotation system. Journal of the Science of Food and Agriculture 88(1): 141-150.

Reuter, D.J., Robinson, J.B. (1997): Plant Analysis. An Interpretation Manual. 2nd ed. CSIRO Publishing, Collingwood, Australia. 572p.

Soil Conservation Service. (1961):Land-CapabilityClassification. Agricultural Handbook No. 220. USDA, Washington, 25p.

Soil Survey Staff. (2014): Keys to Soil Taxonomy, 12thed. USDA-Natural Resources Conservation Service, Washington, DC. 372p.

Sommer, S.G., Christensen, M.L., Schmidt, T., Jensen, L.S. (2013): Animal Manure Recycling Treatment and Management. Wiley, 372p.

Sparks, D.L. (1996): Methods of Soil Analysis. Part 3. Chemical Methods. Soil Science Society of America Book Series, No. 5. 1309p.

Uzoma, K. C., Inoue, M., Andry, H., Fujimaki, H., Zahoor, A., Nishihara, E. (2011): Effect of cow manure biochar on maize productivity under sandy soil condition. Soil Use and Management 27(2): 205-212.

Uzundumlu, A.S. (2012): A Comparison of the Agricultural Structure of EU Countries and Turkey. Alınteri 23(B): 64-73.