The Impact of Tillage and Crop Rotation on Yield and Soil Quality under Arid Soil Conditions

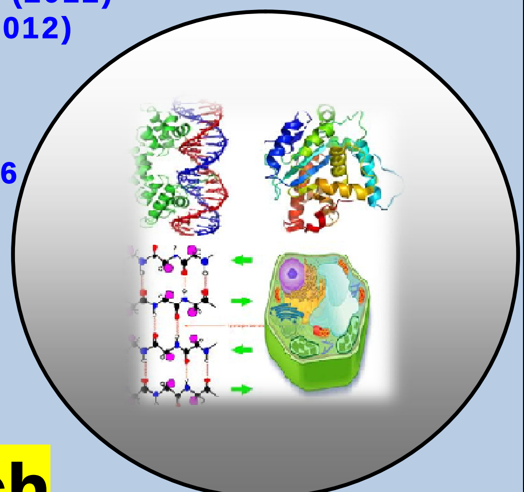
By

Botir Khaitov, Kholik Allanov, Bakhrom Izbosarov, Jonibek Khudaykulov, Bakhrom Azizov, Tulkin Nematov and Oybek Sattorov

ISSN 0970-4973 Print
ISSN 2319-3077 Online/Electronic

Index Copernicus International Value
IC Value of Journal 4.21 Poland, Europe (2012)
Global Impact factor of Journal: 0.587 (2012)
Scientific Journal Impact Factor: 2.597

J. Biol. Chem. Research
Volume 31 (2) 2014 Pages No. 1117-1126



Journal of Biological and Chemical Research

An International Journal of Life Sciences and Chemistry

Indexed, Abstracted and Cited in Various National and International Scientific Databases of the World

Published by Society for Advancement of Sciences®

J. Biol. Chem. Research. Vol. 31, No. 2: 1117-1126 (2014)
An International Journal of Life Sciences and Chemistry

ISSN 0970-4973 Print
ISSN 2319-3077 Online/Electronic


Dr. B. Khaitov Dr. K. Allanov

http:// www.jbcr.in
jbiolchemres@gmail.com
info@jbcr.in

RESEARCH PAPER

Received: 12/08/2014 Revised: 02/09/2014 Accepted: 06/09/2014

The Impact of Tillage and Crop Rotation on Yield and Soil Quality under Arid Soil Conditions

Botir Khaitov, *Kholik Allanov, *Bakhrom Izbosarov, Jonibek Khudaykulov, Bakhrom Azizov, Tulkin Nematov and *Oybek Sattorov

Tashkent State Agrarian University, Department of Plant Science, 100140, Str. University 1, Tashkent, Uzbekistan

*Tashkent State Agrarian University, Department of Farming and Melioration, 100140, Str. University 1, Tashkent, Uzbekistan

ABSTRACT

Crop productivity and soil fertility in arid area are influenced by tillage and crop rotation management. A field experiment was conducted during 2007-2010 at farmers' field located in Jizzakh region, Uzbekistan. The experiments consisted of three rotations: i) cotton-wheat-fallow (farmers' practice) ii) cotton-wheat-soybean and iii) cotton-wheat-maize with two tillage treatments: i) conventional tillage (CT) and ii) conservation tillage. The results revealed that the wheat and cotton grain yield were increased by the conservation tillage treatment. Crop residues retention and planting legumes such as soybean significantly enhanced the seed cotton yield and wheat grain. Conservation tillage in cotton-wheat crop rotation system with inclusion of soybean resulted the growth of cotton yield by 370 kg ha^{-1} and wheat grain 350 kg ha^{-1} than by same crops under conventional tillage treatment. Similarly water use efficiency and cost efficiency were increased significantly under conservation tillage compared to the CT treatment. The soil humus content in surface soil (0-30 cm) was higher in cotton-wheat-summer legume rotation under conservation tillage treatment. The results showed that conservation tillage and legume based rotation treatment could be beneficial in salt affected arid zone of Uzbekistan.

Key words: Conservation Tillage, Conventional Tillage, Cotton, Reduced Tillage, Maize, Wheat, Soybean and Summer Fallow.

INTRODUCTION

Agriculture is very important for the Uzbek economy, accounting for around 60% of employment and more than half of the population lives in the countryside under harsh and poor circumstances. Unsustainable practices of irrigation agriculture and crop residue removal in connection with a one-sided orientation of crop production on cotton monocultures have led to wide-spread soil salinity, loss of soil organic matter and other forms of soil degradation. The decrease in productivity of agricultural lands due to salinization, has a direct impact on the standard of living of the population that seriously reduces food security (Egamberdiyeva, et al. 2007). Obviously, more than 1.5 million ha of irrigated land are freed after harvesting winter grain crops every year in June. The use of these lands for planting different agricultural crops is one of the challenging problems which farmers are facing these days. To plant follow-up crops after winter wheat by conventional tillage (CT) method requires an excessive amount of fuel and extra expenses as well as many other problems related to the land preparation. The soil became more susceptible to wind and water erosion under CT system. CT especially on plowing layer disturbs aggregates of soil and increase soil temperature and soil organic decay (Islam, 2011; Aziz, et al. 2013). In contrast, conservation tillage such as reduced tillage (RT) can reduce the adverse effects of CT (Sayre and Hobbs, 2004). Conservation tillage practices are applied in different form on around 100 million ha worldwide (Derpsch and Friedrich, 2009) and is a suitable alternative to retain crop residues and maintain soil quality on degraded land of arid or semi-arid zone (Wang, et al. 2006). Conservation tillage leaves most of the crop residues on the surface, thus has positive influence to soil chemical, biological and physical quality properties (Aziz, et al. 2013). It has been previously reported that crop cultivation such as organic farming increases microbial diversity due to altering the composition of organic matter and increased nutrient cycling (van Diepeningen, et al. 2006; Davranova, et al. 2013; Egamberdieva and Wirth, 2011). Crop residue holding capability of conservation tillage practices increase soil organic matter content (Egamberdiev, 2007), decrease soil salinity, reduce soil evaporation losses and thus increase water use efficiency (Deng, et al. 2003). The substantial benefits associated with conservation tillage are moisture conservation, which saves 25-30% of irrigation water, improved nutrients availability through proper placement of fertilizer, reduced soil salinity, and similar or higher yields compared to CT (Hassan, et al. 2005; Govaerts, et al. 2005). The degraded cropland of Uzbekistan which affected with salinity and drought can be prioritized for rehabilitation measures through appropriate crop rotation and conservation technology measures. In this study we assessed the comparable effect of CT and RT based crop rotation system to different crop yield and soil fertility in salinated arid land of Uzbekistan.

MATERIAL AND METHODS

Study site description

This study was carried out at farmers' field located Pakhtakor district of Jizzakh region. According to the WRB-FAO (2006) classification, the soil of the selected field was identified as calcisol silt loam serozem.

The soils have been cropped to cotton monoculture for the last 50-60 years under flood irrigation without proper drainage facilities using natural flow system. The selected field (4 ha) was categorized as a moderately saline based on electrical conductivity (5.6±0.6 dS m−1).

The climate of the area is continental with a yearly average rainfall of 200±36 mm and more than 90% of the total rain falling between October to May. The average minimum monthly air temperature is 0°C in January and the maximum of 37°C in July. The average highest relative humidity is slightly more than 80% in January and the minimum is less than 45% in June. The combination of high temperatures and low rainfall under continental climate makes irrigation indispensable for crop production.

Treatments and experimental design

It was a factorial experiment conducted in a split-plot design with four replications. The preceding crop was winter wheat; which has been planted after cotton. Soybean and grain maize planted in different plots as a follow-up crop.

Mineral fertilization norm was the same for all experimental plots during the experiment. Cotton fertilization norm was N-200 kg ha^{-1}, P_2O_5-140 kg ha^{-1} and K_2O-50, wheat fertilization was same amount as cotton (N-200 kg ha^{-1}, P_2O_5-140 kg ha^{-1} and K_2O-50) and follow-up crop (soybean or maize) recommended fertilization norm was N-80 kg ha^{-1}, P_2O_5-45 kg ha^{-1} and K_2O-25 kg ha^{-1}. The whole P and K fertilizer amounts were applied first row cultivation process, while the nitrogen were splitted in two part and applied during first and second row cultivation process.

Tillage treatments comprised of conventional tillage (CT, including disc plow, tiller, rotavator, and leveling operations) and reduced tillage (RT, one tiller followed by rotavator). The experiment consisted of three treatments and conservation and conventional tillage methods and was replicated thrice in a randomized block design. The size of each unit plot was 50 m × 30 m, with inter plot spacing of 1 m and inter block spacing of 2.5 m. Before beginning land preparation for summer crops (soybean or maize) after harvesting wheat under both conventional and conservation tillage irrigation with 600-700 m^3 norms were conducted. During the experiment season the follow-up crops grown under conventional method were irrigated two times and under conservation method were irrigated once.

Crop sowing

Crops under conservation method were seeded on June 27 (2008), but crops under conventional methods were seeded two weeks later. Land preparation ploughing, disking and tilling took more than two weeks for relatively small experimental field.

Irrigation schedule and norms were based on the recommendations for the saline irrigated soils. Harvesting Soybean was done from November 05 (2008) to November 15 (2008) depending upon conservation method and conventional method respectively.

Soil Samples

Soil samples representative of the area were collected at a depth of 0-30 and 30-50 cm layers at the beginning and at the end of experiment from unit replication. Soil moist samples were gently sieved through a 2- mm mesh (visible pieces of crop residues and roots were removed), and a portion of the field-moist soil was analyzed for total carbon, nitrogen and phosphorus.

Contents of total soil carbon (C_t), and total nitrogen (N_t) were determined after dry combustion using a CNS elemental analyzer (LECO Corporation, St. Joseph, MI) according to DIN ISO 10694 (1996), and DIN ISO 15178 (2001), respectively. The content of extractable P was analyzed according to DIN 38414-S (1983).

Statistical analysis

Data were tested for statistical significance using the analysis of variance package included in Microsoft Excel 98 and comparison was done using a Student's *t*-test. Mean comparisons were conducted using a least significant difference (LSD) test (P=0,05). Standard error and a LSD result were calculated.

RESULTS AND DISCUSSION

Agriculture is one the most important sector of the economics in Uzbekistan, accounting for more than 20% of GDP and employing about 40% of the labor force (Qushimov, et al. 2007). Indiscriminate flood irrigation with poor drainage facilities, deep plowing of marginal and naturally saline soils, overexploitation of groundwater, recycling of drainage outflows for irrigation, and monocropping of high water consumptive crops (e.g. cotton) are the major factors accelerating secondary soil salinization in region of Uzbekistan in Central Asia (Egamberdiyeva et al. 2007). Accelerated soil erosion reduces soil fertility and accentuates degradation of vast land areas, which reduce crop production and worsen the environment (Kulmatov, 2014).

Table 1. Crop yields (q ha^{-1}) affected by crop rotation and conventional tillage practice.

Crop rotation	Years of experiment			
	2007	2008	2009	2010
Conventional tillage				
Cotton-wheat-fallow				
Cotton	24.3	-	23.5	-
Wheat	-	28.7	-	28.0
Cotton-wheat-soybean				
Cotton	24.3	-	25.4	-
Wheat	-	27.9	-	30.2
Soybean	-	16.3	-	17.4
Cotton-wheat-maize				
Cotton	24.3	-	23.5	-
Wheat	-	28.6	-	26.9
Maize	-	42,7	-	38.6
Conservational tillage				
Cotton-wheat-fallow				
Cotton	24.3	-	25.5	-
Wheat	-	27,7	-	29.5
Cotton-wheat-soybean				
Cotton	24.5	-	27.2	-
Wheat	-	28.6	-	31.5
Soybean	-	17,1	-	17,5
Cotton-wheat-maize				
Cotton	24.4	-	25.8	-
Wheat	-	20.1	-	29.8
Maize	-	45.6	-	43.6

Sustainable use and management in irrigated lands of Uzbekistan are essential for securing food production in light of climate change, decreasing water resources and growing population and economy, especially given the limited irrigated lands. In our study, cotton yield was higher in RT compared to CT which indicates that RT may be a suitable alternative to CT for irrigated wheat-cotton crop rotation system (Table 1). RT which retains crop residues in the soil surface can effectively conserve resources and enhance crop yield with lowest cost of production (Cantero-Martınez, et al. 2003; Wang, et al. 2007). Recent findings revealed that to ensure effective and sustainable result, conservation tillage must be combined with an appropriate crop rotation system. In sustainable agriculture, the use of legume plants in crop rotations is pivotal for the maintenance of soil fertility. Davranova, et al. (2013) found that to increase the soil fertility of salinated arid soil, it is necessary to use legumes, which can increase microbial population that play an important role N cycle making mineral N bio-available in the soil. Reliance on biological N, fixation through inclusion of legumes in cropping system and maintenance of higher soil organic matter will help to build-up soil fertility and better soil physical and microbial environment with good buffering capacity (Hegde, et al. 2007).

The data presented in Table 1 revealed that cotton yield was higher in RT compared to CT which indicates that conservation tillage may be a suitable alternative to CT for irrigated cotton-wheat rotation system. Conventional tillage contributed to high cost of production, degradation and compaction of soil, soil infertility, and inefficiency of N fertilizer (Tursonov, 2009). Reduced tillage practice with appropriate crop rotation system which provide to keep crop residue on the soil surface can be effective at controlling erosion and weeds and moderate temperature and moisture fluctuations (Magdoff and Weil, 2004).

Incorporating of legume such as soybean in conservation tillage increased the yield both cotton and wheat crops. Legume cropping systems that increase carbon sequestration (CS) and concurrently enhance plant productivity and prevent erosion and desertification are of major interest in many countries in the world (Egamberdieva, et al. 2014). Grain legumes can add 20-60 kg ha^{-1} residual nitrogen (N) to the succeeding crop (Graham and Vance, 2000). There are several reports on the positive effects of legume symbiosis on the soil productivity (Egamberdiyeva and Hoflich, 2005; Jabborova, et al. 2013a).

Cotton yield and wheat grain slightly decreased in continuously cotton-wheat-summer fallow rotation year by year (Table 1). The yield-increasing effect of crop rotation with inclusion soybean was positively proportional to the conservation tillage. Cotton yield was greatest in the cotton-wheat-soybean rotation (24.5-27.2), followed by cotton-wheat-maize tri-culture (24.4-25.8), the cotton-wheat di-culture (24.3-25.5) under conservation tillage system (Table 1).

According to our studies we can conclude that inclusion of legume crop in our case soybean in existing cotton-wheat crop rotation system positively influenced the crop productivity of cotton and wheat by implementing RT method.

The nutrient-use efficiency of all the major, secondary and micronutrients continuously to be low despite increasing consumption of fertilizers in arid region of Uzbekistan (Egamberdiyeva, et al. 2001). Improvement in nutrient-use efficiency is necessary to reduce the cost of production as well as to prevent environmental pollution.

Reliance on biological N, fixation through inclusion of legumes in cropping system and maintenance of higher soil organic matter will help to build-up soil fertility and better soil physical and microbial environment (Egamberdieva and Jabborova, 2013).

Our results demonstrated that total carbon content, total N, and total P availability in the soil slightly improved with using RT and inclusion of soybean in crop rotation system (Table 2, 3).

Table 2. Soil chemical analysis under conventional tillage system.

Crop rotation	Ct	Nt	Pt
Cotton-wheat-fallow			
Before experiment	0.989 ± 0.03	0.087 ± 0.014	0.174 ± 0.015
After experiment	0.877 ± 0.02	0.083 ± 0.006	0.171 ± 0.011
Cotton-wheat-soybean			
Before experiment	0.984 ± 0.01	0.082 ± 0.012	0.169 ± 0.05
After experiment	1.022 ± 0.02	0.093 ± 0,009	0.179 ± 0.04
Cotton-wheat-maize			
Before experiment	0.962 ± 0.01	0.089 ± 0.011	0.174 ± 0.012
After experiment	0.907 ± 0.03	0.078 ± 0.013	0.166 ± 0.02

The total C, N and P concentrations in soil under conventional tillage system depended on crop rotation (Table 2). The existing of summer fallow in the rotation has an adverse effect on soil fertility due to the lack of residue inputs. In salt affected arid soil, the cotton-wheat-fallow rotation together with intensive soil tillage, including mouldboard ploughing, are widespread agricultural management practices. These practices and limited biomass production have led to decrease soil carbon contents. Lower concentration of organic matter, N and P content under cotton-wheat-fallow and cotton-wheat-maize rotation can depend on the reduced microbial activity consequently the reduced C input to soil. According Schimmel and Bennett (2004) N mineralization by soil microbes is the key event in the N cycle making mineral N bio-available, whereas plants only uptake mineral N. Changes in N dynamics in soils are closely connected with altering in microbial activities involved in N cycle by biotic and abiotic factors (Egamberdieva, 2008; 2011). It has been reported that tillage practices, cover crops and application of manure have a substantial effect on the soil organic matter, but also on microbial activities under stressed condition (Rietz and Haynes, 2003; Egamberdieva and Wirth, 2011). We have observed that soil nutrients were increased under cotton-wheat-soybean rotation. It is most probably related to greater release of exudates and availability of C substrates, due to legumes extensive rooting system (Jabborova, et al. 2013b), and the availability of mineral nutrients in soil which are of considerable importance to increasing microbial populations (Bais, et al. 2006). Soybean had a versatile capacity to produce greater root exudates and enrich the soil with nitrogen through nitrogen-fixing activities (Buckley and Schmidt, 2001; Egamberdiyeva, et al. 2004).

A higher C, N and P content was observed under various crop rotation systems with reduced tillage practice (Table 3).

Table 3. Soil chemical analysis under conservation tillage system.

Crop rotation	Ct	Nt	Pt
Cotton-wheat-fallow			
Before experiment	0.967 ± 0.011	0.081 ± 0.02	0.173 ± 0.02
After experiment	1.006 ± 0.009	0.091 ± 0.01	0.172 ± 0.008
Cotton-wheat-soybean			
Before experiment	0.988 ± 0.02	0.088 ± 0.01	0.174 ± 0.02
After experiment	1.208 ± 0.03	0.101 ± 0.012	0.182 ± 0.03
Cotton-wheat-maize			
Before experiment	0.974 ± 0.009	0.087 ± 0.02	0.177 ± 0.03
After experiment	0.913 ± 0.012	0.083 ± 0.014	0.180 ± 0.018

Several authors reported that conservation tillage allows crop residues to remain on the soil surface thus minimizing soil disturbance (Bucher and Lanyon, 2005; Al-Kaisi, et al. 2005). Davranova et al. (2013) observed increased microbial activity in soil under conservation tillage practice which are involved in soil C and N cycle. The studied soil is characterized by a low soil organic matter content and a weak soil structure and the use of RT and the proper crop rotation system may lead to an increase in soil fertility and crop productivity in these agroecosystems.

Based on our results, we concluded that the lowest crop productivity was revealed in the case of the cotton-wheat-fallow rotation under CT. The highest crop productivity was revealed at the cotton-wheat-soybean crop rotation system with RT. Inclusion of soybean in cotton-wheat crop rotation resulted in increased soil nutrients such as C, N and P compared to CT based rotation.

ACKNOWLEDGEMENTS

This research was supported by the project of Scientific Centre of Agricultural Production of Uzbekistan.

REFERENCES

Al-Kaisi, M.M., Yin, X. and Licht, M.A. 2005. Soil carbon and nitrogen changes as affected by tillage system and crop biomass in a cornsoybean rotation. *Applied Soil Ecology* 30:174–191.

Aziz, I., Mahmood, T. and Islam, R.K. 2013. Effect of long term no-till and conventional tillage practices on soil quality. *J Soil & Tillage Research,* 131(30): 28–35.

Bais H.P., Weir, T.L., Perry L.G., Gilroy, S. and Vivanco, J.M. 2006. The role of root exudates in rhizosphere interactions with plants and other organisms. *Annual Review Plant Biology* 57:233–66.

Buckley, D.H. and Schmidt, T.M. 2001. The structure of microbial communities in soil and the lasting impact of cultivation. *Microbial Ecology* 42: 11-21.

Bucher, A.E. and Lanyon, L.E. 2005. Evaluating soil management with microbial community-level physiological profiles. *Applied Soil Ecology* 29:59–71.

Cantero-Martinez, C.P., Angas and Lampurlanes, J. 2003. Growth, yield and water productivity of barley (*Hordeum vulgare* L.) affected by tillage and N fertilization in Mediterranean semiarid, rainfed conditions of Spain. *J Field Crop Res* 84: 341–357.

Davranova, N., Egamberdieva, D., Ismatov, Z. and Wirth, S. 2013. Impact of crop management practice on soil microbial populations in a semi arid soil of Uzbekistan. *J Soil-Water* 2(2(1)): 921-927.

Deng, L., Chen, M., Liu, Z., Shen, Q., Wang, H. and Wang, J. 2003. Effects of different ground covers on soil physical properties and crop growth on saline-alkaline soil. *Chinese J Soil Sci* 34(2): 93-97.

Derpsch, R. and Friedrich, T. 2009. Global overview of conservation agriculture no-till adoption. In: Proceeding book of the 4th World Congress on Conservation Agriculture, New Delhi, India, 4-7 February.

DIN-ISO 10694, 1996. Bodenbeschaffenheit - Bestimmung von organischem Kohlenstoff und Gesamtkohlenstoff nach trockener Verbrennung (Elementaranalyse). Beuth, Berlin Wien Zürich.

DIN ISO 15178, 2001. Bodenbeschaffenheit - Bestimmung des Gesamt-Schwefels durch trockene Verbrennung (Elementaranalyse). Beuth, Berlin Wien Zürich.

DIN ISO 38414-S, 1983. Deutsche Einheitsverfahren zur Wasser, Abwasser und Schlammuntersuchung: Schlamm und Sdediment. Beuth, Berlin Wien Zürich.

Egamberdieva, D., Shurigin, V., Gopalakrishnan, S., Sharma, R. 2014. Growth and symbiotic performance of chickpea *(Cicer arietinum*) cultivars under saline soil conditions. *Journal of Biological and Chemical Research* 31(1):333-341

Egamberdieva, D. and Jabborova, D. 2013. Improvement of cotton production in arid saline soils by beneficial microbes. In: Lijuan Huang and Qiao Zhao (eds), Crop yields: production, management practices and impact of climate change, Nova Publishers USA, 109-122.

Egamberdieva, D. 2011. Role of microorganisms in nitrogen cycling in soils. In: Soil Nutrients, Nova Science Publishers, Inc., USA, 159-176

Egamberdieva, D. and Wirth, S. 2011. Impact of crop cultivation and tillage on microbial activity in saline arid soil. In: Miransari M (ed), Soil tillage and microbial activities, Research Signpost Publisher, India, 85-99

Egamberdieva, D. 2008. Soil microbial population and activities in salinated serozem soil. 2008. Uzbekistan Publishing House, "Patent Press", Tashkent, Uzbekistan, 141 pp.

Egamberdiyeva, D., Gafurova, L. and Islam, K.R. 2007. Salinity effects on irrigated soil chemical and biological properties in the Syr-Darya basin of Uzbekistan. In: Lal R, Sulaimonov M, Stewart BA, Hansen D, Doraiswamy P (eds) Climate change and terrestrial C sequestration in Central Asia. Taylor and Francis, New York, pp. 147–162.

Egamberdiev, O. 2007. Dynamics of irrigated alluvial meadow soil properties under the influence of resource saving and soil protective technologies in the Khorezm region. Dissertation, National University of Uzbekistan.

Egamberdiyeva, D. and Hoflich, G. 2005. Increase in forage maize production by bacterial fertilizers. In: O' Mara FP, Wilkins RJ, Mannetje L, Lovett DK, Rogers PAM, Boland TM (eds), offered papers of XX International Grassland Congress, 734

Egamberdiyeva, D., Qarshieva, D. and Davranov, K. 2004. Growth and yield of soybean inoculated with *Bradyrhizobium* spp in calcareous soil. *Biology and Fertility of Soils* 4: 144-146

Egamberdiyeva, D., Mamiev, M. and Poberejskaya, S. 2001. The influence of mineral fertilizer combined with a nitrification inhibitor on microbial populations and activities in calcareous Uzbekistanian soil under cotton cultivation. *The Scientific World Journal* 1(S2):108-113

Govaerts, B., Sayre, K.D. and Deckers, J. 2005. Stable high yields with zero tillage and permanent bed planting. *J Field Crop Res* 94: 33–42.

Hassan, I., Hussain, Z. and Akbar, G. 2005. Effect of permanent raised beds on water productivity for irrigated maize–wheat cropping system. In: Roth CH, Fischer RA and Meisner CA (eds.) Evaluation and performance of permanent raised bed cropping systems in Asia, Australia and Mexico. ACIAR Proceeding No. 121.

Hegde, D.M., Babu, S.N., Sudhakara, Q. and Aziz, A. 2007. Enhancing nutrient-use efficiency in crop production - a review. *Indian Journal of Agronomy* 52 (4): 261-274.

Islam, K.R. 2011. Continuous no-till impacts on soil biophysical carbon sequestration. Soil *Science Society of America Journal* 09:75.

Jabborova, D., Egambertdieva, D., Davranov, K. and Jabborov, M. 2013a. Restoration of growth of soybean under saline conditions due to inoculation with *Bradyrhizobium japonicum* and *Pseudomonas putida. Uzbek Biological Journal* 5:23-26

Jabborova, D., Qodirova, D. and Egamberdieva, D. 2013b. Improvement of seedling establishment of soybean using IAA and IAA producing bacteria under saline conditions. *Soil and Water Journal* 2(2):531-539

Kulmatov, R. 2014. Problems of sustainable use and management of water and land resources in uzbekistan. J *Water Resource and Protection* 6:35-42.

Luo, Z., Wang, E. and Sun, O.J. 2010. Can no-tillage stimulate carbon sequestration in agricultural soils? A meta-analysis of paired experiments. Agric Ecosyst Environ 139:224–231.

Magdoff, F. and Weil, R.R. 2004. Soil organic matter in sustainable agriculture. CRC Press, Boca Raton.

Qushimov, B., Ganiev, I.M., Rustamova, I., Haitov, B. and Islam, K.R. 2007. Land degradation by agricultural activities in Central Asia. In: R. Lal, M. Suleymenov, B. A. Ste- wart, D. O. Hansen and P. Doraiswamy, Eds., Climate Change and terrestrial carbon sequestration in Central Asia, Taylor & Francis, London. 137-147.

Rietz, D.N. and Haynes, R.J. 2003. Effects of irrigation-induced salinity and sodicity on soil microbial activity. *Soil Biology and Biochemistry* 35:845-854.

Schimmel, J. and Bennett, J. 2004. Nitrogen mineralization: challenges of a changing paradigm. *Ecology* 85:591-602.

Sayre, K. and Hobbs, P. 2004. The raised-bed system of cultivation for irrigated production conditions. In: Lal R, Hobbs P, Uphoff N, Hansen DO (eds) Sustainable agriculture and the Rice-Wheat system. Ohio State University, Columbia, Ohio, USA. pp. 337-355.

Tursonov, M. 2009. Potential of conservation agriculture for irrigated cotton and winter wheat production in Khorezm, Aral Sea Basin. Dissertation, ZEF/Rheinische Friedrich-Wilhelms-Universität Bonn.

Van Diepeningen, A.D., de Vos, O.J., Korthals, G.W. and Van Bruggen, A.H.C. 2006. Effects of organic versus conventional management on chemical and biological parameters in agricultural soils. *Applied Soil Ecology* 31: 120-135.

Wang, X. 2006. Conservation tillage and nutrient management in dryland farming in China. Dissertation, Wageningen University.

Wang, X.B., Cai, D.X., Hoogmoed, W.B., Oenema, O. and Perdok, U.D. 2007. Developments in conservation tillage in rainfed regions of North China. *Soil Till Res* 93: 239–250.

WRB-FAO, 2006. World reference base for soil resources. World Soil Resources Reports No. 103. Rome.

Graham, P.H. and Vance, C.P. 2000. Nitrogen Fixation in Perspective: on Overview of Research and Extension Needs. *Field Crops Research* 65: 93–106.

Corresponding author: Dr. Botir Khaitov, Tashkent State Agrarian University, Department of Plant Science, 100140, Str. University 1, Tashkent, Uzbekistan.
Email: bhaitov@yahoo.com