American-Eurasian J. Agric. & Environ. Sci., 15 (5): 863-867, 2015
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2015.15.5.12651

The Role of Innovative Gradek Beads in Water Evaporation and Retention and in Supporting Plant Growth

[1]N. Ameiri, [2]S. Masoud, [3]N.I. Alkhalaileh, [4]A. Ismail, [5]T. Gradek and [3]S. Herzallah

[1]Department of Plant Protection, Mu'tah University, Karak, Jordan
[2]Department of Biotechnology and Genetic Engineering, Philadelphia University, Amman, Jordan
[3]Mu'tah University, Faculty of Agriculture, Department of Nutrition and Food Technology, Karak, Jordan
[4]McGill University, Department of Food Science, Sainte Anne de Bellevue, QC, H9X 3V9, Canada
[5]Gradek Energy Inc., 162 Brunswick Blvd, Point-Claire, QC, H9R 5P9, Canada

Abstract: An experiment was conducted to evaluate the role of the innovative Gradek beads in protecting, regulating and saving plant irrigation water when used as a bed between 1 to 10 cm depth in a sandy soil. The plant growth and water retention were evaluated through vegetative plant growth including plant height and, dry and fresh weight and moisture contents of soil after irrigation within different time periods (0-72 hr). The experiment involved planting two types of plants (tomato and cucumber) for 5 weeks. Innovative Gradek beads caused retention of about 50% water and about 30% after 24 and 72 hour of irrigation, respectively. The vegetative plant part was also improved when using beads, the height of the plant increased by >20% and the root length decreased by about 30%. The beads also, reduced the evaporation of water by > 50 as well as preventing the growth of molds in a water storage container.

Key words: Irrigation · Innovative Gradek beads · Water retention · Vegetative plant growth

INTRODUCTION

Hot climate and soil characteristics such as sandy soil and water evapotranspiration and the variability of rainfall coupled with water distribution in different soils have a large effect on soil moisture content and on plant growth as well [1, 2, 3]. In such environments, water retention and availability of soil water for plant growth along with the growing season determined the amount of water catchment or water release from soil which is considered a key factor in planting of crops during growing seasons. Water retention by soil depends on soil properties, regional climate, biota and area topography and can be controlled by vegetation, water holding materials and soil depth [4, 5, 6, 7]. Middle Eastern and Arabian Gulf countries are arid and semiarid and face shortages of drinking water and water for agricultural purposes. There is little influence of topography on water retention in arid and semi-arid environment [8, 9, 10]. These countries depend totally on groundwater, dams and water desalination plants as the major water supply sources. Also, the increase in demands for drinking water and agricultural uses requires the use of effective methods of water retention and management, particularly in sandy soils. Under such conditions, these countries are seeking environmentally sound processes for water management and use for agricultural, landscaping and planting of green trees [11, 12, 13].

Therefore, the objectives of the present project were to evaluate the role of using the Innovative Gradek beads (IGB) in water management in both agriculture, to evaluate the effect of using IGB on plant growth parameters such as plant growth performance including plant height, dry and fresh plant weight, to evaluate the effects of irrigation process using IGB as a soil bed on tomato and cucumber plants growth and to evaluate the effect of beads bottom and top layer on reducing the water drainage and evaporation process.

MATERIALS AND METHODS

The experiments were conducted in a greenhouse at Mutah University between April and May, 2013. Tomato and cucumber seedlings were planted in plastic pots having a top diameter of 20 cm and the depth of

Corresponding Author: S. Herzallah, Mu'tah University, Faculty of Agriculture,
Department of Nutrition and Food Technology, Karak, Jordan. E-mail: saqermay30@yahoo.com.

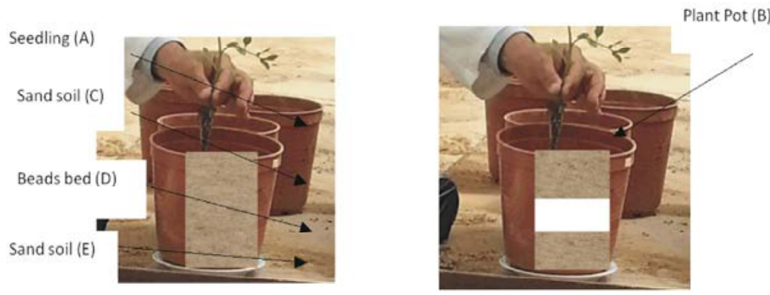

Fig. 1: Seedlings planted in (A) plastic Pot (B) containing sand soil(C), beads (D) and sand layer (E)

Fig. 2: Beads bed at 10 cm depth

20 cm. The diameters of the plastic pots at the depth of 3, 6, 10 and 13 cm from the top were 18.5, 17.0, 16.0 and 15.0 cm, respectively. A layer of IGB was placed at either 10 or 15 cm depth for both cucumber and tomato seedlings (Figs. 1 and 2). The controls were planted in sand without adding any IGB. The plants were irrigated with 500 ml of water every 3 days. The moisture content of the soil and growth parameters were monitored, measured and evaluated for the control and treatments through measuring plant height during the experiment while dry and fresh weight were measured at the end of the experiment period of 5 weeks. Soil moisture content was measured during and at the end of the experiment using AJ-Moisture meter (Detta-T device, Cambridge, England) with Theta-Probe type ML2X.

Statistical Analysis: Results obtained were evaluated using completely randomized design (CRBD) with three replications using least significant difference (LSD) for comparing differences in water retention among the different treatment groups.

RESULTS AND DISCUSSION

The data obtained from determining water retention (WR) and plant characteristics of the current study are presented in Tables 1-4. It can be noted from Tables 1 and 2 that WR was highly affected by the placement of beads bed at either 10 or 13 cm depth in soil compared to control treatments for both tomato and cucumber plants. WR was highly affected with the depth of beads bed as shown in Table 2 that varies with different points. The results of this data show that in the presence of beads as a bed at different levels of the sandy soils support effectively the growth and WR all over the growth period of tomato and cucumber plants. This may also cause positive effect in soil aeration and protection against any infestation and pathogen infection of plant diseases. Practically, the soil treatment with beads as WR support materials exhibit saving large amounts of water that are usually lost as a result of hot climate conditions. The results of WR were in agreement with those obtained by Maghchiche *et al.* [14] that using polymers and cellulosic materials increases water retention against water evaporation and with those obtained by and Nnadi and Brave [15] who found that using a cellulosic complex blend suitable for water retention performance in radish irrigation. The relationships between water, moisture content and time of irrigation were positive with greater than 30% water saving compared with control treatment. For example, the moisture content of sandy soil after irrigation with 500 ml water and measured after 12 hours were 19.4% compared to 15.8% moisture of the control that means WR of > 18% and 50% after 24 hour from irrigation time (Table 1).

Moisture content of soil of the treatment TB1 48 hours after irrigation was 70% greater than control treatment (Table 2). This could be explained by the presence of a bed of beads at either 10 to13 cm depth that retains water above the level of the bed of beads. Additionally, the layer of beads avoids the loss of water by more than 40%.

Table 1: Effect of Gradek beads on water retention of sandy soil

	Soil Moisture Content (SMC)² % v/v									
Treatment¹	SMC_0	SMCAI_0	SMCAI_6	SMCAI_12	SMCAI_24	SMCAI_48	SMCAI_72	SMCAI_96	HTS (cm)	HTE (cm)
TB1	2.7±0.17	25.3±1.47	23.1±6.05	19.4±1.2	18.3±2.93	13.9±1.61	9.1±3.03	6.7±1.22	17.5±0.76	39.3±2.3
TB2	3.0±0.57	24.33±2.31	21.2±5.31	20.2±6.3	19.7±1.08	13.1±0.81	10.1±2.07	5.3±0.69	15.7±2.37	36.3±1.3
TC	3.1±0.10	22.9±0.30	18.8±0.75	15.8±0.7	12.1±0.16	10.3±0.50	6.9±0.21	3.2±0.11	15.8±0.05	32.01±1.1
CB1	2.9±0.05	25.3±2.30	23.4±2.10	21.5±1.5	13.2±3.10	13.5±0.05	10.1±0.55	6.4±0.15	16.5±0.40	39.1±2.1
CB2	3.6±0.1	26.1±0.51	20.3±1.05	20.0±0.5	11.1±0.50	10.2±0.61	10.5±0.52	7.8±0.55	19.2±0.50	42.5±1.5
CC	4.1±0.11	23.5±0.51	18.2±0.7	17.5±0.7	9.8±1.10	8.2±1.12	5.4±1.50	3.6±0.22	15.5±1.31	30.6±2.4

[1]TB1:Tomato plant with beads at 10 cm depth; TB2: Tomato plant with beads placed at 15 cm depth; TC: Tomato plant without beads as a control treatment; CB1: cucumber plant with beads at 10 cm depth; CB2: cucumber plant with beads placed at 15 cm depth; CC: cucumber control treatment without beads.[2]SMC-0: soil moisture content at zero time; SMCAI-0: soil moisture content after irrigation at zero time; SMCAI-6: soil moisture content after 12 hour of irrigation; SMCAI-24: soil moisture content after 24 hour of irrigation; SMCAI-48: soil moisture content after 48 hour of irrigation; SMCAI-72: soil moisture content after 72 hour of irrigation; SMCAI-96: soil moisture content after 96 hour of irrigation; HTS: plant height in cm at planting time; and HTE: plant height in cm after four weeks.

Table 2: Water retention of sandy soils measured at two levels below and above Gradek Beads layers after 48hr of irrigation

	Moisture content (% v/v)²	
Treatment¹	6 cm	15cm
TC_48	8.3±0.8	12.13±0.3
TB1-48	14.1±1.3	6.60±0.1
TB2-48	18.4±1.5	11.03±0.1
CC-48	7.4±0.8	12.90±0.2
CB1-24	10.3±1.1	8.01±2.0
CB2-0	25.2±4.0	14.61±3.0

[1]TC-48: Tomato control soil moisture content after 48 hour of irrigation; TB-48: Tomato soil moisture content with beads measured after irrigation at zero tim48 hour of irrigation; TB2-48: Tomato soil moisture content with beads placed at 13 cm depth; CC-48: Cucumber soil moisture content with beads without beads; CB1-24: cucumber soil moisture content with beads placed at 10 cm after 24 hour of irrigation; CB2-0: cucumber soil moisture content with beads placed at 10 cm measured after 1hour of irrigation. Values are means of three replicates ± SD of soil moisture content measured at 6 or14 cm

Table 3: Effect of using Gradek beads on water retention and on the growth of tomato and cucumber plants

Treatment¹	Root weight (g)	Root length (cm)	Shoot fresh weight (g)	Shoot plant height (cm)
TC	9.1±4.3	18.3±0.7	22.1±2.7	31.3±0.7
TB1	12.6±1.7	12.3±4.5	29.5±1.9	40.3±2.3
TB2	9.3±3.1	14.3±4.6	32.9±7.3	39.3±12.6
CC	3.6±1.2	16.7±0.6	25.3±5.1	36.1±4.6
CB1	3.4±1.1	11.2±0.7	34.2±1.1	41.0±1.0
CB2	3.7±2.3	10.4±0.5	30.3±1.0	42.33±2.1

[1]TC: Tomato plant grown in soil without beads and used as a control treatment; TB1: Tomato plant grown in soil with beads placed at 10 cm depth; TB2: Tomato plant grown in soil with beads placed at depth of 15 cm; CC: cucumber plant grown without beads and used as a control treatment; CB1: cucumber plant grown in soil with beads placed at depth of 10 cm; and CB: cucumber plant grown in soil with beads placed at 15 cm depth.

Table 4: Effect of using Gradek beads on water retention and on the dry weight of roots and shoots of tomato and cucumber plants.

Treatment¹	Root Dry weight (g)	Shoot dry weight (g)
TC	1.35±0.24	1.12±0.08
TB1	0.60±0.21	3.61±0.51
TB2	1.18±0.06	4.21±0.36
CC	0.26±0.03	1.72±0.14
CB1	0.12±0.1	1.74±0.18
CB2	0.32±0.1	2.28±0.26

[1]TC: Tomato plant grown in soil without beads and used as a control treatment; TB1: Tomato plant grown in soil with beads placed at 10 cm depth; TB2: Tomato plant grown in soil with beads placed at depth of 15 cm; CC: cucumber plant grown without beads and used as a control treatment; CB1: cucumber plant grown in soil with beads placed at depth of 10 cm; and CB2: cucumber plant grown in soil with beads placed at 15 cm depth.

Fig. 3: Effect of beads on water evaporation

greater than 40%. The growth parameters of root or shoot length and weight (gm), showed that using the bed of beads improved the plant height and reduced root weight and length when compared with control treatments. The root length and shoot plant height of treatment TB1 were 12.3 cm and 40.3 cm compared to control group of 18.3 cm and 31.3 cm, respectively, for plant root and shoot (Table 3). This could be explained as the availability of water for plant growth near the root of the plant support plant growth and thus as expected increase the production without the need for high root growth. Dry weight was also affected by the presence of the beads bed (Table 4). For example, the dried weight of plant root was found 1.35 gm for the control and 1.12 for the shoot, while the root weight of TB1 was 0.6 gm and 3.6 gm of the plant shoot.

Water evaporation was tested and found that greater than 60% of water was saved from evaporation compared to controlled treatment without using beads (Fig. 3). Such an experiment implicates that the saved water in the pots of the pervious experiments is mainly due to the decrease water evaporation in the pots containing the beads.

CONCLUSIONS

Innovative Gradek Beads (IGB) improve water retention and reduced water evaporation which means that water goes through growing pot without beads was faster than pot with beads. Water evaporation reduced thus water saved for agricultural purposes compared with those without beads. Two layer beads suggested improving better water retention than one layer of 1 to 2 cm bed thickness. Moreover, the growing of plants in an open area with beads bed will improve the growth of the plant better than growing in controlled plant Pot.

ACKNOWLEDGMENTS

The researchers would like to acknowledge the support and/or participation of Mu'tah University/ Faculty of Agriculture/ Jordan, Gradek Energy Inc/ Canada and McGill University/Department of Food Science/ Canada

REFERENCES

1. Famiglietti, J.S., D. Ryu, A.A. Berg, M. Rodell and T.J. Jackson, 2008. Field observations of soil moisture variability across scales. Water Resources Research 44:W01423,DOI:10.1029/2006WR005804.
2. Madden, N.M., R.J. Southard and J.P. Mitchell, 2009. Soil water content and soil disaggregation by disking affects PM10 emissions. Journal of Environmental Quality, 38: 36-43.
3. Rashidi, M. and F. Keshavarzpour, 2008. Effect of different tillage methods on soil physical properties and crop yield of melon (Cucumismelo). American-Eurasian J. Agric. and Environ. Sci., 3: 31-36.
4. Broxton, P.D., P.A. Troch and S.W. Lyon, 2009. On the role of aspect to quantify water transit times in small mountainous catchments. Water Resources Research, 45: WO8427, DOI:10.1029/ 2008WR007438.
5. Gilleret, K.E., E. Witter, M. Corbeel and P. Tittonel, 2009. Conservation agriculture and small holder farming in Africa: The heretic's view. Field Crops Res., 114(1): 23-34.
6. Madsen, M.D., D.G. Chandler and J. Belnap, 2008. Spatial gradients in ecohydrologic properties within a Pinyon-Juniper ecosystem. Ecohydrology 1: 349-360, DOI: 10.1002/eco.29.
7. Tesfa, T.K., D.G. Tarboton, D.G. Chandler and J.P. McNamara, 2009. Modeling soil depth from topographic and land cover attributes. Water Resources Research 45: W10438, DOI: 10.1029/2008WR007474.
8. McNamara, J.P., D.G. Chandler, M. Seyfried and S. Achet, 2005. Soil moisture states, lateral flow and stream flow generation in a semi-arid, snow melt driven catchment. Hydrological Processes, 19(20): 4023-4038.
9. Shrestha, R.B. and C. Gopalakrishnan, 1993. Adoption and diffusion of drip irrigation technology-an econometric-analysis. Economic Development and Cultural Change, 41(2): 407-418.

10. Williams, C.J., J.P. McNamara and D.G. Chandler, 2009. Controls on the temporal and spatial variability of soil moisture in a mountainous landscape: the signature of snow and complex terrain. Hydrology and Earth System Sciences, 13(7): 1325-1336.
11. Abu-Sharar, T.M., I.A. Hussein and O.R. Al-Jayyousi, 2003. The use of treated sewage for irrigation in Jordan: opportunities and constraints. Journal of the Chartered Institution of Water and Environmental Management, 17(4): 232-238.
12. Al-Assaf, A., A.Z. Salman, F. M. Fisher and E. Al-Karablieh, 2007. A trade-off analysis for the use of different water sources for irrigation (the case of Southern Shounah in the Jordan Valley). Water International, 32(2): 244-253.
13. Rabotyagov, S.S., M.K. Jha and T. Campbell, 2010. Impact of crop rotations on optimal selection of conservation practices for water quality protection. Journal of Soil and Water Conservation, 65(6): 369-380. doi:10.2489/jswc.65.6.369.
14. Maghchichi, A., A. Haouam and B. Immirzi, 2010. Use of polymers for water retaining and soil stabilization in arid and semiarid region. Journal of Taibah University for Science, 7: 9-16, DOI: 10.1016/S1658-3655(12)60022-3.
15. Nnadi, F. and C. Brave, 2011. Environmentally friendly superabsorbent for water conservation in agricultural lands. Journal of Soil Science and Environmental Management, 2(7): 206-211.