Effects of Irrigation Frequency and Water Cut-off in Drip Tape Irrigation on Yield and Water Use Efficiency in Potato Cultivars

EFFETS DE LA FREQUENCE D'IRRIGATION ET D'EAU COUPEE EN GOUTTE-TAPE IRRIGATION SUR LE RENDEMENT ET L'EFFICACITE D'UTILISATION DE L'EAU DANS LES CULTIVARS DE POMME DE TERRE

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ABSTRACT

Increasing demands for water and heightened awareness of the role of irrigated agriculture in water quantity and quality protection mandate improved irrigation water and nutrient management. This is particularly true for a high-value, water-sensitive crop like potato that requires large nitrogen fertilizer inputs. The objective of this paper are to evaluate the impacts of irrigation frequency and irrigation cutoff on yield and water use efficiency (WUE) of potato cultivars, using drip-tape irrigation system. This study was conducted during 2006-2008 years in Razavi Khorasan Agricultural and Natural Resources Research Center (Iran). Experimental design was randomized complete blocks design (RCBD) in split split plot with three replications. Design treatments were include irrigation frequency (2, 4, and 6 day) in main plot, irrigation cutoff (full irrigation, irrigation cut-off only in initial growth stage) in sub plot and potato cultivars (Almera, Agria, Sante and Sinora) in sub-sub plot. Results showed that irrigation frequency and irrigation cut-off had no significant effect on yield and WUE. The effect of cultivar on yield and WUE was significant. Among cultivars, the most yield and WUE was belonged to Agria. Three other cultivars (Almera, Sante and Sinora) were in second level, thouth the yield of Almera was a little more that Sante and Sinora. In general regarding to treatments and its interaction effects on yield and WUE, it was concluded that the highest and the least yield and WUE were belonged to drip irrigation with 2 day irrigation frequency and without cut-off in Agria cultivar and drip irrigation with 6 day irrigation frequency and with water cut-off in Sinora cultivar, respectively.

Keywords: Potato, Irrigation frequency, irrigation cutoff, Drip tape irrigation, Water use efficiency.

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1. Introduction

Increasing demands for water and heightened awareness of the role of irrigated agriculture in water quantity and quality protection mandate improved irrigation water and nutrient management. This is particularly true for a high-value, water-sensitive crop like potato that erquires large nitrogen fertilizer inputs. Because of a shallow root zone, potato is irrigated frequently, increasing the potential for over irrigation and nitrate leaching to groundwater.

Potato is the fourth most important food crop in the world after wheat, maize and rice with 311 million tons which produced from 19 million hectares. Proper irrigation method and correct water management on potatoes is important for both yield and quality. Because both over and under-irrigation can cause problems for a potato, irrigation water application should be matched to crop water use. Water use for potatoes starts low, at about 0.05 to 0.1 inch per day from planting until crop emergence. This water use accure due to bare-surface soil evaporation. After the crop emerges, water use increases over about a one-month period to the peak use of 0.3 to 0.35 inches per day.

Drip irrigation has the potentail to reduce both nitrogen and water inputs and greatly reduce nitrogen losses to groundwater since water and fretilizer can be plaeced directly in the crop root zone. Because water and nutrients can be supplied as needed, crop stress can be reduce, water saving obtained, crop quantity and quality improved and water use efficiency increased. Recently, drip irrigation system has been successfully used in Iran for many row crops such as corn, cotton, sorghum, tomato, potato and etc. However, potato production through drip irrigation can also improved nitrogen and phosphorus utilization by the plants due to placement in near the plant active root zone.

Irrigation frequency is one of the most important factors in drip irrigation scheduling. Due to the differences in soil texture, soil moisture holding capacity and wetting pattern, crop yields may be different when the same quantity of water is applied under different irrigation frequencies. Typically, the higher irrigation frequency the smaller the wetted soil volume and the higher mean soil water content can be maintained in the wetted soil volume during a period when the total irrigation water is equal. High irrigation frequency might provide desirable conditions for water movement in soil and for uptake by roots (Segal et al., 2000). Several experiments have shown positive responses in some crops to high frequency drip irrigation (Segal et al., 2000; Sharmasarkar et al., 2001). However, seeming inconsistencies as to what frequency might be optimum can also be found in the literature. Dalvi et al. (1999), found that the maximum yield was obtained at every second day frequency. Pitts et al. (1991), found that two drip irrigation frequencies (three times per day, one time per day) had no effect on tomato yield. Meshkat et al. (2000), went one-step farther by pointing out that an irrigation regime with excessively high moisture frequency could cause the soil surface to remain wet with first stage evaporation persisting most of the time resulting in a maximum rate of water loss. Evidences indicate that root systems under partial soil wetting are dominated by wetting patterns under the drippers (Clothier and Green, 1994; Coelho and Or, 1996). These limited root systems might not affect crop growth, however, when the main nutrients are applied through irrigation system.

Generally in Iran there are tow cultivation such as winter wheat and spring potato during spring season at the same time. Due to water shortage at this time, farmers have difficulty for irrigation practices (intervals) of two mentioned crops in the same time. Therefore in spring, if farmers can eliminate one irrigation turn interval from the first stage of potato grow period without significant reduction on the yield; they can irrigate the last turn interval of wheat. So, the main purposes of this study were to determine the effects of irrigation frequency and water cut off on yield and water use efficiency in potato cultivars in Iran soil and weather condition.

2. Material and methods

This research was conducted in Razavi Khorasan Agricultural and Natural Resources Research Centre in Iran. The study was done during 2006-2007 years. Experimental design was randomized complete blocks design (RCBD) in split-split plot with three replications. Design treatments were three irrigation frequency (2, 4, and 6 day) as main plot, tow irrigation cut-off (full irrigation, irrigation cut-off in initial growth stage) in sub plot and four potato cultivars (Almera, Agria, Sante, and Sinora) in sub-sub plot.
The soil texture was silty loam and loam in 0-40 and 40-80 cm depth, respectively. Water quality was tested and its results are shown in Table 1. Soil physical characteristics of the experimental site were determined by creating a profile in the soil up to 80 cm depth. The soil conditions in four layers from 0-20, 20-40, 40-60, and 60-80 cm were determined. These results are given also in Table 2.
Three planting lines with 10 meters long were considered for each treatment. The distance between rows were 1.5 m and between plants on rows were 25 cm. Potassium and phosphorus fertilizer requirements and one-third of required nitrogen was given based on soil test before planting. Residual nitrogen fertilizer was used as fertigation with irrigation system during the growing season. All practices during the season including pest, diseases and weeds control were alike for all treatments. Drip-tape irrigation method was used for irrigation of potato. In this method, the drippers' distances were 40 cm and the discharge of drippers was 4 liters per hour per meter. However, the thickness of tape tube was 300 microns. Yield of potato, water consumption and water use efficiency of each treatment were determined. Data were analyzed statistically using the MSTAT-C software. However, treatments mean comparison was performed using Duncan's Multiple Range tests.

Table 1. Test results of irrigation water quality
Les résultats des tests de qualité de l'eau d'irrigation

EC (dS/m)	PH	Soluble captions (meq/lit)				Soluble anions (meq/lit)			SAR
		Na^{+}	Mg^{++}	Ca^{++}	K^{+}	CL^{-}	So_4^{--}	Co_3^{--}	
0.8	7.8	3	2.4	2.4	-	-	1.8	2.35	1.93

Table 2. Soil physical properties of the test site
Propriétés physiques du sol du site d'essai

Soil depth (cm)	Particle size Distribution (%)			Texture	Bulk density (g/cm^3)	Soil Moisture (%)		
	Sand	Silt	Clay			FC	PWP	AW
0-20	28	58	14	SL	1.41	27.99	12.20	15.79
20-40	24	54	22	SL	1.51	29.9	12.70	17.20
40-60	26	50	24	L	1.45	26.92	13.30	13.62
60-40	36	46	18	L	1.42	23.71	9.80	13.91

3. Results and discussion

Analysis of variance showed that irrigation frequency and irrigation cut-off had no significant effect on yield and water use efficiency (WUE) in potato cultivation. The effect of cultivar on yield and WUE was significant. Among cultivars, the most yield and WUE was belonged to Agria and three other cultivars (Almera, Sante and Sinora)

were in second level, though the yield of Almera was a little more that Sante and Sinora. Totally it was concluded that regarding the comply effects of treatment on yield and water use efficiency, the most and the least yield and WUE were treatment two day irrigation frequency without cut-off in Agria cultivar and treatment six day irrigation frequency with cut-off in Sinora cultivar, respectively.

Yield in two, four and six days irrigation frequency was 35.197, 33.504 and 33.264 ton/ha, respectively (Table 3). However, the highest WUE (4.278 kg/m^3) was in tow day irrigation frequency, followed by four and six days (with 3.997 and 3.430 kg/m^3), respectively (Table 4). According to Table 3, there was not significant difference between yield in full irrigation and irrigation cut-off that was 33.495 and 33.032 ton/ha, respectively. Water use efficiency in full irrigation and irrigation cut-off was 3.926 and 3.877 kg/m^3, respectively (Table 4). Also, the effect of cultivar on yield and WUE was significant. Yield in Almera, Agria, Sante, and Sinora cultivars were 33.184, 37.318, 32.650, and 32.796 ton/ha, respectively (Table 3). However, water use efficiency also in Almera, Agria, Sante, and Sinora cultivars were 3.700, 5.693, 3.211 and 3.003 kg/m^3, respectively (Table 4).

Table 3. Mean yield comparison of potato in different treatments.
Comparaison de la moyenne de rendement de la pomme de terre dans différents traitements.

Treatment	Yield (ton/ha)
Irrigation frequency (day):	
2	35.197 a
4	33.504 a
6	33.264 a
Irrigation cutoff:	
Full irrigation	33.495a
Irrigation cutoff	33.032 a
Cultivars:	
Almera	33.184 b
Agria	37.318 a
Sante	32.650 b
Sinora	32.796 b

Table 4. Mean water use efficiency comparison of potato in different treatments.
Comparaison de la moyenne d'efficacité de l'utilisation de l'eau de pomme de terre dans les différents traitements.

Treatment	WUE (kg/m^3)
Irrigation frequency (day):	
2	4.278 a
4	3.997 a
6	3.430 a
Irrigation cutoff:	
Full irrigation	3.926 a
Irrigation cutoff	3.877 a
Cultivars:	
Almera	3.700 b
Agria	5.693 a
Sante	3.211 b
Sinora	3.003 b

4. Conclusion and Recommendations

Efficient use of irrigation practice depends on supplementing soil water and rainfall with the minimum amount of water to ensure that crop growth rates are not limited by soil water availability. In arid and semi-arid environments such as Iran where potatoes are grown on light soils, the frequency of irrigation is high, and stored soil water makes only a limited contribution to crop growth. In this experiment we found that irrigation Frequency and irrigation cut-off had no significant effect on yield and water use efficiency, but when frequency of irrigation was low, the yield was high. This was due to availability of water, low water stress, and low energy consumption for cultivated crops.

5. References

1. Clothier, B.E. and Green, S.R. 1994. Root zone processes and the efficient use of irrigation water. Agric. Water Manage. 25: 1–12.
2. Coelho, E.F. and Or, D. 1996. A parametric model for two-dimensional water uptake by corn roots under drip irrigation. Soil Sci. Am. J. 60: 1039–1049.
3. Dalvi, V.B., Tiwari, K.N., Pawade, M.N. and Phirke, P.S. 1999. Response surface analysis of tomato production under microirrigation. Agric. Water Manage. 41: 11–19.
4. Meshkat, M., Warner, R.C. and Workman, S.R. 2000. Evaporation reduction potential in an undisturbed soil irrigated with surface drip and sand tube irrigation. Trans. ASAE 43 (1): 79–86.
5. Pitts, D.J., Tsai, Y.J., Obreza, T.A. and Myhre, D.L. 1991. Flooding and drip irrigation frequency effects on tomatoes in South Florida. Trans. ASAE 34 (3): 865–870.
6. Segal, E., Ben-Gal, A. and Shani, U. 2000. Water availability and yield response to high-frequency micro-irrigation in sunflowers. In: Proceedings of the Sixth International Micro-irrigation Congress on 'Micro-irrigation Technology for Developing Agriculture', Conference Papers, 22–27 October, Capetown, South Africa.
7. Sharmasarkar, F.C., Sharmasarkar, S., Miller, S.D., Vance, G.F. and Zhang, R. 2001. Assessment of drip irrigation and flood irrigation on water and fertilizer use efficiencies for sugerbeets. Agric. Water Manage. 46: 241–251.