Effects of Water Infiltration to Soil in Increasing Yield and Water Use Efficiency in Peanut

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Abstract: An experiment was conducted to evaluate the Effects of water infiltration to soil in increasing yield and water use efficiency in peanut in Astaneh Ashrafiyeh, North of Iran. A was studied split-plot in a complete random block plan with 3 replications in the 2009 crop year. Irrigation management included no irrigation (dryland) and irrigations with 6, results of this research indicated that average final infiltration was 9.4 (cm/day) and the highest biomass, pods and seeds values for the 6 days irrigation management were 9453, 4093 and 2345 (kg/ha), respectively. The highest water use efficiency based on biomass, pods and seeds in the 6 days irrigation treatment were 2.88, 1.24 and 0.71(kg/m^3). Volumetric moisture variations in different depths indicated that the moisture content in upper soil layers such as 0-20 cm and 20-40 cm was less than those of 40-60 cm and 60-80 cm layers which was due to water absorption in the first and second layers by the plant.

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1. Introduction

Surface irrigation is one of the oldest irrigation methods in which water is distributed as an open flow throughout a field. In fact, influenced by the gravity, water flows and moisturizes the whole surface of the field or part of it (Sohrabi and Paydar, 2009). Infiltration is considered as one of the important parameters for designing irrigation systems based on which irrigation management and planning is done (Sohrabi and Behnia, 2007). At the beginning, the infiltration rate is high, but in the long-run, it gradually decreases until it reaches an approximately constant rate. Hence, the infiltration rate is of great significance in terms of irrigation because it is a determining factor for storing a certain amount of water in the soil. Final soil infiltration is the permeability which the soil shows in long durations. Moreover, during early stages, soil moisture is more effective on the infiltration rate. When air becomes stuck between the wetting front and the confining layer, its pressure increases and in turn, reduces the infiltration rate (Sohrabi and Paydar, 2009).

Peanut is a perennial shrub of the pea family and has a main straight root. It is cultivated in tropical and semi-tropical regions and is quite rich in terms of its oil quality and protein content [3]. This crop is used for its oil and also as a dry nut by human beings (2002). At the moment, drought is one of the limiting factors of the yield in plants such as peanut (Reddy *et al*, 2004). Thus, certain planning for water consumption level and how to optimize it should be done (Deming et al, 1999; Reddy *et al,* 2004). Bingru and Hongwen (2000) believe that supplying sufficient water for a plant during its growth and development and prior to the occurrence of adverse effects of water stress are very important for physiological processes inside a plant. In their study results, Li *at al.* [8] showed that under recommended complete irrigation conditions and supplementary irrigation programs, plants would have higher yields compared with those without any irrigation. Also, Lai and Katul (2000) reported that under water deficit conditions in the soil, the plant's physiological characteristics and root density at different layers are of great significance. For example, as stress occurs in surface layers, roots in lower layers are more effective and efficient in terms of water absorption. By examining eleven peanut cultivars under stress and unstressed irrigations, Songsri *et al.* (2009) concluded that drought stress results in the reduced efficiency of seeds' water consumption. Improved efficiency is usually accompanied by consuming water under limited water resources conditions and helps increase the yield. Furthermore, by studying four peanut cultivars under stressful and unstressed conditions, Vorasoot *et al.* (2003) concluded that under the latter conditions, pods had higher yield than in the former. El-Boraei *et al.* (2009) studied the effect of alternative irrigation with 1, 2 and 3 days intervals and obtained results revealed that peanuts irrigated on a daily basis had the highest yield. In their researches on peanut cultivars, Songsri *et al.* (2008) and Haro *et al.* (2008) observed that under complete irrigation conditions, the total biomass was more than in the water stress condition. The present research was done with the purpose of studying the effects of infiltration on increased yield and water consumption efficiency of peanut in Astaneh Ashrafiyeh in the north of Iran.

2. Material and Methods

This experiment was done in Astaneh Ashrafiyeh in the north of Iran situated at 37°16' and 46°56' with an average altitude of 3m [above the sea level), based on the studied split-plot in a complete random block plan with 3 replications in the 2009 crop year. Meteorological data were obtained from the respective stations in Astaneh Ashrafiyeh (Table 1). Prior to tillage, in order to determine physical and chemical properties of the soil, samples were taken from different parts of the field (Table 2). Each experimental unit was 6×2.5m in dimensions consisting of 7 rows. Irrigation management included no irrigation (dryland) and irrigations with 6, 12 and 18-days intervals. At first, the field went under a complete tillage on May 5, 2009 and followed by creating ridges and furrows, cultivation of NC_2 variety seeds started. Prior to cultivation, the seeds were disinfected in 2:1000 carboxin thiram as a fungicide (Craufurrd *et al,* 2002). Crop management operations included weeding (to control weeds) and side dressing around the root. Harvest was done on September 20, 2009. Surface irrigation method used in this research was of the ridges and furrows system type where the distance between the ridges was 80 cm with the distance between plants in each ridge being 30cm. Soil moisture content was measured using a TRIME-FM model TDR device in 0-20 cm, 20-40 cm, 40-60 cm and 60-80 cm depths based on moisture volume percentage during the growth period in different irrigation managements at 4 spots and in the center of each plot. Water level for each irrigation was determined based on soil moisture Deficit up was to 60 cm deep (effective root depth) in each plot. Then, 6, 12 and 18 days intervals irrigation managements were applied in the field.

Consumed water level during the growth period was determined through measuring the amount of irrigation water and the precipitation level. In order to measure the amount of Water for irrigation for each experimental unit, a contour was used. For 6, 12 and 18 days irrigation managements, 8, 4 and 3 irrigation frequencies were considered, respectively in which 328, 300 and 264 mm water was consumed. In order to measure the infiltration rate in the field, the Double cylinder method was used. To determine the total biomass (dry matter) at maturity, after excluding two rows on both sides in each plot, 12 plants were randomly selected. Then, pods, leaves and stems were placed in a 70°C oven for 48 hours. When dried, initially, mature pods' weight for each plant was measured by the ratio of mature pods weight to the number of mature pods per 12 plants.

To estimate seed and pod yields, after the exclusion of two rows on the sides, mature pods and seeds were weighed using an accurate laboratory scale. Calculation of efficient water consumption rate based on total biomass, seeds and pods was done through the values of the total biomass and produced weeds and pods (kg) divided by the amount of the consumed water (m^3) (Andrade *et al,* 2002). For variance analysis and the comparison of mean values (Duncan test, probability level of 5%) and in order to draw relevant diagrams, *MSTATC* and *Excel* software were used.

Table 1. Information on meteorological data

	Month			
	May	Jun	Jul	Aug
Max Temperature (°C)	27.3	41.9	29.5	28.4
Min Temperature (°C)	17.3	20	18.8	18.5
Sun Shine (h)	6.5	8.5	3.9	4.4
Rain fall (mm)	39.5	0	149.5	11
Wind Speed (m/s)	1.2	0.9	0.3	0.9
Max Humidity (%)	92	85.5	93.4	91.3
Min Humidity (%)	58.9	49	66.9	63.8

Table 2. Characteristics of soil in the study area

	Soil depths (Cm)			
	0-20	20-40	40-60	60-80
Sand (%)	49	49	45	45
Silt (%)	32	32	38	38
Clay (%)	19	19	17	17
Total nitrogen (%)	0.084	0.065	0.051	0.036
Organic carbon (%)	0.68	0.66	0.36	0.30
Potassium absorbent(ppm)	239	191	119	119
Phosphor absorbent(ppm)	0.07	2.17	0	0
Potassium absorbent(ds/m)	0.631	0.565	0.681	0.755

3. Results

Results from this research showed that after 130 minutes of measurement, infiltration intensity reached the constant rate of 0.39 (cm/h) which was equal to 9.4 (cm/day) (Fig 1). It seemed that the infiltration process depended on the physical properties of the soil surface, initial distribution of water in soil prior to irrigation and the flow of water on and in the soil (Rashidi and Seyfi, 2007). Mean values of the cumulative infiltration [D] (cm) and average infiltration intensity [i] (cm/h) as a function of time [t] (min) indicated that the infiltration rate was high at the beginning and then decreased with the passage of time until it reached a constant rate (Fig 1). Accuracy of water advance and depth infiltration equations will have significant effects on the success of irrigation design and management

(Sohrabi and Behnia, 2007). Results from the volumetric moisture changes of different depths revealed that the moisture content in upper soil layers such as 0-20 cm and 20-40 cm was less than those of 40-60 cm and 60-80cm layers which was due to the absorption of water in the first and second layers by the plant. In all depths, without-irrigation management and 6 days irrigation management led to the minimum and maximum moisture contents, respectively in superficial depths during the growth period which was attributed to using more water for irrigation. However, in lower layers, the moisture content of 6 and 12 days irrigation managements were close to each other (Fig. 2). Moisture variations in different layers along with water level in irrigated layers at different times suggested that before applying water stress, moisture conditions were equal in all layers. However, as stress was applied, the upper layers lost their moisture. These layers affected the continuation of the plant's growth such that for the existing roots, water was not absorbable. By studying the moisture rate in soil depths (30, 60 and 90 cm) under stress and irrigation conditions for peanut, Songsri *et al.* (2008) observed that moisture content difference in surface layers was quite apparent, while in lower layers this difference for irrigation managements was negligible in a way that moisture rates were corresponding during the growth period. Results showed that irrigation management had a significant effect (P<0.01) on the seed yield (Table 3) and the 6 days irrigation treatment had the highest seed yield (M=2345 kg/ha) compared with other treatments (Table 4). By studying the effect of drought stress on peanut, Vorasoot *et al.* (2003) and El-Boraei *et al.* (2009) concluded that under stress conditions, the yield decreases. Results from their research showed that irrigation management had a significant effect (P<0.01) on the pod yield (Table 3) and that the highest pod yield (M=4093kg/ha) was that of the 6-days irrigation management. Also, in his research, Abou Kheira (2009) revealed that drought stress during different peanut growth stages caused a significant decrease of seed and pod yields. Irrigation management was an indication of the insignificance of the total biomass at the probability level of 1% (Table 3) and that the total biomass of the 6 days irrigation treatment (M=9453 kg/ha) was the highest relative to others (Table 4). This research confirmed the findings of Songsri *et al.* (2008). In their results, the total biomass of the irrigation condition was more than that of the stressful condition. Also, Haro *et al.* (2008) studied two peanut cultivars under stressful and irrigation conditions for two years and concluded that the total biomass under stressful conditions was 34 to 67% less than under irrigation conditions. Water shortage is usually accompanied by reduced accumulation of aerial organs and the production of photosynthesis substances which seemed to be due to reduced absorption of nutrients and the production and transfer of processed substances. It is likely that increased dry matter production in the 6 days irrigation management causes the extension of the leaf surface. Water use efficiency in the irrigation management based on total biomass, seeds and pods was significant (P<0.01) (Table 3). In the 6 days irrigation treatment for the total biomass, pods and seeds, this efficiency was 2.88, 1.24 and 0.71kg/ha, respectively (Table 4). Results obtained from the study conducted by Songsri *et al.* [10] showed that drought stress resulted in the reduced efficiency of the seeds water consumption from 1.69 (kg/ha) under unstressed conditions to 0.98 (kg/ha) under stressful conditions in different peanut cultivars.

Table 3. Mean squares form the combined ANOVA for Biomass yield, pod yield, seed yield, $WUE_{Biomass}$, WUE_{Pod} and WUE_{Seed}

Source	Irrigation	CV(%)
Biomass yield	**	6.90
Pod yield	**	6.80
Seed yield	**	7.71
$WUE_{Biomass}$	**	6.05
WUE_{Pod}	**	7.55
WUE_{Seed}	**	7.63

**: Significant at 1% level

Table 4. Mean comparative on Biomass yield, pod yield, seed yield, $WUE_{Biomass}$, WUE_{Pod} and WUE_{Seed}

	Irrigation			
	non irrigation	6 day	12 day	18 day
Biomass (kg/ha)	4612d	9453a	7200a	6111c
pod yield (kg/ha)	2618c	4093a	3021b	2846b
seed yield (kg/ha)	955.5c	2345a	1510b	1423b
$WUE_{Biomass}$(kg/m^3)	2.30b	2.88a	2.39b	2.26c
WUE_{Pod}(kg/m^3)	1.30a	1.254a	1.00b	1.05b
WUE_{Seed}(kg/m^3)	0.47c	0.71a	0.5bc	0.52b

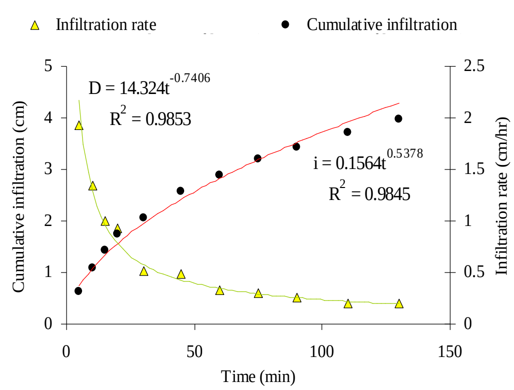

Figure 1. mean infiltration rate (cm/hr) and mean cumulative infiltration (cm)

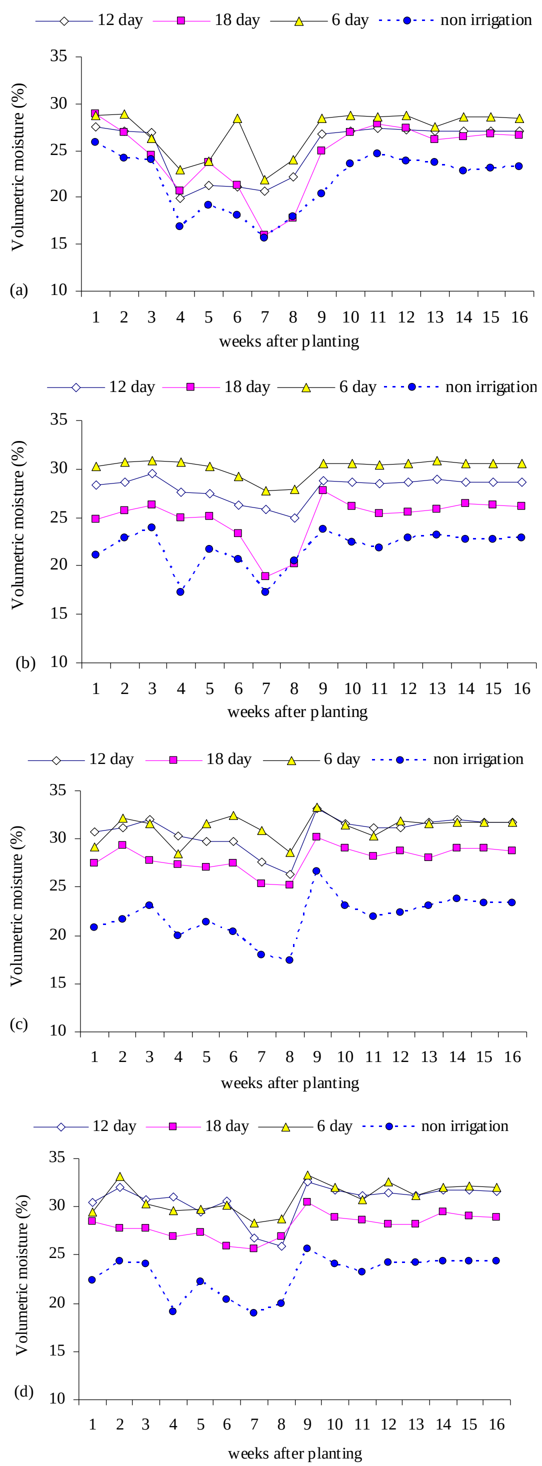

Figure 2. Trend Volumetric moisture in deeps the 0-20cm (a),20-40 cm (b),40-60 cm (c),60-80cm (d)

4. Discussions

In general, results of this research indicated that average final infiltration was 9.4 (cm/day) and the highest biomass, pods and seeds values for the 6 days irrigation management were 9453, 4093 and 2345 (kg/ha) respectively. The highest water use efficiency based on biomass, pods and seeds in the 6 days irrigation treatment were 2.88, 1.24 and 0.71(kg/m^3). Volumetric moisture variations in different depths indicated that the moisture content in upper soil layers such as 0-20 cm and 20-40 cm was less than those of 40-60 cm and 60-80 cm layers which was due to water absorption in the first and second layers by the plant. Hence, irrigation time should be reduced so that by compensating the infiltration reduction, water consumption efficiency would increase. In the present experiment, it can be concluded that by applying irrigation managements and providing sufficient water during sensitive growth stages of peanut, economizing the consumed water, maximum seed yield and water consumption efficiency could be achieved. Also, applying deficit irrigation treatments during early growth stages would increase exploiting valuable water resources without any adverse effects; hence, the stability of agricultural systems could be improved.

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