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Irrigation Management and Fertilizer of Peanut (*Arachis hypogaea* L) with a Drip Irrigation System: Yield, HI and Water Use Efficiency

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ABSTRACT: To investigate the effect of drip irrigation and nitrogen fertilizer rates on the yield of peanuts, split plot randomized complete block design with three replications of irrigation treatments, Including management of irrigation and drip irrigation with 60, 80 and 100% of the water requirements of plants. Minimum amounts of nitrogen fertilizer treatments consisted of 0, 30, 60 and 90 kg.N.ha^{-1} in crop year 2013 was conducted in Guilan province in the Astaneh Ashrafiyeh city. The results showed that the effect of irrigation and nitrogen fertilizer on biological yield, pod yield and seed yield was significant at the one percent level. But their interaction on biological yield, pod yield and seed yield was not significant. in The irrigation treatments, biological yield, seed yield and pod yield in 100% water requirement per plant, respectively was with values 6817.2, 2448.2 and 1877.5 kg/ha. Among the different amounts of nitrogen fertilizer, amounts 60 kg N ha^{-1} fertilizer, maximum biological yield was with an average 7519.8, the maximum amount of pod yield was with 2667 kg/ha, and maximum seed yield with 2012.2 kg/ha. The maximum water use efficiency based on biological yield, pod yield and seed yield with 0.42, 0.14 and 0.11 kg/m^3, respectively. Among the different levels of nitrogen fertilizer, the maximum water use efficiency was in 60 kg N.ha^{-1} for biological yield, pod yield and seed yield with 0.30, 0.11 and 0.08 kg/m^3, which was higher than the other treatments.

Keyword: Peanut, water requirement, water use, yield.

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is an important crop that provides food for direct human subsistence and other several food products (Ngo Nkot *et al.*, 2008). Peanut is legume cash crop for the farmers in arid and semi-arid regions and its seeds contain high amounts of edible oil (43-55%), protein (25-28%), and minerals (2.5%) (Abou Kheira, 2009). The origin of this plant is an area called Granchaco in Brazil (Abdzad Gohari and Amiri, 2011). China, India, the United States, Nigeria, Indonesia, Burma and Senegal are the major peanut producing countries. In Iran, this product is grown in Golestan, Khouzestan and Guilan provinces. In Guilan, it is mostly planted in Astaneh Ashrafiyeh and also along Sepidroud river margin (Abdzad Gohari, 2012). Peanut is grown under both rainfed and irrigated conditions, more than half of the production area in this region is rainfed (Woli *et al.*, 2013; Kambiranda *et al.*, 2011; Leclerc, 2010). Rainfall in the region of 500 to 700 mm per annum will be satisfactory for good yields of Peanuts. Drought is one the limiting factor in the yield of peanut in most of the countries (Awal and Ikeda, 2002). In recent years, due to drought and its yield has declined (Abdzad Gohari and Amiri, 2011). Drip irrigation delivers water through the use of pressurized pipes that run close to the plants and that can be placed on the soil surface or below ground. This method is highly efficient because only the immediate root zone of each plant is wetted. This system also allows precise application of water-soluble fertilizer and other agricultural chemicals. Drip irrigation is reported to help achieve yield gains of up to 100%, water savings of up to 40-80%, and associated fertilizer, pesticide, and labor savings over conventional irrigation systems. Drip irrigation systems can have different levels of sophistication and costs. Peanut has a good ability for growing in lightly soil, and thrives in improving the characteristics of the newly reclaimed sandy soils which commonly suffer from some constraints such as poor physical properties and nutrients deficiency. Fertilizers play an important role in the recent changes in global agricultural commodity markets. Fertilizer use is directly connected to the forces driving crop supply through the increase in productivity. The use of fertilizers in agriculture also has direct and indirect consequences for the environment. For these reasons, it is important to understand how fertilizers respond to changes in the global economy and how fertilizers interact with the crops for which they are used.

Nitrogen deficiency can be corrected with an application of nitrogen fertilizer. Crop response to fertilization with nitrogen is generally very prompt, depending on the source of nitrogen, stage of plant growth, rainfall and temperature. Nitrogen has a critical role in producing agricultural products and selecting the amount of nitrogen containing fertilizers is necessary for having the highest production level. Adsorption of adequate amounts of nitrogen by a plant leads to more protein content and larger cereal and legume seeds. Generally, the more the concentration of nitrogen in leaves, the more the intensity of carbon making would be because aside from being found as protein in plants, nitrogen is the main element in the chlorophyll synthesis and its fixation could lead to more growth of aerial parts. Usually, nitrogen shortage is observed when plant nutrition is not managed properly and this element is not provided in adequate amounts, which could result in the older leaves to turn yellow and eventually, the plant's growth stops. In other cases, when too much nitrogen is provided for the plant, it normally leads to watering of protoplasm and brittleness of the plant itself which would result in becoming vulnerable to diseases and pests. The continuous population explosion and the increasing standard of living, the demand on agricultural productivity and water resources is sharply increasing. Improper irrigation management not only causes variation in crop yield but also wastes scarce and valuable Water resources (Abou Kheira, 2009). Insufficient water during these critical points reduces seed yield substantially and fails to maximize water use (Reddy *et al,* 2003). The present research was done with the purpose of studying the effects of drip irrigation and nitrogen fertilizer on yield and water use efficiency in peanut.

MATERIALS AND METHODS

In order to study the effect of irrigation management and nitrogen fertilizers on peanut, during the 2013 crop year, an experiment was done in Astaneh Ashrafiyeh located in 37°16' latitude and 46°56' longitude in the north of Iran at an average altitude of 3 meters. Climatic data of the studied were obtained from Astaneh Ashrafiyeh meteorological station. From the climatology perspective, this town is considered a temperate and humid region and has a loam soil with 7.4 pH value. Information on soil specifications and climatic data of the studied region are given in Tables 1 and 2. The experiment was done as a split-plot in a completely random blocks plan with three replications. Each experimental unit was 3 × 2 m in area and had 10 rows of plantation. The agricultural land was at first plowed on May 5, 2013 and then, eleven days later (May 16, 2013) peanut seeds of the cultivar (NC2) were sown both manually and in rows 3-4cm deep. Irrigation was as main-plot factor which consisted of four levels of dry farming, different level irrigation consisting of 60, 80 and 100 percentage of different level of water requirement (I1, I2, I3 and I4 respectively). Sub-plot factor was nitrogen fertilizer in four levels 0, 30, 60 and 90 kg/ha (abbreviated as N1, N2, N3 and N4). Half of the nitrogen fertilizer was used as the base fertilizer and the remaining was used in three equal portions 20, 30 and 40 days after plantation. Crop management measures in the field included three phases of weeding to control the weeds and also side dressings around the root. The crop was harvested on September 20, 2013. In order to estimate seed yield, after excluding two rows from both sides, first, mature pods were harvested from the shrubs in each plot and then, they were exposed to open air for one week so that their moisture content would be reduced. The seed yield was calculated as kg/ha. After determining the number of mature pods in each plot, they were put in an oven at 60-65ºC for 48 hours until they reached a constant dry weight. Then, the mature pods of each plot were weighed using a scale with a 0.01 precision. Then, they were dried for 48 hours in an oven at 60°C.

Table 1. Characteristics of soil in the study area.

	Particle size distribution (%)							
Soil depths (Cm)	**Sand**	**Silt**	**Clay**	**Total nitrogen**	**Organic carbon**	**Soil Texture**	**Potassium absorbent (ppm)**	**Phosphor absorbent (ppm)**
0-20	49	32	32	0.084	0.68	Loamy	239	0.07
20-40	49	19	19	0.065	0.66	Loamy	191	2.17

Table 2: Information on meteorological data.

Month	**Max Temp(°C)**	**Min Temp(°C)**	**Sun Shine(h)**	**Rain fall (mm)**	**Evaporation of pan (mm)**	**Max Humidity (%)**	**Min Humidity (%)**
May	27.3	17.3	6.5	39.5	4.1	92	58.9
Jun	41.9	20	8.5	0	6.3	85.9	49
Jul	29.5	18.8	3.9	149.5	2.5	93.4	66.9
Aug	28.4	18.5	4.4	11	3.4	91.3	63.8
Sep	32.3	21.0	7.9	16.1	5.1	94.0	54.3

Management of irrigation in 60%, 80% and 100% water requirement was respectively 230, 315 and 390 mm. To analyze the variance of data and to compare the mean values (Duncan test at the probability level of 5%), MSTATC software and in order to draw relevant diagrams, Excel software was used.

RESULTS AND DISCUSSION

A. Biological Yield

Effect of irrigation and nitrogen fertilizer on yield was significant at 1% level, but the interaction was not significant (Table 3). The results showed that the average yield in treatments of 60, 80 and 100% of the water requirements of plants was similar, and irrigation was significantly higher than controls (Table 4). In between treatments, the application of 60 $kg.N.ha^{-1}$ with an average highest 7519.8 kg/ha average 4099.6 $kg.N.ha^{-1}$ with no fertilizer, had the lowest yield (Table 4). Relationship between water use and biomass yield shown in Fig. 1.

Songsri *et al.,* (2008) research found that full irrigation and irrigation regime, peanut plant studied and concluded that full irrigation water stress is greater than the total amount of biomass. Haro *et al.,* (2008), two varieties of peanut irrigation in drought conditions and studied for two years, and concluded that 34 to 67 percent less stress on biomass from irrigated conditions. In a study Abdzad Gohari (2009), the amount of nitrogen fertilizer on peanut reviewed and maximum yield of 60 kg N ha fertilizer treatments reported. Stress can exacerbate the shortage of nitrogen because nitrogen fixation by legumes is limited under drought stress (Reddy *et al.,* 2003). Drought stresses also form the nodes of delay in the legume plants (Reddi and Reddy, 1977). There is some evidence to suggest that stress fertilizer uptake by plants is reduced (Kulkarni *et al.,* 1998). Pimratch *et al* (2008) in their study showed that severe drought stress conditions, the number of nodes and the nodes of nitrogen activity and drastically reduce weight.

Table 3: Variance analysis for effects of irrigation and nitrogen fertilizers on peanut.

Source of variation	df	Mean squares						
		Biological yield	Pod yield	Seed yield	Harvest index	$WUE_{Biological}$	WUE_{Pod}	WUE_{Seed}
Blocks	2	2752709.87^{ns}	1331546.87^{ns}	615802.32^{ns}	0.002^{ns}	0.001^{ns}	0.002^{ns}	0.001^{ns}
Irrigation	3	30569164.94^{**}	4578452.96^{**}	2532888.31^{**}	0.039^{**}	0.190^{**}	0.072^{**}	0.012^{**}
Error	6	2541162.42	261233.3	225928.59	0.004	0.003	0.004	0.001
Nitrogen	3	24872706.59^{**}	3068461.09^{**}	1552844.74^{**}	0.001^{ns}	0.035^{**}	0.047^{**}	0.003^{**}
Interaction	9	2283575.85^{ns}	236379.84^{ns}	121912.92^{ns}	0.003^{ns}	0.003^{ns}	0.004^{ns}	0.001^{*}
Error	24	1274322.42	361464.03	215537.52	0.002	0.001	0.006	0.001
CV (%)		20.15	30.51	3.65	18.59	15.83	30.51	3.87

**,*: Significant at 1, 5% level and ns: Not significant

Table 4: Mean comparative on Biological yield, Pod yield, Seed yield, $WUE_{Biological}$, WUE_{Pod}, WUE_{Seed}

Treatment	Biological yield	Pod yield	Seed yield	Harvest index	$WUE_{Biological}$	WUE_{Pod}	WUE_{Seed}
Irrigation management							
I_1	3343.8b	1107.8b	858.8b	0.16b	0.42a	0.14a	0.11a
I_2	5618.9a	1944.9a	1543a	0.28a	0.18b	0.06b	0.05b
I_3	6634a	2382.8a	1780.3a	0.27a	0.17b	0.06b	0.05b
I_4	6817.2a	2448.2a	1877.5a	0.29a	0.14b	0.05b	0.04b
Nitrogen fertilizer levels							
N_1	4099.6c	1474.4c	1169.4b	0.26a	0.17b	0.06b	0.04b
N_2	5081.7b	1781.5b	1368.3b	0.25a	0.21b	0.07b	0.06b
N_3	7519.8a	2667.0a	2012.2a	0.25a	0.30a	0.11a	0.08a
N_4	5712.8b	1959.4b	1509.6b	0.24a	0.23b	0.07b	0.06b

Means for groups in homogeneous subsets are displayed

B. Pod Yield

Analysis of variance showed that the management of irrigation and nitrogen fertilizer on the yield of pods per cent level of significance (Table 3). The results showed that the mean pod yield in treatments of 60, 80 and 100% of the water requirements of plants was similar and irrigation was significantly higher than controls (Table 4).

In between treatments, the application of 60 $kg.N.ha^{-1}$ with an average of 2,667 kg per hectare with no fertilizer with the highest average 1474.4 $kg.N.ha^{-1}$, the lowest of the sheath (Fig. 4). Relationship between water use and pod yield shown in Fig. 2. Due to the growing need of peanut pod development stage, nitrogen, dry nitrogen adds to the deficit and nodule formation and nitrogen fixation delays.

Therefore, the application of nitrogen fertilizer nitrogen in water shortages and to some extent on the pod yield increases (Abdzad Gohari and Noorhosseini Niyaki, 2010). Pallas *et al., (*1979) found that 71 to 105 or 105 peanuts to 145 days if drought occurs, pod yield decreased to the same extent and duration of grain filling period, a period critical water requirements have been introduced. Since moisture is a key factor for the development peg peanut shortage of water decreases performance and lack of moisture during seed development and seed pods and seeds reduces weight (Janamty *et al,* 1986). Dry pod yield by reducing the length of the sheath reduces development (Stirling and Black 1991). Shinde and Laware in another study in 2010 showed that the lack of moisture will reduce the performance of peanuts.

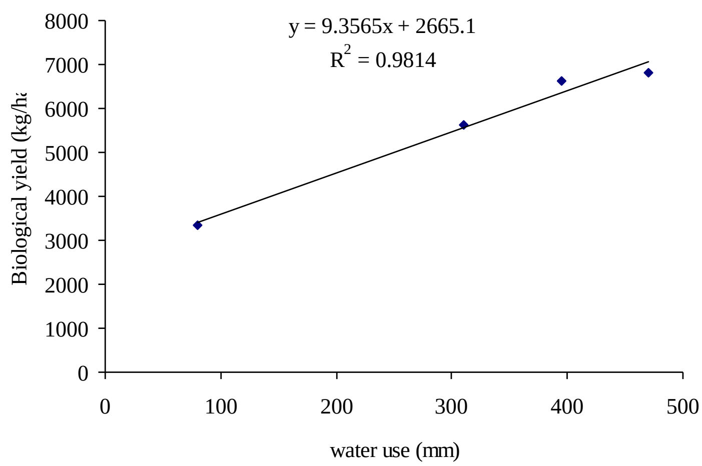

Fig. 1. Relationship between water use and biomass yield.

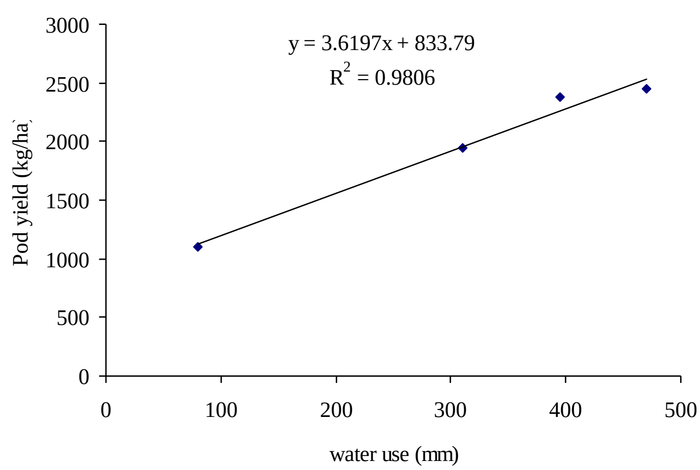

Fig. 2. Relationship between water use and pod yield.

C. Seed Yield

Analysis of variance results showed that there was a significant difference between different irrigation management and nitrogen fertilizer treatments in terms of seed yield with 99% confidence coefficients (Table 3). Seed yield values of four levels of dry farming, different level irrigation consisting of 60, 80 and 100 percentage of different level of water requirement was 858.8, 1543, 1780.3 and 1877.5 kg/ha.

Furthermore, the use of 60 kg/ha nitrogen fertilizer resulted in the highest seed yield amounting to 2012.2 kg/ha (Table 4). Relationship between water use and seed yield shown in Fig. 3. Irrigation is critical in peanut production because it allows us to take advantage of other inputs. Water is needed to move Ca from land plaster into the pegging zone and to keep soil Ca in solution and available to the pods.

Vorasoot *et al.,* (2003) and El Boraei *et al.,* (2009) with the effect of drought stress on peanut concluded that stress conditions, reduced performance. Janick and Simon (1993) suggested that too much nitrogen caused food synthesis in the plant which in their research, it led to more vegetative growth and less seed yield. Haro *et al.* (2008) studied two types of peanut under watering and stress for two years and found that the yield under stress was less than that under the irrigated conditions (Haro *et al.,* 2008). Water stress imposed on peanut throughout the growing stages reduced vegetative growth and affects flowering and yield. El-Boraie *et al.,* (2009) concluded that peanut yield is reduced under water stress.

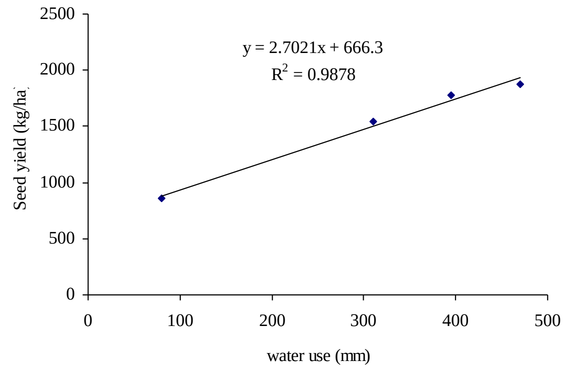

Fig. 3. Relationship between water use and seed yield.

D. Harvest Index

The effect of irrigation on harvest index was significant at 1% level, the interaction of different levels of nitrogen fertilizer and irrigation and nitrogen harvest index was not significant (Table 3). The results showed that the mean values of the treatments were harvested 60, 80 and 100% crop water requirements are the same and mean, respectively 0.28, 0.27 and 0.29, respectively (Table 3). Harvest index indicates the fraction of dry matter allocated to seeds. And the management and breeding of crops seed harvest index attempts to be increased to the maximum extent possible. Stage of crop development in time of stress and stress intensity factors are affecting harvest index. Spaeth *et al.,* (1984) have stated that the stress effect on harvest index was not different. The researchers believe that the processes of vegetative and reproductive plant water stress are equally affected. And so the harvest index in different conditions of humidity of great stability. And the sensitivity of plant biomass and grain yield is higher than the harvest index to water stress. In a study of Vorasoot et al., (2003) peanut genotypes under stress and non-stress test were investigated and reported to cause stress, harvest index decreased in all genotypes. In this Songsri *et al.,* (2009) showed that the drought has led to a dramatic drop in the harvest of peanuts. Shinde *et al.,* (2010) in their research concluded that drought reduced harvest index.

E. Water Use Efficiency Biological

The results indicate that the effect of irrigation and nitrogen fertilizer on water use efficiency based on biological yield was significant at the 1% level (Table 3). Interaction of drip irrigation and nitrogen fertilizer on water use efficiency based on biological yield was not significant (Table 3). The yield based on the amount of water use efficiency in rainfed plots with mean 0.42 kg/m^3 was observed (Table 4). The amount of water use efficiency based on biological function at different levels of nitrogen fertilizer treatments of 60 kg N ha with an average of 0.30 kg per cubic meter was observed (Table 4). Adcock and McNeill (2003) yield and water use efficiency in wheat cultivation of rapeseed, agricultural, pasture grass, barley and wheat were investigated and found that the maximum water use efficiency of wheat after the cultivation of rapeseed kg ha millimeters of, 8 and then cultured at least equal to 8.6 kg ha-mm machine, respectively. Anis et al (2001) to study the effects of supplemental irrigation on yield and water use efficiency in wheat Full and concluded that supplemental irrigation to full irrigation water use more efficient. Studies Deming (1999) in the context of optimizing the irrigation and water use efficiency in irrigation management has a very important role.

F. Water Use Efficiency Pod

The results indicate that the effect of irrigation and nitrogen fertilizer on water use efficiency based on pod yield was significant at the 1% level (Table 3). Interaction of drip irrigation and nitrogen fertilizer on water use efficiency based on pod yield was not significant (Table 3). The amount of water use efficiency based on pod yield in rainfed plots with mean 0.14 kg/m3 was observed (Table 4). The amount of water use efficiency based on pod yield at different levels of nitrogen fertilizer treatments of 60 kg N.ha^{-1} with an average of 0.11 kg/m^3 was observed (Table 4).

In a study Songsri *et al* (2009), eleven type peanut stresses and non-stress criterion was tested and concluded that drought stress resulted in the reduction of water use efficiency in irrigated grain from 1.69 to 0.98 kg/m^3 is under stress. In another study, Howell *et al* (1966) stated that the increased harvest index, increased water use efficiency. Li Feng *et al* (2001) compared three irrigation regimes on different fractions of soil moisture in the root zone of plants on the upper and lower layers of the water use efficiency of spring wheat genotypes concluded that while 50 to 60 percent of the total irrigation water the bottom layer is the maximum use of available soil water use efficiency is obtained.

G. Water Use Efficiency Seed

The results indicate that the effect of irrigation and nitrogen fertilizer on water use efficiency on grain yield was significant at 1% level (Table 3). Interaction of drip irrigation and nitrogen fertilizer on water use efficiency on grain yield was significant at the 5% level (Table 3). The yield based on the amount of water use efficiency in rainfed treatment was observed by means of 0.11 kg/m^3 (Table 4). The amount of water use efficiency based on pod yield at different levels of nitrogen fertilizer treatments of 60 kg.ha^{-1} with an average of 0.08 kg per cubic meter was observed (Table 4).

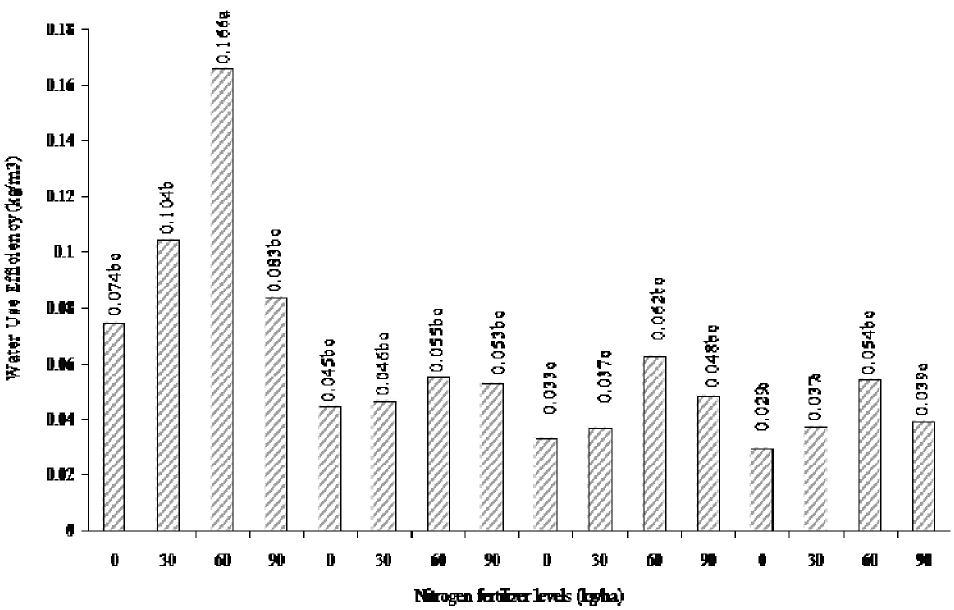

Fig. 4. Interaction of irrigation and Nitrogen fertilizer on $WUE_{Seed.}$

Maximum interaction of drip irrigation and nitrogen fertilizer on water use efficiency on seed yield indicated in the treatment without irrigation, fertilizer treatments, with an average of 60 kg N ha 0.163 kg/m^3 was observed (Fig. 4).

CONCLUSION

The results showed that the effect of irrigation and nitrogen fertilizer on biological yield, pod yield and seed yield was significant at the one percent level. But their interactions on biological yield, pod yield and seed yield were not significant. In the irrigation treatments, biological yield, seed yield and pod yield in 100% water requirement per plant, respectively was with values 6817.2, 2448.2 and 1877.5 kg/ha. Among the different amounts of nitrogen fertilizer, amounts 60 kg N.ha^{-1} fertilizer, maximum biological yield was with an average 7519.8, the maximum amount of pod yield was with 2667 kg N.ha^{-1}, and maximum seed yield with 2012.2 kg N.ha^{-1}. The maximum water use efficiency based on biological yield, pod yield and seed yield with 0.42, 0.14 and 0.11 kg.m^{-3}, respectively. Among the different levels of nitrogen fertilizer, the maximum water use efficiency was in 60 kg N.ha^{-1} for biological yield, pod yield and seed yield with 0.30, 0.11 and 0.08 kg/m^3, which was higher than the other treatments.

REFERENCES

Abdzad Gohari A. and Amiri, E. (2011). The Effect of Nitrogen Fertilizer and Irrigation Management on Peanut (*Arachis hypogaea* L.) Yield in the North of Iran. *ICID 21st International Congress on Irrigation and Drainage,* 15-23 October 2011. Tehran, Iran.

Abdzad Gohari, A and Noorhosseini Niyaki, S.A. (2010). Effect of Iron and Nitrogen fertilizer on yield and yield Components of Peanut (*Arachis hypogea*) in Astaneh Ashrafiyeh, Iran. *J. Agri. Environ. Sci.* **3**: 256-262.

Abdzad Gohari, A. (2012). Effect of Nitrogen Fertilizer and Various Irrigation Regimes on yield and Physiological Traits in peanut (*Arachis hypogaea* L.), 1.1.26-32.

Abou Kheira, A.A. 2009. Macromanagement of deficit-irrigated peanut with sprinkler irrigation. *Agri Water Manage.* **96**: 1409-1420.

Adcock, D., and A. Mc Neill. (2003). Water use efficiency of wheat in asemi-arid environment. *11th Australian Agronomy Conference, Geeling.*

Anis, U.R., Well, R.G and Thomas, G. (2001). Reproduvtive allocation on branching of virgiana-type peanut cultivars bred for yield in North Carolina. *Crop Sci.* **41**: 72-77.

Awal, M. W. and Ikeda, T. (2002). Recovery strategy following the imposition of Episodic soil moisture deficit in stands of peanut (*Arachis hypogaea* L.), *J. Agron. Crop Sci.* **188**, 185-192.

Deming, H., C. Willeke-Wetstein and J. Steinbach. (1999). Optimizing the irrigation scheduling strategy and the water use efficiency in stoppe and irrigated crop production ecosystems in north western China. *Tsinghua Science and Technology.* Vol. **4**, No. 3.

El-Boraie, F.M. Abo-El-Ela, H.K and Gaber, A.M. (2009). Water Requirements of Peanut Grown in Sandy Soil under Drip Irrigation and Biofertilization. *Australian Journal of Basic and Applied Sciences.* **3**(1): 55-65.

Haro, R. Dardanelli, J. Otegui M. and Collino, D. (2008). Seed yield determination of peanut crops under water deficit: Soil strength effects on pod set, the source sink ratio and radiation use efficiency. *Field Crops Research.* **109**: 24-33.

Howell, T.A., S.R. Evett, J.A. Tolk, A.D. Schneider, and J.L. Steiner (1996). Evapotranspiration of corn-Southern High Plains. In: Proceeding of the Conference on International Evapotranspiration and irrigation Schedule. ASAE, San Antonio, TX, PP. 381-387.

Janamatti V.S., SashidharV.R., Prasad I.G. and Sastry K.S.K. (1986). Effect of cycles of moisture stress on flowering pattern, flower production, gynophore length and their relationship to pod yield in bunch types of groundnut. *Narendra Deva J. Agric. Res.* **1**(2): 136-142.

Janick, J., and Simon, I.E. (1993). Newcropa willey. New York. Pp: 636-639.

Kambiranda, D.M., Vasanthaiah, H.K.N., Katam, R., Ananga, A., Basha, S.M., Naik, K., (2011). Impact of drought stress on peanut (*Arachis hypogaea* L.) productivity and food safety. In: Vasanthaiah, H. (Ed.), Plants and Environment, InTech, pp. 249-272. <http://cdn.intechweb.org/pdfs/21740.pdf> (accessed 12.11.12).

Kulkarni, J.H.; Ravindra, V., Sojitra, V.K. & Bhatt, D.M. (1988). Growth, nodulation and N uptake of groundnut (*Arachis hypogaea* L.) as influenced by water deficits stress at different phenophase. *Oleagineus*, Vol. **43**, pp. 415-419.

Leclerc, M., 2010. Viewing impact statement measurements of CO_2 nocturnal respiration as an indicator of stress response in peanuts. The University of Georgia College of Agricultural and Environmental Sciences. http://www.caes.uga.edu/Applications/ImpactStatements/index.cfm?referenceInterface=Impact_Statement&Subinterface=Detail_Main&PK_ID=3385>(Accessed 12.11.12).

Li Feng, M., Xun Ylan., Feng-Rui Li, and An-Hong Guo (2001). Effects of different water supply regimes on water use and yield performance of spring wheat in a simulated semi-arid environment. *Agricultural Water Management,* Vol. **47**(1): 25-35.

Ngo Nkot, L. Krasova-Wadem T. Etoa, F.X. Sylla, S.N. and D. Nwaga (2008). Genetic diversity of rhizobia nodulating *Arachis hypogaea* L. in diverse land use systems of humid forest zone in Cameroon. *Applied soil ecology*. **40**. 411-416.

Pallas, J. E. Jr., J. R. Stansell and T. J. Koske. (1979). Effects of drought on florunner peanuts. *Agronomy Journal*. **71**: 853-858.

Pimratch, S., Jogloy, S., Vorasoot, N. and Toomsan, B. (2008). Effect of drought stress on trait related to N_2 fixation in eleven peanut (*Arachis hypogaea* L.) Genotypes differing in degree of resistance to drought. *Asian Journal of Plant Science.* **7**: 334-342.

Reddi, G.H. and M.N. Reddy. (1977). Efficient use of irrigation water for wheat and groundnut. *Mysore J. Agric. Sci.* **11**: 22-27.

Reddy, T.Y., Reddy, V.R. and Anbumozhi, V. (2003). Physiological responses of groundnut (*Arachis hypogea* L.) to drought stress and its amelioration: a critical review. *Plant Growth Regulation*, **41**: 75-88, 2003.

Shinde, B.M. and Laware, L. (2010). Effect of drought stress on agronomic Contributing characters In Groundnut (*Arachis hypogae* L.). *Asian. J. Exp. Biol. Sci.* Vol. **1**: 968-971.

Shinde, B.M., Limaye, A.S., Deore, G.B. and Laware. L. (2010). Physiological response of groundnut (*Arachis hypogae)* varieties to drought stress. Asin J. Exp.Biol.SCI. SPL. 65-68.

Songsri, P. Jogloy, S. Kesmala, T. Vorasoot, N. Akkasaeng, C. Patanothai, A and Holbrook, C. (2008). Heritability of Drought Resistance Traits and Correlation of Drought Resistance and Agronomic Traits in Peanut. *Crop Science Society of America.* **48**: 2245-2253.

Songsri, P. Jogloy, S. Holbrook, C.C. Vorasoot, N. Kesmala, T. C. Akkasaeng, C and Patanothai A. (2009). Association of root, specific leaf area and SPAD chlorophyll meter reading to water use efficiency of peanut under different available soil water. *Agricultural Water Management.* 790-798.

Spaeth, S.C., Randau, H.C., Sinclair, T.R. and Vendeland, J.S. (1984). Stabbility of soybean harvest index. *Agron. J.* **76**: 482-486.

Stirling C.M. and Black C.R. (1991). Stages of reproductive develop ment in groundnut (*Archis hypogaea* L.) most susceptible to environmental stress. *Trop. Agric*. (Trinidad) **68**(3): 296-300.

Vorasoot, N. Akkasaeng, C. Songsri, P. Jogloy, S and Patanothai A. (2003). Effect of available soil water on leaf development and dry matter partitioning in 4 cultivars of peanut (*Arachis hypogaea* L). *Songklanakarin J Sci Technol*. **26**(6): 787-794.

Woli P, Joel O. Paz, Hoogenboom G, Axel Garcia y Garcia, Clyde W. Fraisse. 2013. The ENSO effect on peanut yield as influenced by planting date and soil type. *Agricultural Systems* **121**. 1-8.