The Effect of Irrigation Regime and Nitrogen Fertilizer on Seed Yield and Qualitative Characteristics of Peanut *(Arachis hypogaea L)*

(Case study of Gilan Province, Iran)

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Abstract

In order to evaluate the effect of irrigation on seed yield, oil and protein content of peanut *(Arachis hypogaea L.)*, an experiment was conducted in the form of a completely random block plan with three replications in Gilan province for 2013 and 2014. The main treatments included no irrigation (dry farming) and irrigation frequencies of 6 days, 12 days, and 18 days, and the secondary treatments included Nitrogen fertilizer at levels of 0, 30, 60, and 90 kg/ha. The study determined that the interaction of irrigation and nitrogen fertilizer with oil and protein content was significant at level of 5 percent confidence. The effect of irrigation on seed yield was significant at 1 percent, and the highest amount of seed yield was observed at 6-day frequency of irrigation with an average of 2665/8 kg/ha.

Keywords: Irrigation, Nitrogen fertilizer, Peanut, Quality performance, Seed yield.

Introduction

Peanut is an annual shrub of Leguminous family and Arachis genus (FAO, 2013). According to scientists, the origin of the plant is South America. India, China and Nigeria have the largest area under cultivation of this plant .In 2011, area under cultivation peanut in China was 4,581,000 ha, and production of 16,046,000 tons had the highest production in the world (Anonymous, 2010). Arid and semi-arid climate and limited water resources are the most important obstacles to agricultural development. Increased population, water shortage, as well as high consumption of water in the agricultural sector than in other sectors has intensified water shortage, which is now a major concern of many experts. Due to the climatic situation of Iran, most of lands are located in arid and semiarid regions; therefore, the proper use of water resources and improving water consumption efficiency in agriculture will be realized when infrastructural and technical programs such as optimized irrigation management, reduced water losses, and using proper

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irrigation are implemented. On the other hands, using nitrogen fertilizers in small quantities increases the total nitrogen in the plant per area, while using nitrogen as fertilizer which have negative effects on nitrogen fixation enzyme (Majnun Hosseini, 1993).

Seed yield

To estimate the seed yield, after removing two rows of plants in each side, mature pods and seeds were harvested and weighed by accurate laboratory scales.

Water use efficiency in seed yield

The amount of water use efficiency in seed yield was calculated as follows (Wright et al. 1996):

$$\text{water use efficiency in seed yield (kg/m}^3\text{)} = \frac{\text{Seed yield (kg)}}{\text{Water consumed (m}^3\text{)}}$$

In recent years ,due to the drought and its impact on plants' yield, specific programs should be planned and implemented in the field of optimal water consumption, since dryness is one of the limiting factors in peanut yield for most countries (Reddy et al., 2003). Songsri et al. (2009) examined eleven varieties of peanuts in irrigation under stress and non-stress conditions, and concluded that dryness stress reduced harvest index, Relative Water Content (RWC) and water use efficiency for seed under stress. When water resources are limited, improved water use efficiency can enhance the yield. In addition, Webber et al. (2006) concluded that moisture stress reduced the yield in bean plant.

In another study, different irrigation levels in peanuts were examined, and it was reported that the oil and protein content showed significant differences in the level of 1 percent, and the highest percentage of protein, obtained from full irrigation rate, was 24 percent; while the lowest in dry farming state, was 20.90 %. The results in the different irrigation treatments showed that the protein content in full irrigation state with an average of 46.64 % had the highest percentage of oil among all treatments (Guilani, 2008). However, the difference was not significant in other treatments. It was also reported that increasing irrigation area improved the protein content of peanut, while the increase trend was the opposite in the case of oil content, so that increasing irrigation area reduced the oil content of peanut. Pilehvari et al. (2008) and Lee et al. (1995) used different amounts of methanol on the quality characteristics of peanuts in Gilan, and demonstrated that the interaction of different levels of methanol and Zink did not affect the oil and protein content of peanut seeds.

Peanut growing and producing areas in Iran and the world

According to the statistics, China, India, USA, Nigeria, Indonesia, Burma, and Senegal are the major producers of peanut in the world (Anonymous, 2010 and 1998). In Iran, this product is cultivated in Golestan, Khuzestan, and Gilan provinces. In Gilan, it is mainly cultivated Anzali, Rasht, Roudbar, Some'esara, Astaneh Ashrafieh, as well as along Sepidroud river margin (Table1).

Table 1. information on peanut cultivation in Gilan province

Row	Area	Area under cultivation (ha)	Production (kg/ha)	Yield (kg)
1	Astaneh Ashrafieh	2507	8502.2	3392
2	Anzali	2	3.6	1800
3	Rasht	70	175	2500
4	Roudbar	2	4.2	1200
5	Some'esara	3	8	2667

According to Table 1, it can be seen that the yield and cultivated area in Astaneh Ashrafieh is higher than the rest of the province, and even higher than the national average. Therefore, to increase its influence and applicability, this research was conducted on the protein and oil content of peanuts in Gilan province.

Materials and methods

The study was conducted in Astaneh Ashrafieh/Gilan located in latitude of 37º 16', and longitude of 49º 56', and the average height of 3 meters above sea level, for crop year 2013-2014. Meteorological data were obtained from synoptic meteorological station of Astaneh Ashrafieh. From the climatology perspective, the region is considered temperate and humid. Data on soil specifications and weather are given in Tables 2 and 3.

Table 2. The meteorological data

Month	Evaporation of pan surface	Min. humidity (%)	Max. humidity (%)	Wind speed (m/s)	rainfall (mm)	Hours of sunshine	Max. temperature©
May	3.1	58.9	92.0	1.2	39.5	6.5	27.3
June	6.3	49.0	85.9	0.9	0	8.5	31.9
July	2.5	66.9	93.4	0.3	149.5	3.9	29.5
August	3.4	63.8	91.3	0.9	11	4.4	28.4

Table 3. The soil specifications

Depth(cm)	Soil texture	Sand (%)	Silt (%)	Clay (%)	Available Potassium (mg/kg)	Available Phosphorus(mg/kg)	Total Nitrogen (%)	Organic Carbon (%)	EC (ds/m)
0-20	Loam	49	32	19	239	0.07	0.084	0.68	0.631
20-40	Loam	49	32	19	191	2.17	0.065	0.66	0.656

In this research, the experimental split plot randomized complete block design with 3 replications which was carried out in the field. In this study, the split plots experiment was implemented in the form of a completely random block plan with three replications. Each block had a size of 6*2.5 m and 7 rows of plantation. The main treatments included no irrigation and irrigation frequencies of 6 days, 12 days, and 18 days, and secondary treatment included Nitrogen fertilizer at levels of 0, 30, 60, and 90 kg Nitrogen per hectare. To determine the seed

performance, after removing two rows of plants in each side, mature seeds weighed using an accurate laboratory scale. After determining peanut yield, samples were sent to the laboratory and their oil and protein content was calculated. To measure the oil, Soxhlet apparatus[†] , and to measure protein concentration, Kjeldahl[‡] were used (Hangrya, 2000).

Based on the results of chemical analysis of the soil, 150 kg/ha of triple superphosphate fertilizer was spread equally throughout the farm before sowing. The cultivated variety of peanut was local Gil peanut, and the planting date was 22 May. Before planting, the seed were disinfected with 2:1000 carboxin thiram as fungicide. Crop management measures at farm level included three phases of weeding for weed control and soil dressing around the roots. Harvest date was 10 Sep. in 2013 and 2014.

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irrigation method and measurement

Irrigation method used in this study was drip irrigation, so that the distance between two rows was 80 cm and between plants in each row was 30 cm. To measure the amount of water delivered to each plot a contour was used. In this irrigation system, a dripper was used, so as the main pipe was perforated in specific intervals, and water discharge pores were installed on it by special equipment. The main pipe was made of polyester and it was 6 meters in length and 1 inch in diameter. The main pipe was located at the top of rows and the water was supplied by a well. The amount of water used in each management and the frequency of irrigations are provided in Table 4.

Table 4. The frequency of irrigations and water used in irrigation management

Irrigation management	Water used (mm)	Frequency of irrigations (day)
No irrigation	200	0
6 days	328	8
12 days	300	4
18 days	264	3

Results and discussion

Data analysis and mean comparison of measured parameters (Duncan test at level of 5 percent) was performed using MSTATC[§] Software, and Excel software was used for graphs.

[†] It was originally designed for the extraction of a lipid from a solid material. Typically, a Soxhlet extraction is used when the desired compound has a *limited* solubility in a solvent, and the impurity is insoluble in that solvent. It allows for unmonitored and unmanaged operation while efficiently recycling a small amount of solvent to dissolve a larger amount of material.

[‡] Kldal or Kjeldahl is a method for the quantitative determination of nitrogen in chemical was discovered in 1883 by Johann Kldal.

[§] - Statistic software.

The effect of irrigation on seed yield

The effect of irrigation on seed yield was significant at level of 1 percent (Table 5). The highest seed yield was obtained in 6-days irrigation with an average of 2665.8 kg/ha (Fig 1). This is while in dry farming condition, seed yield was the lowest with a minimum of 1082.1 kg/ha (Fig1).

Table 5. ANOVA for seed yield based on the irrigation method, 2012-2014

variation	Degree of freedom	Seed yield
Year	1	4185813.419**
Year and replication	4	2686334.02**
Irrigation	3	31942378.78**
Year and irrigation	3	1318775.388*
error	12	345726.008
	CV%	24.97

ns, *, **: no significant difference, significant difference at level of 1%, significant difference at level of 5%, respectively.

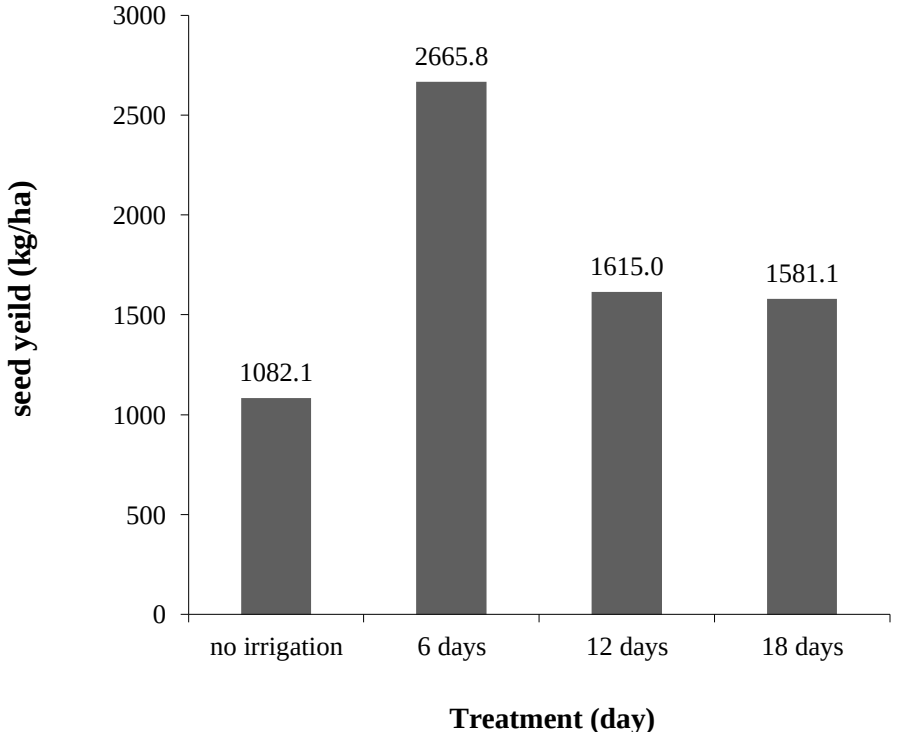

Fig 1. The effect of irrigation on seed yield of peanut

Vorassot et al. (2004) and El-Boraie et al (2009) introduced dryness stress as a factor in reduced seed yield of peanut.

The effect of irrigation on seed oil

According to table 6, the effect of irrigation on oil content was not significant. In other words, different irrigation regimes (including dry farming) did not affect seed oil content of peanuts. However, it seemed that irrigation with frequency of 6 days was the most appropriate irrigation, indicating the change in oil percent from 47.3% in dry farming, to 48.6%. According to Tables 6 and 7, the ANOVA and mean comparison indicated that the amount of nitrogen fertilizer on oil content was significant at level of 1 percent, so that it changed from 46.7% at the treatment with no Nitrogen fertilizer to 49.1% for use of 30 kg of Nitrogen fertilizer.
According to Table 8, the interaction of irrigation and nitrogen fertilizer with oil content was significant at the level of 5 percent. The highest impact was observed in treatment of irrigation frequency of 6 days and nitrogen fertilizer of 30 kg.

The effect of irrigation on seed protein content

ANOVA of the effects of irrigation on seed protein of peanut showed that the protein content in different treatments under irrigation frequency is significant at level of 5 %. The maximum amount of seed protein was obtained for the treatments of irrigation frequency of 12 days (Tables 7 and 8). Since during the period of peanut pods growth under the soil, first inside the pod is filled with starch, and protein formation and oil synthesis begins after a while, the effect of irrigation on the protein content is higher than the oil content. As a result, irrigation treatments impact on seed protein content was higher and significant ((Tabatabaei et al., 2000), (Harrow et al., 2008). However, the effect of nitrogen fertilizer on protein content was not significant.

According to the ANOVA, interaction of irrigation and nitrogen fertilizer with protein content was significant at the level of 5 percent (Table 6).

Table 6. ANOVA for qualitative parameters based on the irrigation frequency and Nitrogen fertilizer (2013-2014)

Source of variation	Degree of freedom	Protein content (%)	Oil content (percent)
Replication	2	2.702ns	3.356ns
Irrigation	3	6.266*	9.307ns
Error	6	0.779	4.230
Nitrogen fertilizer	3	2.195ns	15.322**
Irrigation ×Nitrogen fertilizer	9	5.433*	5.747*
Error	24	2.291	2.929
	CV٪	5.42	3.600

ns, *, **,: no significant difference, significant difference at level of 1%, significant difference at level of 5%, respectively.

Table 7. Comparing the average qualitative parameters based on irrigation frequencies and Nitrogen fertilizer in peanut

Treatments	Protein content (%)	Oil content (%)
No irrigation	27.3 b	47.3 ab
6 days	27.35 b	48.6 a
12 days	28.3 a	47.9 ab
18 days	28.76 a	47.4 b
No treatment	28.21 a	46.7 b
30 kg/ha	27.48a	49.1 a
60 kg/ha	27.66 a	46.8 b
90 kg/ha	28.37 a	47.8ab

Table 8. interaction of irrigation frequency and Nitrogen fertilizer on qualitative parameters of peanut

Irrigation frequency treatments	Protein content (%)	Oil content (%)	Nitrogen fertilizer treatments
No irrigation	25.85 e	47.7a-d	No fertilizer
	28.23 a-e	47.7 ab	30 kg/ha
	27.07 b-e	45.8 cd	60 kg/ha
	28.04 a-e	46.2 cd	90 kg/ha
6 days	28.75 a-d	46.2 cd	No fertilizer
	25.71 e	49.9 a	30 kg/ha
	28.16 a-e	48.4 abc	60 kg/ha
	26.79 cde	49.8 a	90 kg/ha
12 days	30.07 a	47.3 bcd	No fertilizer
	27.07 b-e	49.4 ab	30 kg/ha
	26.63 de	45.5 d	60 kg/ha
	29.33 ab	49.7 ab	90 kg/ha
18 days	28.16 a-e	47.1 cd	No fertilizer
	28.90 a-d	46.8 a-d	30 kg/ha
	28.77 a-d	48.5 a-d	60 kg/ha
	29.20 abc	48.3 cd	90 kg/ha

The results revealed positive effect of irrigation and nitrogen as methods for increasing yield of peanuts, so that applying irrigation frequency of 6-days and nitrogen fertilizer of 30 kg/ha will result in the highest oil content of 49.9%.

References

1. Anonymous. (1998). The Ministry of Agriculture. Department of Management and Finance, Office of Statistics, Bank of Agricultural Information. Tehran.

2. Anonymous. (2010). Ministry of Agriculture. Database and Statistics of Gilan Agriculture Administration.

3. Pilehvari, Kh., Safarzadeh Vishkaei, M, and Sajedi, N. (2008) The effect of methanol and Zink on the quantitative and qualitative characteristics of peanut in Gilan. *Modern Agriculture Findings Journal*, vol. 2. No. 4.

4. Majnoun Hosseini, A. (1993). *Beans in Iran*, Tehran University Jihad Publications. First Edition.

5. 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: 55-65.

6. 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.

7.Hungria M., and Vargas M.A.T. 2000. Environmental factors affecting N2 fixation in grain legumes in the tropics, with an emphasis on Brazil. *Field Crops Res*. 65. 14: 151–164.

8. Li, Y., Gupta, G., Joshi, J. M. and Siyumbano, A.K. 1995. Effect of methanol on soybean photosynthesis and chlorophyll. *J. Plant Nutr*. 18:1875-1880.

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

10. Soxhlet, F. Die gewichtsanalytische Bestimmung des Milchfettes, Polytechnisches J. (Dingler's) 1879, 232, 461

11. 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.

12. Tabatabaei S.A., Normohammadi Gh., Hashemi Dezfoli A., and Majidi Heravan A. 2000. Evaluation of effect of different irrigation regimes and planting dates on different traits and water use efficiency of pearl millet (nutrifid variety). *Iranian Journal of Agricultural Science.* 31: 59-70.

13. Vorasoot N., Akkasaeng C., Songsri P., Jogloy S., and Patanothai A. 2004. 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.

14. Webber H.A., Madramootoo C.A., Bourgault M., Horst M.G., Stulina G., and Smith D.L. 2006. Water use efficiency of common bean and green gram grown using alternate furrow and deficit irrigation. *Agricultural water management*. 10: 259 – 268.