Diyala Journal for Pure Science

Evaluating the Effect of Four Irrigation Water Levels on the Quantity and Quality of Soybean Crop Yield in Moara Domneasca of Romania

Kanan M. Kadir

College of Agriculture engineering science – Garmian University – As Sulaymaniyah – KRG of Iraq

can3an.mad@hotmail.com

Received: 2 February 2020 **Accepted: 15 April 2020**

DOI: https://dx.doi.org/10.24237/djps.16.04.528A

Abstract

In order to quantitatively and qualitatively evaluate soybean yield under conditions of reducing the amount of irrigation water, a field experiment was carried out according to the design of the randomized whole lots with four replicates and four treatments in Moara Dominica in Romania in 2015 included four irrigation levels and as follows the first treatment (T1) with a decrease of 40 % Of the water requirement and treatment (T2), a decrease of 20% of the water requirement. As for the treatment (T3), irrigation was carried out according to the water requirement and the fourth treatment (T4), irrigation was carried out using a 20% increase over the water requirement. The study included in addition to the grain yield, the measurement of the biological yield, the weight of dry stems, pods, protein, protein and oil yield and water efficiency. The highest and lowest quantities of cereals were recorded 1950 kg. h^{-1} and 1085 kg. h^{-1} in T4 and T1 respectively. Reducing the amount of irrigation water results in a decrease in the crop yield and the percentage of oil in the seeds. The rate of oil decrease in seeds was more severe compared to other indicators. The oil yield in transactions (T2) and (T1) decreased significantly compared to the control treatment (T3).

Evaluating the Effect of Four Irrigation Water Levels on the Quantity and Quality of Soybean Crop Yield in Moara Domneasca of Romania

Kanan M. Kadir

Water productivity indicators showed a clear effect of the amount of irrigation water on all indicators of this study. Depending on the efficient use of water we can conclude that T2 was the best treatment compared to other treatments.

Keywords: Deficit irrigation, Moara Domneasca, Oil seed crop, Soybean, Water stress.

تقييم تأثيرأربعة مستويات لمياه الري في كمية ونوعية محصول فول الصويا في مورا دومنيسكي في روماني

كنعان مدحت قادر

كلية العلوم الهندسية الزراعية - جامعة گارميان – السليمانية – حكومة اقليم كردستان العراق

الخلاصه

من اجل التقييم الكمي و النوعي لانتاج محصول فول الصويا في ظل ظروف تقليل كمية ماء الري، نفذت تجربة حقلية وفق تصميم القطعات الكاملة المعشاة بأربعة مكررات وأربعة معاملات في موارا دومنياسكا برومانيا سنة 2015 تضمنت أربعة مستويات ري وعلى النحو التالي المعاملة الأولى (T1) بانخفاض 40% من المتطلب المائي والمعاملة (T2) بانخفاض بنسبة 20% من المتطلب المائي أما المعاملة (T3) فقد تم الري حسب المتطلب المائي والمعاملة الرابعة (T4) فقد تمت الري باستخدام زيادة 20% عن المتطلب المائي. شملت الدراسة اضافة الى حاصل الحبوب، قياس الحاصل البايولوجي، ووزن السيقان الجافة ، والقرون، والبروتين، وحاصل البروتين والزيت و كفاءة استخدام المياه. سجلت أعلى وأدنى كمية لحاصل الحبوب 1950 كغم.هـ$^{-1}$ و 1085 كغم. هـ$^{-1}$ في المعاملتين T4 وT1 تتابعا. تقليل كمية ماء الري نتج عنه انخفاض في كمية المحصول و نسبة الزيت في البذور. كان معدل انخفاض الزيت في البذور اكثر حدة مقارنة بغيريها من الموءشرات المدروسة. إنخفض حاصل الزيت في المعاملات (T2) و (T1) بشكل ملحوظ قياسا بمعاملة المقارنة (T3). موءشرات انتاجية المياه اظهرت انخفاضا تأثيرا واضحا لكمية مياه الري على جميع مؤشرات الدراسة . أخذا بنظر الاعتبار كفاءة استخدام الماء يمكن القول إن المعاملة T2 كانت الافضل بين بقية المعاملات.

كلمات المفتاحية: العجز الاروائي، موارا دومنياسكا، حاصل الزيت في البذور، فول الصويا، الاجهاد المائي.

Diyala Journal for Pure Science

Evaluating the Effect of Four Irrigation Water Levels on the Quantity and Quality of Soybean Crop Yield in Moara Domneasca of Romania

Kanan M. Kadir

Introduction

Soybean is one of the oldest crop plants and one of the major sources of vegetable oil and protein production [1]. Soybean plant could be used as pasture, dry forage, green manure or fresh forage. Soybean has excellent nutritional value, and it is widely used in food products. Soybean meal is used in animal feed. One of the most important environmental factors to detect the seed yield is the condition of the soil humidity. Water deficit stress is one of the limiting factors in soybean growth [2]. Water deficit stress at the vegetative growth stage decreases plant growth rate. Amount of soybean water consumed due to changing weather conditions, management and length of growing season is deferent [3]. Low Irrigation, offering water less than the actual water requirement of the plant (approximately equivalent to evapotranspiration). Less irrigation strategy, deficit irrigation is used to reduce water consumption and increase water use efficiency. The required conditions for the success of this strategy include the precise determination of the plant's water need under drought stress conditions. To determine the amount of water needed for planting in low irrigation conditions, the physiological characteristics of the plant, how the plant responds to drought, and information on weather conditions during the stress period are required [4]. In fact, deficit irrigation is a desirable solution for the productive crop under water scarcity, which could be offset by crop loss per unit area by increasing crop area [5]. Amini Farr *et al.* [6] concluded that soybean yield was significantly decreased by reducing irrigation on soybean yield. Babazadeh and coauthor to investigate the effect of deficit irrigation on qualitative traits and some morphological traits of soybean, depletion of irrigation reduced soybean growth and increased soybean cultivation period [7]. Vira *et al.* [8] stated that reduced water stress by reducing grain filling duration reduced seed size and significantly decreased seed yield (32 to 42 percent). The highest yield was obtained when the environmental conditions of the moisture content are available at all stages of plant growth to a desirable level [9]. Reduction of stomatal conductance, decrease in burn rate and carbon footprint have been found as factors contributing to reduced yield under water scarcity conditions [10]. The results of earlier studies showed that crop quality is also affected by irrigation conditions. Protein and grain oil content are the most important characteristics of soybean product which have been studied in some earlier studies. Kober and Veldang showed that the relationship between protein and soybean oil content is usually inverted, with one of them increasing, the other decreasing [11]. The amount of water consumed also varies depending on the change in water status, management and the length of the growing season [12]. Water productivity is one of the most important indicators in using water resources [13]. Evaluation of agricultural water productivity in plants or in the field is based on yield per cubic meter of water consumed [14]. Sinit and Kramer stated that to evaluate the low-irrigation strategy and improve water productivity, the selective irrigation system is effective in using a certain amount of water and is very effective in increasing yields. Researchers differ on the effects of different levels of irrigation on water productivity, with some reporting an increase in low irrigation conditions [15]. Many studies argued that the highest water productivity is achieved under best irrigation conditions and decreases water productivity by decreasing the amount of water consumed [16]. Due to limit water resources and reduced rainfall in recent years, irrigation water efficiency in crops, developing an appropriate irrigation plan is inevitable. In most previous studies in Romania, the effect of deficit irrigation has mainly been investigated on quantitative yield and little has been done on the effect of deficit irrigation on its quantitative and qualitative yield. Since soybean cultivation has not been common in Moara Domneasca region of Romania, this study needs to investigate the quantitative and qualitative characteristics of soybean product in Moara Domneasca region under irrigated conditions.

Materials and Methods

The experiment was conducted in 2015 at the research farm of Moara Domneasca region of Romania. The soil texture of the test site loam hydrometry. The meteorological characteristics of the experiment site during the experiment are as follows in table 1. The experiment was conducted in a randomized complete block design with four replications in four irrigation treatments. Treatments consisted of four levels of irrigation with 40% low irrigation (T1), 20%

low fertilizer (T2), complete irrigation (T3) and 20% full irrigation (T4). The reason for choosing T4 treatment was the uncertainty in the accurate estimation of crop evapotranspiration potential due to possible errors in the calculation of reference evapotranspiration and crop potential. Seeding was done by barley and stack by hand on June 24, 2015. Each plot was cut into four horizontal rows in eight vertical rows. The spacing between the rows was 50 cm, and the distance between plants on each row was 5 cm. Before sowing, the seeds were treated with fungicide. Weeds were removed manually. An equal amount of water was added during germination period. Treatments were carried out from the fourth irrigation with a 7-day cycle. Irrigation was performed by hose and volume contour with a accuracy of 1% liter. The amount of water needed for irrigation was calculated through the www. Fieldclimate.com site information. The daily meteorological information was sent to the www. Fieldclimate.com site for analysis by the Intelligent Weather Station at Moara Domneasca region. Field meteorological information is transmitted hourly to GPRS via mobile. On this site, the potential evapotranspiration (ETo) of the reference plant is calculated daily on the basis of the average daily meteorological data using the modified FAO Penman Monteith formula. The site calculates the evapotranspiration and transpiration potential of the crop from the reference evapotranspiration potential of the reference plant at the same crop coefficient and is included in the defined farm water requirement table. Before any irrigation, water requirement was extracted from the previous irrigation site and considered as T3 treatment water requirement. The amount of water required for T1, T2 and T4 treatments was 60%, 80% and 120% of control water requirement (T3), respectively. After each irrigation, the site was re-visited and the depth of irrigation water applied to the T3 treatment was entered for the day of irrigation. The total volume of irrigation water applied during soybean growth is presented in Table 2. At the physiological ripening stage, the final harvesting operation was done manually. The Final harvest date for T1, T2, T3 and T4 treatments was on days 3, 5, 10 and 11, respectively, in October of 2015. The reason for the earlier harvesting of the low-irrigation treatments was the faster productivity of these treatments. At the time of each crop, two square meters were taken from two rows (160 plants) in the middle of each plot, and seed weight, stem weight, pod weight and plant weight were measured. To determine the dry weight of each plant organ, the samples were dried in oven for 70 h at 70 ° C and then weighed.

In the laboratory, the percentage of protein was determined by using Soxhlet fat percentage and Kjeldahl method. The obtained data were analyzed using MSTATC software and the means were compared using Duncan's multiple range test.

Table 1: Average of meteorological parameters at the research farm during the growth season of soybean in 2015

Parameter	June	July	August	September	October
Maximum temperature (^{0}c)	39.8	41.6	42.9	41.2	30.6
Minimum temperature (^{0}c)	9.9	11	15.9	11.1	11.5
Sunshine hours (hr)	10.7	11.2	10.9	11.3	9.06
Wind speed (m. s^{-1})	4.36	4.14	4.42	3.62	5
Potential evapotranspiration (mm. day^{-1})	7.4	8.2	8.1	6.7	5.9
Rainfall (mm)	0	0	0	0	0
Average relative humidity (%)	25	22	18	17	28

Table 2: Total volume of applied irrigation water in the studied treatments

Treatment	Percentage of irrigation	Amount of seasonal irrigation	
		Cubic meter per plot	Cubic meter per hectare
T1	(40% less irrigation)	8.04	4498.77
T2	(20% less irrigation)	10.38	5966.99
T3 (Control)	(full irrigation)	12.73	7442.12
T4	(20% over irrigation)	15.08	8899.44

Results and Discussion

The results of analysis of variance of the studied traits at different irrigation levels are presented in table 3. These results are discussed separately in each trait.

Table 3: Analysis of variance traits soybean in different irrigation levels

Source of variations	Degree of freedom	Mean of squares							
		Oil percent	Protein percent	Performance of grain oil	Performance of grain protein	Dry weight of pod	Dry weight of stem	Performance of biomass	Performance of grain
Replication	3	4.473	1.839	182 ns	166 ns	1895 ns	27888 ns	256661 ns	8951 ns
Treatment	3	37.153	14.668*	58518 **	29046 **	19828 **	51463 ns	2094290 *	571815 **
Error	9	3.93	3.445	919	3636	7228	983166	408443	13456

* Significant at 5% probability level, ** Significant at 1% probability level, and ns non-significant

Grain yield

Grain yield is one of the most important traits evaluated in seed crops such as soybean. Analysis of variance showed significant effect of deficit irrigation treatment on grain yield (at 1% probability level) (Table 3). By decreasing the amount of water applied, grain yield was decreased (Table 5). Soybean in T1 and T2 treatments yielded 20% and 36% less than T3 treatment, respectively, but T4 treatment showed a 13 % increase in yield compared to T3 treatment (Table 5). Reaching the crop faster in low irrigation treatments means shorter reproductive stage (grain filling) which results in lower yield in these treatments. T4 and T3 treatments were in one statistical group, and the other two treatments were divided into two separate groups (P value = 0.05). The reason for the T4 and T3 treatments being in a statistical group is that the crop has reached its best yield in the complete irrigation treatment and the seeds have almost reached their greatest growth. By 20% more irrigation, grain yield increased by 13% and this increase did not cause a significant difference between the two treatments. A 13% increase in grain yield in T4 treatment relative to T3 treatment indicated that T3 treatment did not meet the potential conditions and considering 120% water requirement was reasonable.

Biological yield

This trait is one of the main characteristics of plants affected by yield components. Mean comparison of treatments showed that the highest yield belonged to T4 and the lowest to T1 (Table 4). However, the difference between biological yield in T2 and T3 treatments was not significant (P value ≤0.05). With decreasing the amount of irrigation, biological yield was decreased as grain yield (with less intensity). Maximum yield reduction in T1 treatment was 24% compared to T3 treatment (Table 5).

Table 4: Mean comparison of studied soybean traits in the irrigation treatments

Irrigation treatment	Protein percentage of grain (%)	Oil Percentage of grain (%)	Grain protein (Kg.ha^{-1})	grain oil (Kg.ha^{-1})	Dry weight of pod (Kg.ha^{-1})	Dry weight of stem	Biomass (Kg.ha^{-1})	Dry grain (Kg.ha^{-1})
T1	32 b	17.2 c	347 b	161 d	771 b	1588 a	3578 c	1085 c
T2	30 ab	20.07 bc	399 ab	185 c	955 b	1655 a	4095 bc	1368 b
T3	30 ab	21.62 ab	492 a	353 b	116 a	1795 a	4714 ab	1717 a
T4	38a	24.4 a	519 a	455 a	128 a	1825 a	5113 a	1950 a

Stem dry weight

Although the different levels of irrigation affected the dry weight of the stems, the statistical analysis showed no significant differences between the treatments (Table 4).

Pod dry weight

With the decrease in available moisture, the emergence of pods was delayed, subsequently, irrigation deficiency significantly affected the seed filling stage. The shearing stage is one of the most sensitive stages of soybean growth due to water scarcity. By applying stress, the number of pods per plant decreases and consequently the grain yield decreases.

According to the results of analysis of variance (Table 3), there was a statistically significant difference at (P value $\leq$ 0.01). Mean comparison showed that two treatments T3 and T4 were in one statistical group, and two treatments T1 and T2 were in another statistical group (Table 4). Decrease in pod yield in low irrigation condition was estimated about 90% decrease in grain yield (Table 5).

Grain protein yield and percentage

Analysis of variance among different irrigation treatments for soybean protein showed that there was a significant difference between these treatments at (P value $\leq$ 0.05). The maximum protein content of soybean seed was 38% in T4 and the lowest protein content was in T3 and T2 (Table 4). Generally grain protein content decreased with the decrease in irrigation water requirement. Kuber and Veldang [11] also stated that irrigation had a significant effect on soybean protein content.

Grain oil yield and percentage

Analysis of variance of the effect of low irrigation treatments on soybean oil percentage showed that there was a significant difference between treatments (p value $\leq$ 0.01) (Table 4). In this study, T4 treatment had the highest percentage of oil and grain oil content . With increasing irrigation water, oil percentage of soybean seed increased . The lowest oil percentage was related to the 40% irrigation treatment T1. Due to low irrigation of grain yield and reduced oil percentage, this has led to a sharp decrease in oil yield. The highest percentage of oil yield reduction was observed at 50% in 40% dehydration, and in 20% moisture treatment 27% decrease in oil yield was observed (Table 5). The results of this study are consistent with the results presented by Oweis *et al.* [17] and are not consistent with the report presented by Karrou and Oweis [18]. Farooq *et al.* [19] reported a significant effect of water restriction on the storage of protein and oil content in soybean seeds, but also decreased with increasing dehydration of oil and protein production per unit area, while Ferers and Soriano [20] mentioned that drought stress had little effect on soybean oil and protein levels. Oweis *et al.* [21] reported that drought stress increased soybean oil and protein.

Productivity index relative to grain, biological, oil and protein yields

Specificity of irrigation water productivity in different irrigation treatments showed that T1 had more productivity in terms of grain yield and biological yield than other irrigation treatments (Table 6). Although the mentioned treatment had significantly lower seed yield than T4 treatment, but for quantitative and qualitative limitation of water resources during T1 treatment plant growth can be a good choice. According to the results of this experiment the increasing in seed yield and biological yield was due to increase in water productivity index (Table 2), the highest irrigation volume was obtained in T4 treatment with 8899 m3 . ha^{-1}. Due to the dry matter content in the consumed water, this treatment had low yield. The results showed that in general, with increasing drought stress water productivity decreased with respect to oil and protein yield. According to the results of water productivity with respect to oil yield, three treatments T2, T3 and T4 were in one statistical group, and T1 was placed in another statistical group, while according to the results of water productivity in relation to protein yield, all treatments were in one statistical group and no significant difference was observed among all irrigation treatments (Table 6).

Table 5: Relative changes of studied soybean traits in irrigation treatments

Irrigation treatment	Performance of grain protein	Performance of grain oil	Dry weight of pod	Dry weight of stem	Performance of biomass	Performance of grain
T1	-32.3	-50.1	- 34.5	- 12.3	- 25	- 37.7
T2	-19.9	- 27.2	- 19.7	- 8.3	- 14.1	- 21.6
T3	0	0	0	0	0	0
T4	+5.48	+ 29.6	+10.5	+ 3	+ 9.2	+ 14

Table 6: Means Comparison water productivity of soybean traits

Irrigation treatment	Water productivity to performance of protein	Water productivity to performance of oil	Water productivity to performance of biomass	Water productivity to performance of grain
T1	0.088 a	0.05 b	0.91 a	0.25 a
T2	0.078 a	0.055 a	0.79 b	0.24 b
T3	0.077 a	0.058 a	0.65 b	0.24 b
T4	0.060 a	0.062 a	0.68 c	0.23 b

Conclusion

The results showed that grain yield and biological yield were significantly decreased by decreasing the amount of water consumed. The highest yield was obtained in T4 treatment and the lowest in T1 treatment. The two treatments also showed the highest yield of water compared to grain yield and biological yield, respectively. This indicates that T3 treatment did not have the recurred conditions. Therefore, it is suggested that similar studies of T4 treatment be defined in uncertainty studies due to the uncertainty in estimating the water need of crops. The soybean seed oil content and protein content significantly decreased with with increasing water stress. Because of deficient irrigation both reduces yield and decreases oil percentage, as a result, the amount of oil produced is drastically reduced. According to the results obtained for water resources storage, T2 treatment is the best option for recommending low irrigation. Because T2 treatment has good oil content, protein and yield. Since the main purpose of soybean cultivation is to produce oil, so low irrigation for soybeans irrigation should be done cautiously and require an economic review.

Diyala Journal for Pure Science

Evaluating the Effect of Four Irrigation Water Levels on the Quantity and Quality of Soybean Crop Yield in Moara Domneasca of Romania

Kanan M. Kadir

References

1. M. Mahluji, M. Karimi, S.F. Mousavi, Iran Journal for Agriculture Science, 31(11), 445-454 (2009).
2. E.A. Brown, C.E. Caviness, D.A. Brown, Agronomy Journal, 77 (2), 274-278 (1985)
3. S. Kang, W. Shi, J. Zhang, Field Crop Research,67(3), 207-214 (2000).
4. J.O. Payero, S.R. Melvin, S. Irmak, ASABE, 48(6), 2189- 2203 (2005)
5. B. Behtari, K. Ghassemi – Golezani, A. Dabbagh - Mohammadi Nasab, S. Zehtab – Salmasi, M. Tourchi, JOURNAL OF AGRICULTURAL SCIENCE (UNIVERSITY OF TABRIZ), 17(4), 65-73 (2008).
6. J.Aminifar, G.H. Mohsenabadi, M.H. Biglouei, H. Samiezadeh, IRANIAN JOURNAL OF FIELD CROPS RESEARCH, 10 (2),428-434(2012).
7. H. Babazade, M. Sarai Tabrizi, Journal Soil Water, 26 (2),329-339 (2012).
8. R.D.Vieira, D.M. Tekrony, D.B. Egli, Crop Science, 32 (2), 471-475 (1992).
9. F. Karam, R. Masaad, T. Sfeir, O. Monzer, Y. Rouphael, Agricultural Water Management, 75 (3), 226-244 (2005).
10. A.M. González-Rodrıguez, A. Martın-Olivera, D. Morales, M.S. Jiménez, Environmental and Experimental Botany, 53 (2),195-204 (2005).
11. E.R. Cober, H.D. Voldeng, Crop Science, 40 (1), 39-42 (2000).
12. G.H. Khajouei Nejad, H. Kazemi, H. Alyari, A. Javanshir, M.J. Arvin, J. Sci. Tech. Agri. Natural. Res. Water. Soil. sci, 9(4),137-151 (2006).
13. E. Hobbs, H. Mundel, Can. J. Plant Sci, 63 (4), 855-860 (1983).
14. M. Karimi, M. Esfahani, M.H. Bigluei, B. Rabiee, A. Kafi Ghasemi, J. Crop Prod, 6(2), 91-110 (2009).
15. Sinit N. and Kramer P. 1997. Agron. J, 69 (2), 274-277.
16. B. Pasban-Eslam, S.H. Mehrniya, M. Roshdi, J. Plant Prod, 18 (2), 45-60. (2011).
17. T. Oweis, A. Hachum, M. Pala, J. Agri. Water Manag, 68 (3), 251-265 (2004).
18. M. Karrou, T. Oweis, J. Agri. Water Manag, 107, 94–103 (2012).

19. M. Farooq, A. Wahid, N. Kobayashi, D. Fujita, S.M.A. Basra, J. Agron. Sustain. Dev, 29 (1), 185-212 (2014).

20. E. Ferers, M.A. Soriano, M.A, Deficit irrigation for redusing agricultural water use. J. Exp. Bot, 58(2), 147-159 (2007).

21. T. Oweis, A. Hachum, M. Mantal, M. Pala, Lentil production under supplemental irrigation in a Mediterranean environment. J. Agri. Water Manag, 69(4), 231-235 (2008).