International Journal of Research in Agriculture and Forestry
Volume 4, Issue 7, 2017, PP 9-19
ISSN 2394-5907 (Print) & ISSN 2394-5915 (Online)

Yield Response of Faba Bean to Various Irrigation Strategies in the Mediterranean Region

Attila Yazar[1], Dürdane Mart[2], Yeşim Bozkurt Çolak[3], Çiğdem İnce Kaya[4]

[1]*Çukurova University, Irrigation and Agricultural Structures Department, Adana, Turkey*
[2]*Çukurova Agricultural Research Institute, Adana, Turkey*
[3]*Alata Horticultural research Institute, Soil and Water Resources Research Unit, Tarsus, Turkey*
[4]*Adana Agricultural Directorate, Adana, Turkey*

***Corresponding Author:** Attila Yazar, Çukurova University, Irrigation and Agricultural Structures Department, Adana, Turkey*

Received Date: 08-08-2017 ***Accepted Date: 16-08-2017*** ***Published Date:05-09-2017***

ABSTRACT

Faba bean experiment was set up in 2009 through 2011 at the Hacıali Farm of the Cukurova Agricultural Research Institute in Adana, Turkey, in order to evaluate the effect of full, deficit irrigation partial roort-zone drying (PRD) applied during the faba bean growing season on growth, yield, yield components, and water productivity under the Mediterranean climatic conditions. In the study, four different treatments were tested under the Mediterranean climatic conditions. These treatments are: full irrigation (FI), deficit irrigation (DI), partial root-zone drying (PRD) and non-irrigated treatment (DRY). Full irrigation (FI) treatment plots were irrigated at weekly interval throughout the growing season and weekly soil water deficit in the effective root zone depth was replenished to field capacity. DI and PRD treatment plots received 50% of the water applied to FI plots. In PRD treatment plots, drip laterals laid out at the center of adjacent crop rows supply water in an alternate matter. Thus, half of the root-zone remains dry. Experiment was designed as randomized blocks with four replications. A local faba bean (Vicia faba) variety ERESEN-87 was used.

Due to sufficient rainfall received during the 2009 and 2011 growing seasons no irrigation was applied and average faba bean yield of 4206 kg per ha was obtained. In 2010, although faba bean was irrigated differentially but there was no significant difference in yields and yield components among the treatments, and yields were generally lower than those in 2009 and 2011. In 2011 year, treatments produced greater average yield (5448 kg/ha) than in other two years. Water use efficiency values ranged from 0.498 kg/m3 in FI to 0.912 kg/m^3 in DRY treatment in 2010. In irrigated year, WUE decreased with increasing irrigation amount. Therefore, it can be concluded that faba bean can be grown under rainfed conditions in the Mediterranean region of Turkey, however suplemental irrigation can increase significantly faba bean yields in below average rainfall years.

Keywords: *Supplemental irrigation, deficit irrigation, water use efficiency*

INTRODUCTION

In the dry areas, water, not land, is the most limiting resource for improved agricultural production. Maximizing water productivity, and not yield per unit of land, is therefore a better strategy for dry farming systems. Under such conditions, more efficient water management techniques must be adopted. Supplemental irrigation (SI) is a highly efficient practice with great potential for increasing agricultural production and improving livelihoods in the dry rainfed areas (Oweis and Hachum, 2006; Tavakoli et al., 2010; Sommer et al., 2011). Irrigated agriculture in dry areas mostly confront with water shortages due to limited amount of water available for agriculture and competition with other water-use sectors. Therefore, irrigation practices in dry areas needs to be highly efficient and productive where deficit irrigation can play a crucial role to increase water-use efficiency and save water for use in other areas (Du et al., 2010; Karrou and Oweis, 2012).Using deficit irrigation, the amount of irrigation water used is less than the full requirement of the crop, thereby compromising on small reduction in yield but saving considerable amount of water for use on other land.

Faba bean (*Vicia faba*) is one of the oldest crops domesticated in the Near East and grown by man providing high-protein seeds for human consumptions and quality straw for animal feed. It is one of the most important cool-season food legumes in the world. Faba bean is the fourth most important pulse crop in the world. The total cultivated area is 2.4 million ha with a production of 4.5 million metric tons (FAO-STAT, 2016). Faba bean (*Vicia faba* L.) is one of the major winter-sown legume crops grown in the Mediterranean region. The period during which the crop's evaporative demand is high coincides with the end of the rainy season; thus, faba bean experiences considerable soil moisture stress during the reproductive growth stage and often produces poor yields. Limited water supply through supplemental irrigation (SI) can boost and stabilize faba bean production (Manzoor, 2013).

Drought is one of the most important environmental constraints to crop productivity (Chaves et al. 2003). Faba bean is reputed to be more sensitive to drought than other grain legumes (McDonald and Paulsen, 1997; Amede and Schubert, 2003). In many of the production regions of Mediterranean region (Sau and Mínguez, 2000), Western and Central Europe (Link et al. 1999), faba bean generally relies on stored soil moisture and current rainfall for its growth and development. The crop often experiences intermittent drought during vegetative growth and in many areas, suffers from terminal drought during reproductive development (Wery et al., 1994; Siddique et al., 2001; Ricciardi et al., 2001). Generally, the differences in the amount and distribution of rainfall are the major reasons for variability in seed yield of faba bean (Bond et al., 1994; Abdelmula et al., 1999). Supplemental irrigation during those periods reduces pod abortion and is expected to have a significant impact on final yield. The amount and distribution of rainfall during the season greatly affects rainfed faba bean yield. Therefore, sowing date would have a profound influence on crop performance because of the environmental conditions to which various phenological stages of the crop will be exposed. Experiments on rainfed faba beans, including a range of sowing dates from end of October to beginning of February, were conducted in Syria and Lebanon during the 1980s (Saxena et al., 1991). Results indicated that the optimal sowing time for high seed yield and yield stability is the first half of December (Oweis et al., 2005).

Faba bean is cultivated under rainfed above 450 mm of rainfall, full and supplemental irrigation conditions. It is commonly grown in dry areas under the fragile agro-ecosystems where drought and temperature extremes are of common occurrence with varying intensity and frequency. These stresses are predicted to rise further in intensity, frequency and uncertainty under climate change with cascading effects on their production unless these crops are manipulated genetically to adapt to the future production environment and/or the latter is manipulated agronomically to suit the crop requirement (Maalouf et al., 2013).

Field experiments on faba bean sown at different dates were conducted during three consecutive winter seasons (1998–1999 to 2000–2001) in northern Jordan (Turk and Tawaha, 2002).

Early sowing significantly increased seed yield of faba bean. The reduction in yield due to delay in sowing could be attributed to shorter growth period. Under early sowing, flowering, and pod filling were largely completed before the onset of moisture stress and rising temperature in spring thus help faba bean to escape the drought.The objective of this study is to evalualte the effect of supplemental irrigation, full and deficit irrigation on yield and yield components as well as water productivity of faba bean under the Mediterranean climatic conditions in Turkey.

METHODS

Exprimental Site, Soil and Climate

The faba bean experiment was set up at the Hacıali Farm of Çukurova Agricultural Research Institute (36^{o}48’ N and 35^{o}17’ E, 7 m msl), in Adana, Turkey in 2008/2009 through 2010/2011. Typical Mediterranean climate prevails in the experimental area. Mean annual rainfall is 650 mm, and about 65 % of total falls during the winter months. The soil at the site is a fine textured, but texture varies from upper to lower layer. The soil is calcareous throughout the profile, and low in organic matter (about 1.3

%). Water table depth is several meters below the soil surface in the area. Some physical and chemical properties of the experimental soil is given in Table 1a and Table 1b, respectively.

Table1. *Physical properties of experimental soil at Hacıali Farm*

Depth	Sand	Silt	Clay	Texture	Bulk Density	Field Capacity	Wilting Point
cm	%	%	%	Class	g/cm^3	%	%
0-30	15.5	40.4	44.1	SiC	1.26	30.19	17.12
30-60	10.1	46.1	43.8	SiC	1.28	29.8	17.27
60-90	18.1	50.0	31.9	SiCL	1.25	26.01	13.67
90-120	54.7	28.4	16.9	SL	1.54	13.61	7.15

Table2. *Chemical and productivity properties of experimental soil at Hacıali Farm*

Depth cm	Saturation %	ECe dS/m	Total Salt %	Plant Available		Organic Matter %	Total N %	Organic Carbon %
				P_2O_5	K_2O			
0-30	66	1.181	0.050	2.87	77.10	1.36	0.07	0.79
30-60	66	1.023	0.043	0.54	50.13	0.96	0.05	0.56
60-90	60	0.935	0.036	0.23	30.11	0.56	0.03	0.32
90-120	46	0.684	0.020	0.31	24.33	0.15	0.01	0.09

Soil has silty-clay texture in the upper 60 cm, and silty-caly-loam in 60-90 cm soil layer, and sandy-loam in the 90-120 cm soil layer. Thus water holding capacity decreases with depth in the profile. Soil salinity (ECe) varies from 0.684 dS/m in 90-120 cm layer to 1.181 dS/m in 0-30 cm soil layer. Organic matter content decreases with increasing depth in the profile.

Experimental Design and Treatments

Experiment was designed as randomized blocks with four replications. In the study, four different treatments in Faba bean were tested under the Mediterranean climatic conditions. These treatments are: full irrigation (FI), deficit irrigation (DI), partial root-zone drying (PRD) and non-irrigated treatment. Full irrigation (FI) treatment plots will be irrigated at weekly interval throughout the growing season and weekly soil water deficit in the effective root zone depth will be replenished to field capacity. DI and PRD treatment plots will receive 50% of the water applied to FI plots. In PRD treatment plots, drip laterals laid out at the center of adjacent crop rows will supply water in an alternate matter. Thus, half of the root-zone remains dry. A drip system was installed in the experiment. Drip laterals of 16 mm in diameter, with discharge of 2 L/h inline emitters spaced at 20 cm apart were laid in the center of adjacent crop rows.

Agronomic Practices and Measurements

A local faba bean (*Vicia faba)* variety ERESEN-87 was planted at 45 cm row spacing and 10 cm on the row with a four row planter on December 12, 2008, December 8, 2009 and on December 12, 2010. Experimental plots were 6 rows wide and 5 m long with four replications. Faba bean was harvested by hand on 2 June, 2009 by cutting all plants in the center 4 rows 6 m long. At planting 120 kg/ha ammonium nitrate (26% N; 30 kg/ha N) and 120 kg triple super phosphate (50-60 kg/ha P2O5) was applied broadcast and incorporated into the soil.

Biomass samples were collected by cutting all the plants in the 50 cm row section at the ground level, then leaf area was measured with an optical leaf area meter (LiCor-3000, Lincoln, NE) and dry matter yield was obtained at two weeks intervals. Leaf area index (LAI) was expressed as leaf area per unit land area.

Soil water was measured with a profile probe at two weeks intervals in the plots. For this purpose, acces tubes were installed at the center of each plot. The profile meter used in the study is ΔT Devices PR2/6 model measures soil water at 6 depths down to 100 cm. The PR2 access tube requires an installation hole 27 mm in diameter, allowing easy installation and minimal soil disturbance.

Crop water use (ET) was estimated based on a one-dimensional water balance equation using soil water measured by the neutron and gravimetric sampling methods. Water use is the total of seasonal water depletion (planting to harvest) plus rainfall and irrigations during the same period. The water balance equation is as following:

$$ET = I + P \pm \Delta S - Dp \quad (1)$$

Where ET is evapotranspiration (mm), I irrigation (mm), P precipitation (mm), Dp deep percolation (i.e., drainage, mm) and ΔS is change of soil water storage in a given time period Δt (days) within plant rooting zone. Deep percolation losses below the root zone are assumed to be negligible in the study.

Water use efficiency (WUE) is computed as the ratio of grain yield to seasonal water use. Irrigation water use efficiency (IWUE) is determined as the ratio of grain yield for a particular treatment minus rainfed yield to the applied water for that treatment. Harvest index (HI) is calculated as the ratio of the grain yield (GY) to above-ground dry matter yield (DM) at harvest.

Data were analyzed with a randomized complete block model using the MSTAT-C (MSTAT-C is a computer based Statistical software packages developed by the Crop and Soil Sciences Department of Michigan State University, USA). Treatment means were compared using Fisher's least significant difference (LSD) test at P = 0.05.

Results And Discussion

Typical Mediterranean climate prevails in the experimental area. Climatic data for the experimental years are given in Table 3. Monthly rainfalls received during experimental years as compared to historical means at Hacıali Farm are provided in Figure 1. The 2009 growing season is unexceptionally wet year after experiencing several years of dry years in the region. Monthly rainfall received in the experimental area was 157 mm in January, 140 mm in Februray, 138 mm in March and 11 mm in the first two weeks of April. Therefore, no supplemental irrigation was applied in this growing season in 2009. However, 2010 season was relatively drier as compared to previous year Monthly rainfall received in the experimental area in 2010 was 105 mm in January, 54 mm in February, 2.6 mm in March and 38.6 mm in April, and 0.4 mm in May. The 2011 growing season was relatively wet year as compared 2010. Monthly rainfall received in the experimental area was 70 mm in January, 99 mm in February, 110.5 mm in March and 76.6 mm in April, 59.5 mm in May and, 67.2 mm in June (Figure 1).

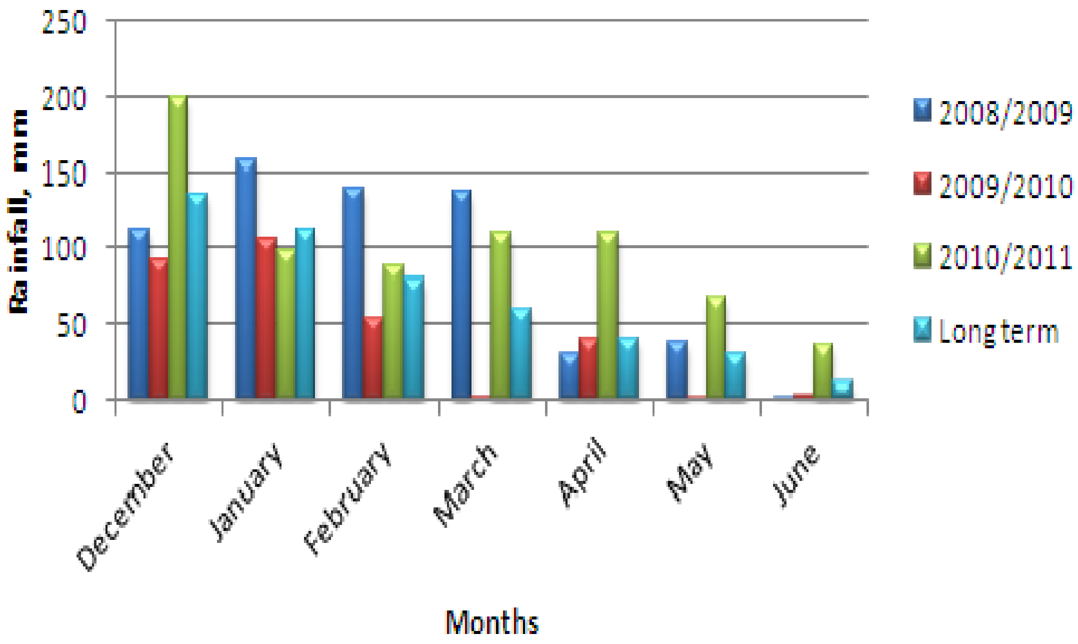

Fig1. *Monthly rainfalls received during experimental years as compared to historical means at Hacıali Farm.*

Table3. *Monthly mean climatic data for the experimental years of 2009/2010 and 2010/2011 at Haciali Farm.*

Climatic Parameter	Nov.	Dec.	Jan.	Feb.	March	April	May	June
	2008/2009							
Mean Temp. °C	15,7	8,8	8,9	10,3	12,1	16,7	21	25,8
Max. Temp., °C	27,6	23,3	14,1	15,2	17,9	24,6	28,5	33,1
Min. Temp., °C	5,6	-1,4	4,4	6,2	6,9	9,8	14	18,9
Wind Speed, m/s	1,5	1,4	2,0	1,5	1,6	1,0	1,5	1,4
Rainfall, mm	40,2	42	104,3	136	157	36	45	0
Rel. Humidity %	67,2	58,9	68,5	74	62	58	55	53
	2009/2010							
Mean Temp. °C	14,4	12,1	11,1	11,9	14,9	17,6	21,5	24,5
Max. Temp., °C	26,6	21,8	21,6	22,6	28,3	31,7	35,5	30,1
Min. Temp., °C	3,8	3,7	-2,5	-1,7	1,6	7,3	12,4	19,3
Wind Speed, m/s	0,7	0,9	1,4	1,2	0,8	0,8	0,6	1,0
Rainfall, mm	106,2	91,2	105,6	54	2,6	38,6	4,6	0,0
Rel.Humidity, %	80,1	83,7	80,2	77,3	73,4	73,2	76,6	72
	2010/2011							
Mean temp. oC	15,2	10,8	8,4	9,5	11,4	14,9	19,6	23,8
Min. temp., oC	7,6	5,8	3,2	3,2	3,7	8,5	13,1	17,8
Max. Temp. oC	27,1	18,4	14,9	17,1	19,8	22,1	26,9	29,7
Wind Speed, m/s	0,9	0,9	1,20	1,40	0,9	0,77	0,64	0,65
Rel. Humidity %	73,88	86,13	80,80	81,19	82,93	85,48	81,53	83,67
Rainfall, mm	1,8	210,8	96,8	86,4	104,8	109	67,2	36,6

The amount of irrigation water applied, crop water use (Evapotranspiration), grain yield and water use efficiency values in the experimental years are presented in Table 4. No irrigation was applied in 2009 due to above normal rainfall received during the faba bean growing season. Total amount of water applied to different treatments varied from 130 to 260 mm in irrigation treatment plots in 2010. PRD and DI-50 treatment plots received irrigation water varying from 130 mm. Due to rainfalls received during the growing season was well above long-term average, no irrigation was applied to faba bean in 2011. Therefore, measurements were carried out under rain-fed conditions. Seasonal crop water use 642 mm for all treatments in 2009; and ET ranged from 365 to 625 mm 2010. Actual crop evapotranspiration (ET) value in 2011 was 704 mm in all treatments since no irrigation was applied in this particular growing season. Thus, seasonal ET of the faba bean increased with increased irrigation water. Maalouf et al., (2013) reported that faba bean is cultivated under rainfed above 450 mm of rainfall in the Mediterranean region. Since the rainfall in the three growing season was well above 450 mm, so that no irrigation was applied in two out of three years. In the second year of the study although total rainfall was over 650 mm, there were some drought periods during the growing season so that irrigation was applied.

Table4. *The amount of irrigation, evapotranspiration (ET), mean faba bean yield and water use efficiency (WUE) values for different treatments in the experimental years.*

Treatments	I, mm	ET, mm	Mean Yield, kg/ha	WUE, kg/m3
2009				
DRY	0	642	4206	0,655
DI	0	642		
PRD	0	642		
FI	0	642		
2010				
DRY	0	365c	3330	0,912a
DI	130	490b	3244	0,662b
PRD	130	502b	3256	0,649b
FI	260	625a	3110	0,498c
LSD		102	ns	0.210
2011				
DRY	0	704	5448	0,774
DI	0	704		
PRD	0	704		
FI	0	704		

LSD is the least significant difference at P = 0.05.

Faba bean was not irrigated in 2009 growing season due to sufficient rainfall received in that particular season, and average faba bean yield 4260 kg/ha, and 100 bean weight was 169.2 g. There was no significant difference in faba bean yields and most of the yield components among the irrigated and rain-fed treatments in 2010 growing season. Average yields varied from 3110 to 3330 kg/ha among the treatments. In 2011 was also a wet year with sufficient rainfall and no irrigation was applied in this year and an average yield of 5448 kg/ha was obtained (Figure 2). In contrast to the idea that faba bean is a drought-sensitive crop (De Costa et al., 1997; Grashoff, 1990), and low yielding under irrigation (with a yield less than 2.0 t/ha according to Oweis et al., (2005), our results showed that faba bean can give high yields if its water requirements are met by winter rainfalls. Many studies have reported very substantial increases in faba bean seed yields as a result of proper irrigation, including studies in regions where rainfall is abundant throughout the growing season (Krogman et al. 1980; McEwen et al. 1981; Day and Legg 1983; Hebblethwaite et al. 1984; Green et al. 1985; Husain et al. 1988; Grashoff 1990; De Costa et al. 1997). Bryla et al. (2003) reported similar results to our results from the study carried in central California to determine the water requirements for growing fababean (Vicia faba L.) as a winter cover crop using subsurface drip irrigation (SDI) and irrigation had no effect on crop production when rainfall was above normal (>330 mm) and irrigation improved production and water-use efficiency in drier years, however.

Field studies carried out at ICARDA to evaluate the crop production functions of cereals and food legumes under supplemental irirgation in 2007 through 2010. Thier results showed that, in general, the treatment with 1/3 of full supplemental irrigation (FSI) gave the highest rate of increase in grain yield and water productivity. The mean grain yield from rainfed, 1/3SI, 2/3SI, and FSI were 1.57, 2.35, 2.86, and 3.54 t/ha for faba bean. Grain yield reductions due to the application of 2/3SI were around 10.2% of FSI on average for faba bean. Deficit irrigation at 2/3SI increased water productivity compared to rainfed treatments, by 126 % for faba bean. However, differences in total water productivity of crops grown under full irrigation compared to deficit irrigation were not significant (Karrou and Oweis, 2012).

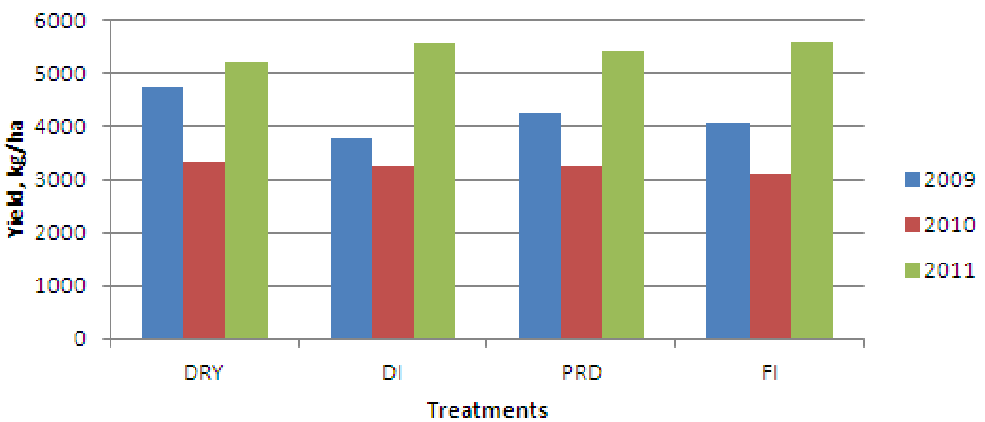

Fig2. *Faba bean yield for the different irrigation treatments in then experimental years*.

Water use efficiency values ranged 0.498 to 0.912 kg/m^3 in then experimental years. DRY treatment resulted in the greatest WUE of 0.912 kg/m^3 and FI treatment had the lowest WUE as 0.498 kg/m^3 in 2010 mainly due to higher consumed water quantity. However, the maximum WUE in 2011 was 0.794 kg/m^3. In irrigated year, WUE decreased with increasing irrigation amount. Rainfed treatment (DRY) recorded highest WUE and this was due to less water consumption, followed by DI and PRD. Pulses such as field pea and faba bean have WUEs of about 1.0 kg/ha and are considered to be highly efficient in their water use (Munoz-Perea et al. 2007). Other studies indicate that improved WUEs can be realized when a transpiration deficit is imposed at certain growth stages of dry beans and other crops without significant yield penalties (Eck et al. 1987; Kovacs et al. 1999; Ziska and Hall 1983). Hirich et al., 2012 reported that under deficit irrigation applied during vegetative growth using half of required water supply we can have a yield production and water productivity higher than where full irrigation is provided (+4% for yield and +24% for crop water productivity). Under deficit irrigation during the vegetative growth applying 50% of ETm nearly 17% of whole volume of applied water could be saved. Oweis et al. (2005) reported that that a 2/3 SI level gives the optimum water use efficiency for both grain and biomass under SI. Biomass water use efficiency under SI decreased with the delay of sowing from 1.72 kg/m^3 for early to 1.33 kg/m^3 for late sowing dates.

Yield and yield attributes in faba bean for the irrigation treatments in the experimental years are summarized in Table 5. Average plant heights varied from 99 cm to 122 cm in the experimental years. Irrigations did not have significant effect on plant height. First bean height (FBH) above ground level changed from 31.2 cm in 2009 to 50 cm in FI in 2010. Irrigations had significant effect on first bean height in 2010. PRD treatment had FBH value of 35 cm while FI resulted in FBH value of 50 cm. Thus irrigation increased the FBH values. PRD resulted in greatest number of pods per plant and number of beans per plant. However, the bean mass was relatively smaller as compared to other treatments. Full irrigation increased the first pod height from the ground level, PRD resulted in smallest first bean height. Full irrigation increased plant height as compared to other treatments. Number of beans per plant values ranged form 25.4 in 2009, 23.4 in DRY and 39.2 in PRD in 2010; and 32.7 cm in 2011. Irrigation had significant effect on this particular trait. Aveage 100 seed weigh values ranged 169.2 g in 2009; 149.7 and 155 g in 2010; and 189,7 g in 2011. Irrigation did not have significant impact on 100 bean weight. Rainfed treatment produced the highest yield, but the difference was not significant. The results revealed that under the eastern Mediterranean environment in Turkey where average rainfall is over 650 mm, faba bean can be grown under rain-fed condiirons. However, incase water shortage during the growing season, then supplemental irrigation can improve yields and yield components.

Table5. *Faba Bean yield and yield components, plant characateristics in 2009, 2010 and 2011growing seasons*

Yield and Yield attributes	2009	2010				2011
	DRY	DRY	DI50	PRD	FI	DRY
Yield, g/plant	46,4	37,4	43,6	58,9	37,1	61,4
Yield, kg/ha	4206	3330	3244	3256	3110	5448
LSD	ns	ns				ns
Number of pods/plant	7,9	9,7b	10,3ab	13,3a	8,3b	10,9
LSD	ns	2.95				ns
Number of beans /plant	25,4	24,3b	28,1b	39,3a	24,6b	28,9
LSD	ns	8.95				ns
100 bean mass, g	168,8	154	155,5	149,7	151	189,7
LSD	ns	ns				ns
Plant height, cm	100	98b	115a	108ab	104ab	102
LSD	ns	8.04				ns
First pod height, cm	29,7	41ab	43b	35b	48a	32,7
LSD	ns	4.46				ns

Evolution of faba bean plant biomass yield with time in the experimental years is shown in Figure 3, 4 and 5, respectively. Maximum dry matter yield was observed as 1800 g/m^2 on April 28, 2009 and April 27, 2011. Faba bean in the third year of the study was harvested on July 1, 2011. Biomass yields were relatively lower in 2010 as compared to 2009 and 2011 growing season. Irrigations significantly increased biomass yield as compared to DRY and deficit irrigation treatments (DI and PRD). FI treatment produced a biomass yield of 800 g/m^2 in 2010. DRY treatment had a biomass yield of 570 g/m^2 while DI and PRD treatments produced abobe ground biomass yields of 700 and 680 g/m^2, respectively. Biomass yield increased rapidly at the beginning of April then decreased towards the harvest season. With winter sowing faba bean develops large green leaf area and rapid ground cover, which reduces soil evaporation losses, and absorbs a significant proportion of available solar radiation early in the season when vapor pressure deficits are low. As a result winter sowing of faba bean produced more biomass. Faba bean can produce impressive dry matter and seed yields in a range of dryland mediterranean environments, however early sowing is critical for high seed yields in low rainfall conditions (Loss and Siddique, 1996). Oweis et al. (2005) reported that that a 2/3 SI level gives the optimum water use efficiency for both grain and biomass under SI. Early sowing date of faba bean steadily increased grain yield: 1.73 t/ha for early; 1.60 t/ha for normal; and 1.38 t/ha for late. Biomass yield followed a similar trend: 5.13 t/ha for early; 3.86 t/ha for normal; and 3.48 t/ha for late.

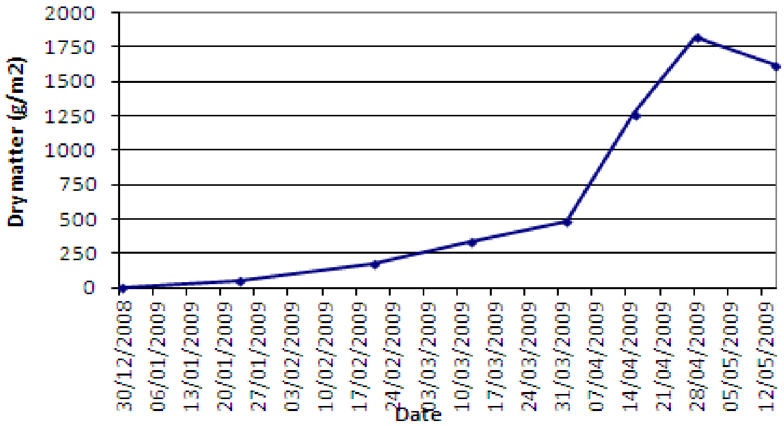

Fig3. *Faba bean above-ground dry matter yield with time in 2009 (rain-fed)*

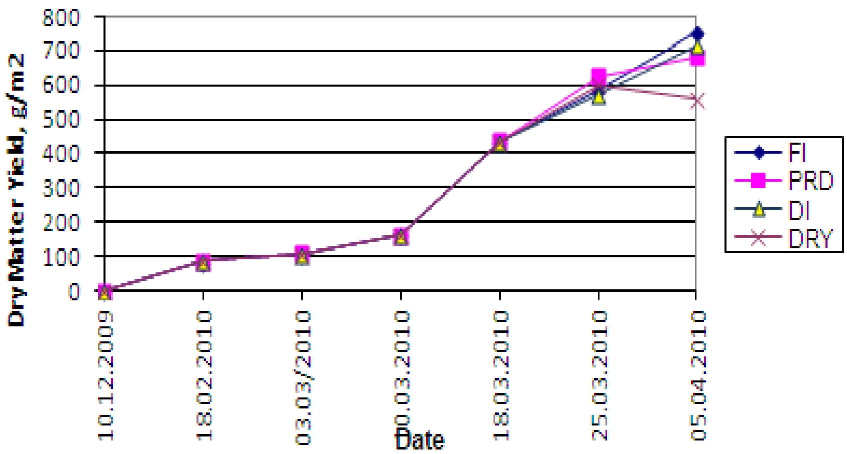

Fig4. *Evolution of faba bean above-ground dry matter yield with time in 2010*

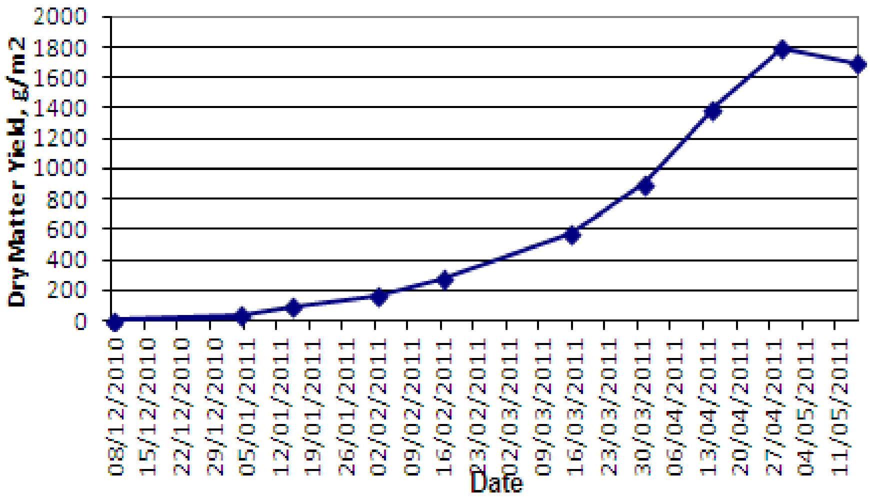

Fig5. *Evolution of faba bean above-ground dry matter yield with time in 2011*

Development of leaf area index with time in the 2009 and 2010 growing seasona are depicted in Figures 6 and 7. Maximum LAI was observed as 6.1 on April 7, 2009 in the experimental years. In 2010, maximum LAI of 5.6 was observed in FI treatment. DRY treatment had the lowest LAI (4.4) at maturity. PRD treatment resulted in a LAI value of 5.5.

Thus irrigations in 2010 growing season caused a slight increase in LAI values. Faba bean has vigorous early growth during winter when rainfall is reliable and temperatures are low (Loss and Siddique, 1996).

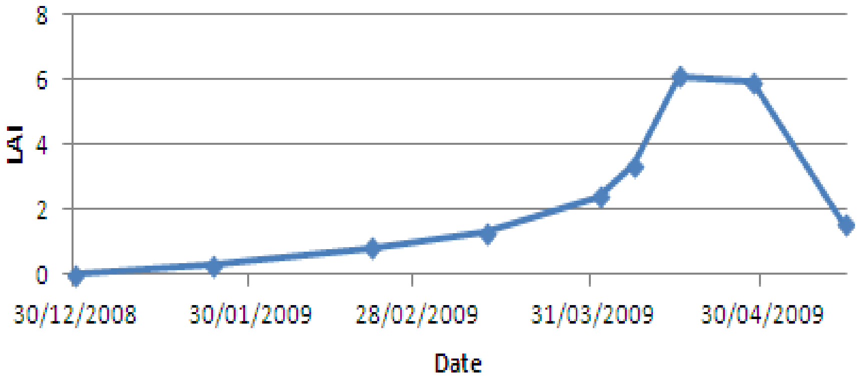

Fig6. *Development of Leaf area index (LAI) in 2009 growing season.*

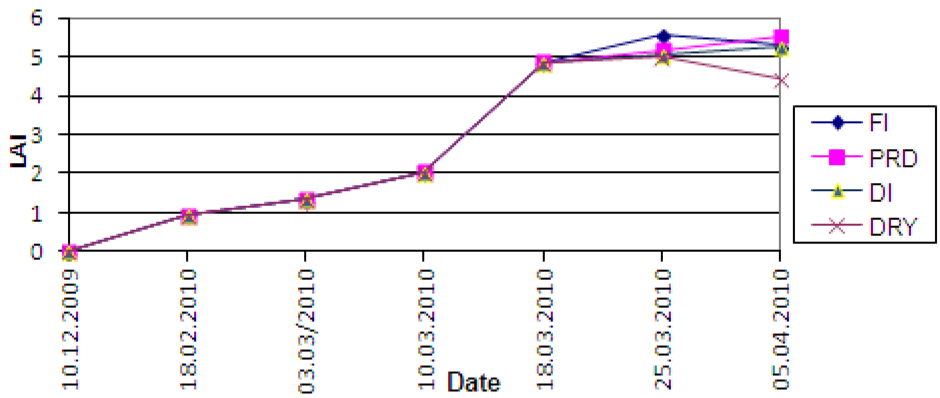

Fig7. *Evolution of LAI of faba bean with time under the different treatmens in 2010*

CONCLUSIONS

Irrigation had no significant effect on faba bean yield and yield components in 2009, 2010 and 2011 in the Mediterranean region of Turkey. Due to rainy growing season in 2009 and 2011, no irrigation was applied to faba therefore the results are obtained under rainfed conditions. The three years results revealed that faba bean can be produced under rainfed conditions without requiring any supplemental irrigation under normal (650 mm average annual rainfall, of which 65 % falls during the winter months) and/or above normal rainfall conditions in the Mediterranean region of Turkey. However, in dry years, supplemental irrigation during the critical growth stages of faba bean (flowering and seed filling) increases yields considerably. In Syria, supplemental irrigation resulted in significant yield increase (Manzoor, 2013).

Faba bean was not irrigated in 2009 and 2011 growing seasons due to sufficient rainfall received, and average faba bean yields of 4206 and 5448 kg/ha, respectively in these years. Mean 100 bean weight was 169.2 g in 2009; ranged from 149.7 to 155.0 g in 2010, and 189,7 g in 2011. As shown, there was no significant difference in faba bean yields and most of the yield components among the irrigation and rain-fed treatments in 2010 growing season. Average yields varied from 3110 to 3330 kg/ha among the treatments. PRD resulted in greatest number of pods per plant and number of beans per plant. However, the bean mass was relatively smaller as compared to other treatments. Full irrigation increased the first pod height from the ground level, and PRD resulted in smallest first bean height. Full irrigation increased plant height as compared to other treatments. Rainfed treatment produced the highest yield, but the difference was not significant.

Supplemental irrigation is a viable option that can be used by farmers in the Mediterranean region to increase and stabilize their rainfed faba bean production. Furthermore, deficit supplemental irrigation can effectively boost water use efficiency (water productivity). This is particularly important in water-scarce areas, where the water saved as a result of this practice can be used to irrigate additional land, thus, allowing farmers to achieve higher levels of production. In these areas, early sowing of winter faba bean not only increases yield but also, when combined with supplemental irrigation, can help the crop to escape terminal drought, thus, assuring stabilized yield. However, irrigation in rainfed areas comes at a cost. Therefore, economic studies are highly recommended, in order to evaluate its feasibility and to identify any constraints that might affect its implementation.

ACKNOWLEDGEMENTS

This research was financially supported by the EU SWUP-MED project (Sustainable Water Use Securing Food Production in Dry Areas of the Mediterranean Region) under the seventh framework.

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Citation: *Y. Attila, M. Dürdane, B. Yeşim and İ. Çiğdem, "Yield Response of Faba Bean to Various Irrigation Strategies in the Mediterranean Region", International Journal of Research in Agriculture and Forestry, vol. 4, no. 7, pp. 9-19, 2017.*