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1

Effects of Irrigation on the Flowering and Maturity of Chickpea Genotypes

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1. Introduction

In Tunisia, chickpea (*Cicer arietinum L.*), particularly Kabuli genotypes, is the second pulse crop after faba bean. It is grown, in spring rainfed conditions (Wery, 1990), in humid and sub humid regions, mainly at Bizerte, Mateur, Béja, Jendouba and Nabeul areas (DGPA, 2006). Feeble production, about 13.518 tons with a reduced grain yield, nearly 0,67 $t.ha^{-1}$ (DGPA, 2008), characterized by inter annual fluctuations, does not satisfy national needs. Tunisian government makes recourse to massive annual imports, about 19.000 tons (AAC, 2006), which account 141% of the national production. To satisfy national needs of this foodstuff, it would be useful to undertake researches to increase chickpea production through drought and thermal tolerant stress genotypes and extension of this species culture area to the semi-arid zones. Spring chickpea culture is subjected to drought stress, generally, combined with a thermal stress. These two abiotic stresses explain, partly, the production irregularity and the chickpea grain yield instability in our regions. Kumar and Abbo, (2001) reported that throughout the world, 90% of the chickpea cultures are rainfed and final dryness is the principal abiotic stress which blocks the production increase. Golezani *et al,* (2008) indicated that, in many areas of leguminous culture, such as chickpea, the climate is characterized by extremely variable precipitations and rather often deficit. Under such environmental conditions, scientists and farmers try to identify crops and soil management techniques for an adequate water use efficiency. Both temperature and moisture supply during the growing period had a strong influence on chickpea plant phenology (Silim and Saxena, 1993). Nayyar et al., (2006) reported that the flowering and pod setting stages appear to be the most sensitive stages to water stress. McVicar et al., (2007) noticed that the moisture stress is required to encourage seed set and to hasten maturity. If weather turns warm and dry, plants will be delayed in maturity and produce lower yields. However, Summerfield and Roberts (1988) announced that the chickpea flowering time is variable depending on season, sowing date, latitude, and altitude. According to Roberts et al., (1985), time to flowering was a function of temperature and photoperiod in chickpea. Ellis et al., (1994) further noticed that in some chickpea genotypes, time to flowering was influenced by photoperiod and temperature, whereas in others, flowering time was determined solely by photoperiod. Gumber and Sarvjeet (1996) studied the chickpea genetics of time to flowering and found that it was controlled by two genes. Kumar and van Rheenen (2000) announced the presence of one major gene (Efl-1/ efl-1) plus polygenes for this trait. Or et al., (1999) also supported this result, but they associated the major gene with sensitivity to photoperiod (Ppd/ppd).

This present study aims to evaluate the effects of amounts of irrigation on flowering and maturity of eight kabuli chickpea genotypes conducted in spring culture under Tunisian semi-arid edapho-climatic conditions.

2. Material and methods

2.1 Edapho-climatic conditions of the experimental site

The experiment was conducted at the Higher Institute of Agronomy of Chott Mariem, Tunisia (Longitude 10°38E, Latitude 35°55N, altitude 15 m) from May to July 2008 (three months). The climate is typically Mediterranean with 370 mm annual rainfall and an average of 6 mm day^{-1} evaporation from a free water surface. The minimum and maximum temperatures have respective mean values 14 and 23 °C. Relative hygroscopy and wind speed are respectively 70 % and 2,3 m/s. This zone is characterized by seven months annually dryness period (mid-March – beginning of October) (Fig. 1). It is defined by reduced and rare precipitations, high evaporation and maximum temperatures. During trial, temperature and relative hygroscopy variations are followed using a thermohygrographe beforehand calibrated (Fig. 2).

Soil is characterized by 52, 5% of total porosity, 20,5% of field capacity and 8,2% of permanent fading point. It is a silt-clay-sandy type (USDA, 1951), alkaline, relatively poor in organic matter (3,5%) and low salinity. The soil electric conductivity, measured at 25 °C temperature, is 0,27 ms.cm^{-2}.

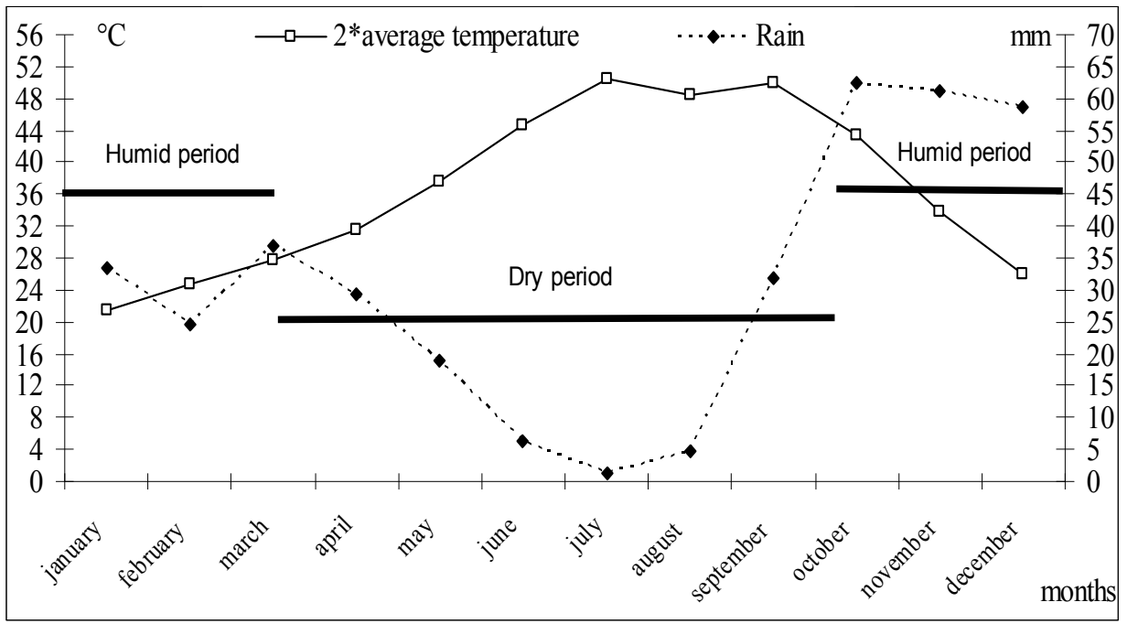

Fig. 1. Ombrothermic diagram of the Chott Mariem zone

2.2 Vegetable material, sowing and harvest dates

The vegetable material is composed of eight kabuli chickpea genotypes. Six of them, namely: Béja1, Amdoun1, Nayer, Kasseb, Bochra and Chétoui (ILC3279), are commercial varieties

registered by the National Tunisian Agronomic Research Institute (INRAT) in the obtaining vegetable Tunisian catalogue. The two others, improved lines, FLIP96-114C and FLIP88-42C, were pleasantly provided by the ICARDA within the framework of the "International Vegetable Testing Program (LITP) " Alep; Syria (Table 1).

N°	Name	Pedigree	Origin
1	Béja1	INRAT 93-1	Tunisian
2	Amdoun1	Be-sel-81-48	Tunisian
3	Nayer	FLIP 84 - 92 C	Tunisian
4	Kasseb	FLIP 84 - 460 C	Tunisian
5	Bochra	FLIP 84 - 79 C	Tunisian
6	FLIP96-114C	X93 TH 74/FLIP87-51CXFLIP91-125C	ICARDA/ICRISAT
7	FLIP88-42C	X85 TH 230/ILC 3395 x FLIP 83-13C	ICARDA/ICRISAT
8	Chetoui	ILC3279	Tunisian

Table 1. Kabuli chickpea (*Cicer arietinum* L.) genotypes

Culture is conducted, in *situ*, under controlled conditions, in pots 24 cm diameter and 24 cm height. Pots, filled with arable land, are arranged under hemispherical greenhouse covered with polyethylene (180 µ thickness) and aired on the two sides. Sowing is realized on April 16, which is four weeks delayed date compared to the normal spring sowing (Malhotra and Johansen, 1996) at a rate of three chickpea seeds per pot. After plant establishment, the plants were culled with only one seedling left in the pot. Harvest took place at the end of July of the same year.

2.3 Irrigation

Water irrigation, coming from the Nebhana dam, is characterized by 1,09 ms.cm^{-2} electric conductivity (measured at 25 °C temperature). It contains 0,70 g.l^{-1} of dry residue of which 0,25 g.l^{-1} are sodium chlorides. The easily usable reserve (EUR), evaluated with 464 ml, is calculated according to the formula stated by Soltner, (1981)

$$EUR = 1/2\left[\left(Fc - pF\right)/100\right] * D_{ap} * V$$

With Fc: Field capacity; pF: Permanent fading point; D_{Ap}: Apparent density; V: Pot soil volume.

Studied factor is water regime mode with four treatments or amounts irrigation (DI) namely: 100%, 75%, 50% and 25% of the EUR in a randomized block experimental design with three replications. Irrigations are achieved on the basis of the crop evapotranspiration (ETc) (Ben Mechlia, 1998). Reference crop evapotranspiration (ET_0) was calculated from Blanney-Criddel formula (Doorenbos and Pruitt, 1977). Crop coefficient (Kc) and adopted chickpea physiological phases durations are those used by FAO (Allen et al., 1998).

2.4 Studied parameters

Parameters studied are:

- Early flowering date (EFlDt, in days after sowing (DAS)): blooming date of the first flowers,

- 50% flowering date (FlDt, in DAS): blooming date of 50% of flowers,
- Flowering phase duration (FlDr, in days): the time passed between the blooming of the first and the last flowers,
- Early pods maturity date (EMtDt, in DAS): yellowing date of the first pods,
- 50% pods maturity date (MtDt, in DAS): yellowing date of 50% pods,
- Pods maturity duration (MtDr, in days): the time passed between yellowing of the first and the last pods.

XLSTAT and SPSS (version 10) Software were adopted to achieve statistical analyses. From obtained data, variance analysis (ANOVA,) and means comparison (Student-Newman-Keuls test at 5% level) were performed.

3. Results and discussion

3.1 Evaluation of the farming site climatic conditions

The chickpea (*Cicer arietinum* L.) biological cycle lasted 104 days. During the biological cycle, the relative hygroscopy varied from 47,5 to 73%. It fell with less than 50% at the beginning and the end of the pods maturity phase duration. Mean temperatures recorded during growth, initial, development, filling and maturity phases are respectively of 24 °C, 26 °C, 30 °C and 33 °C (Fig. 2).

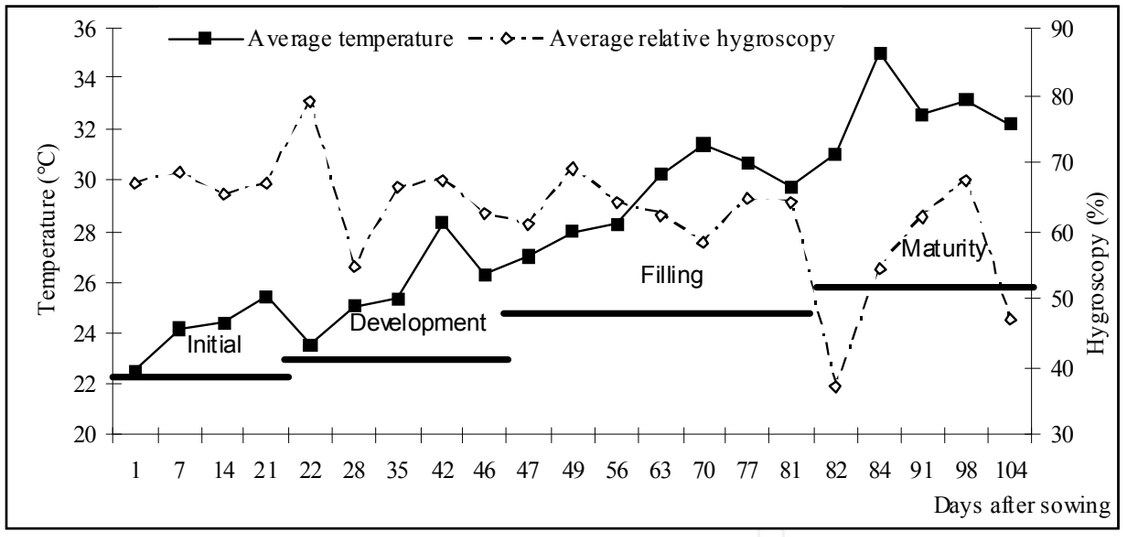

Fig. 2. Averages temperatures and relative hygroscopy of the chickpea (*Cicer arietinum* L) farming cycle conducted *in situ*

Summerfield et al., (1981) observed that chickpea reproductive phase suffers considerably from high temperatures (35/18 °C, day/night). Under such thermal conditions, grain yield is reduced to 33% per comparison to that under lenient conditions such as 30/10 °C day/night. According to Wery et al., (1994), critical temperature during the reproductive phase which includes flowering, filling and enlargement seeds chickpea is evaluated with 30 °C. Recorded temperatures showed that critical temperature was exceeded only during

the pods maturity phase duration (Fig. 2). This reveals that this chickpea culture did not suffer from thermal stress.

Crop coefficient (Kc) varies according to the chickpea culture growth phases. The crop evapotranspiration (ETc) is relatively low during the initial and pods maturity phases duration, whereas it is greatest during the filling and enlargement seeds phases (Fig. 3). Slama, (1998) indicated that the chickpea fears drought stress and crop water requirements are high during the reproductive growth phase, in particular, the flowering and filling seeds stages. A chickpea culture water requirement is evaluated to 392 mm (Fig. 4). They are divided into 8,4% during the initial phase, 24,5% during the development, 61,7% during the filling and the enlargement seeds and 5,4% during pods maturity. With the amount irrigation 100% of EUR, cumulated water irrigation provided appear equivalent to the culture water needs (Fig. 4). It appears that the chickpea culture did not undergo drought stress. These results are in conformity with those indicated by Slama, (1998) which stated that the chickpea culture water requirements vary, according to genotypes, from 300 to 400 mm. With 75 % of EUR amounts irrigation, that equivalent to 300 mm, chickpea culture submit to drought stress during the semi-filling and seed maturity phases. With 50 % of EUR amounts irrigation, that equivalent to 200 mm, chickpea culture submit to drought stress during the semi-development, filling and seed maturity phases (Fig. 4). According to Nayyar et al., (2006), flowering and filling seeds seem the most sensitive chickpea growth phases to drought stress. With 25 % of EUR amount irrigation, equivalent to 100 mm, drought stress affected chickpea seedlings during all vegetative and reproductive culture phases (Fig. 4). Saxena (1987) noticed that, *in situ*, chickpea water consumption depends on the ground moisture and the discounted grain yield.

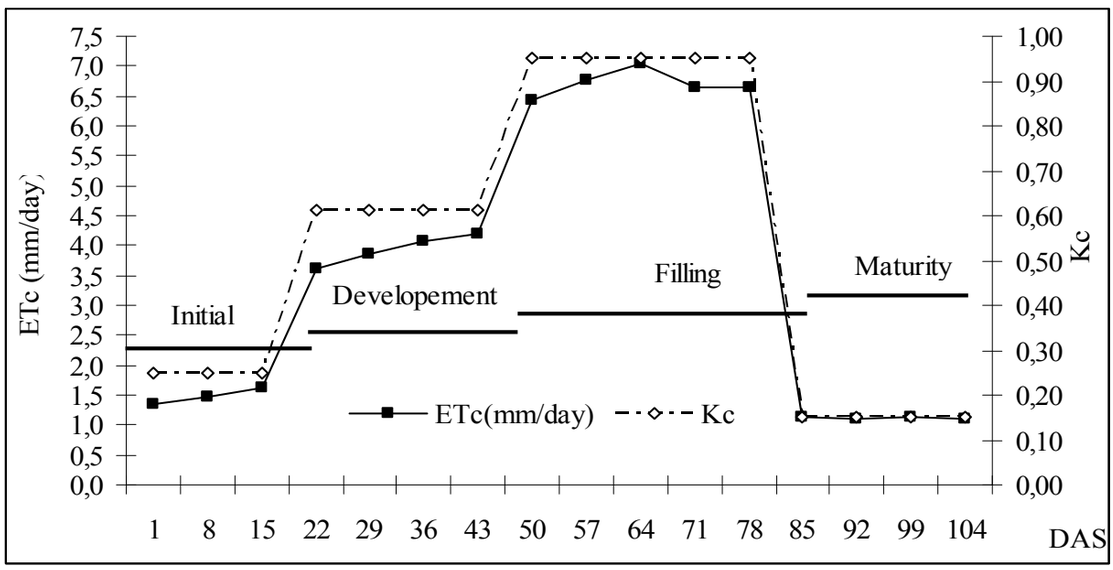

Fig. 3. Crop evapotranspiration (Etc) and crop coefficient (Kc) according to the chickpea (*Cicer arietinum* L.) phonologic growth phases

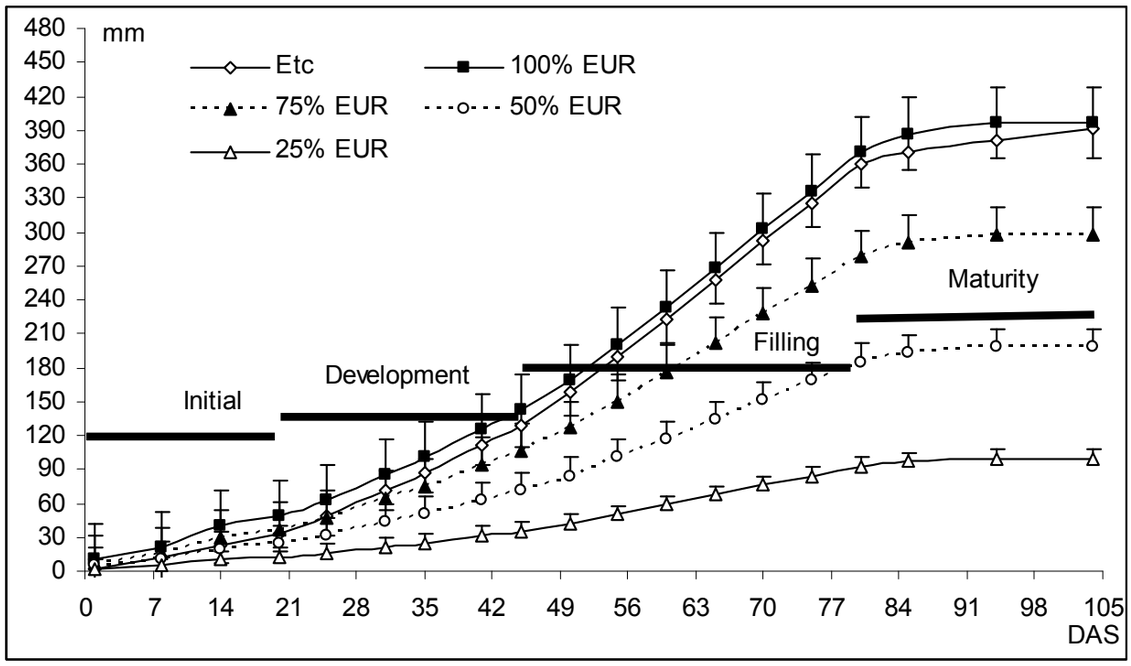

Fig. 4. Crop evapotranspiration (Etc) and cumulated water requirements varations accorading to the chickpea (Cicer arietinum L.) phonologic stages development

3.2 Individual analysis of the studied phenologic parameters

The variance analysis showed that the differences between amount irrigation are very highly significant (P≤0.001) for the early and 50% flowering dates, the early pods maturity date, the flowering and pods maturity phase durations and significant at 5% level for the 50% pods maturity. Genotypic variability is very highly significant (P≤0.001) for the early and 50% flowering dates, the early and 50% pods maturity dates, significant at 5% level for the flowering phase duration and non significant for pods maturity phase duration. The interaction (Genotype X Amount irrigation) is very highly significant (P≤0.001) for the flowering phase duration, highly significant (P≤0.01) for the early pods maturity date, significant at 5% level for the 50% flowering and 50% pods maturity dates and non significant for the early flowering date and the pods maturity phase duration. Variation coefficients vary from 4,8 to 41,1% (Table 2). These results indicate that the studied chickpea accessions present a large genotypic diversity at the level of the flowering and pods maturity dates and heir phase's duration. It appears that the chickpea flowering and pods maturity dates and the duration of these two phases are controlled by the crop water requirement. The early flowering and 50% flowering dates are inversely proportional to the amounts of irrigation. The early flowering date varied from 50,5 to 58,2 DAS; whereas the 50% flowering date varied from 61,7 to 66,5 DAS. Seedlings irrigated with 100% and 75% of EUR amount irrigation presented an early flowering; whereas those having received 50% and 25% of EUR amount irrigation expressed a late flowering (Table 3).

The abiotic stresses, in particular, drought and thermal, delay the spring chickpea flowering phase (Silim, and Saxena, 1993). Whereas Anbessa et al., (2006) noticed that early flowering is a key factor in the formation and maturation of pods before the occurrence of these abiotic

stresses. Hughes et al., (1987) announced that the exposure of the culture to the final dryness shortens its biological cycle and delays its flowering. Ellis et al., (1994) indicated that high temperatures, higher than 38 °C, delay considerably the chickpea flowering. Day temperatures recorded during the flowering phase did not exceed 30 °C (Fig. 1). This reveals that the chickpea culture did not undergo thermal stress. On the other hand, the delay flowering date of the treatments irrigated with low irrigation doses, particularly, 50% and 25% of EUR amount irrigation, is allotted to the crop water requirement.

Variation source	df	EFlDt (DAS)	FlDt (DAS)	FlDr (days)	EMtDt (DAS)	MtDt (DAS)	MtDr (days)
Amount irrigation (AI)	3	261***	104***	121.2***	111.4***	59.5*	139.6***
Genotypes (G)	7	205***	109***	43.6*	56.6***	87.5***	21.6ns
Bloc	2	104ns	76.6*	17.4ns	39.2ns	42.3ns	21.3ns
AI * G	21	57.8ns	36.2*	52.6***	33.9**	44.9*	11ns
Error	62	37,7	20,3	20,5	16,313	22,2	11,5
Variation coefficient (%)	-	11,2	7,1	24,0	4,8	5,6	41,1

***: significant at 1‰ level; **: significant at 1% level; *: significant at 5% level; ns: not significant

Table 2. Variance analyzes and F tests of the chickpea (*Cicer arietinum* L.) genotypes flowering and maturity parameters

Amount irrigation	EFlDt (DAS)	FlDt (DAS)	FlDr (days)	EMtDt (DAS)	MtDt (DAS)	MtDr (days)
100% EUR	54.9a	62.6b	**20.2a**	83.5a	84.2a	9.5a
75% EUR	**50.5b**	**61.7b**	21.6a	**80.7b**	**82.6a**	**10.9a**
50% EUR	56.3a	64.1ab	16.9b	84.8a	85.5a	**5.5b**
25% EUR	**58.2a**	**66.5a**	**17.3b**	**85.7a**	**86.2a**	7.1b

Table 3. Mean comparisons (Newman-Student and Keuls test at 5% level) of the chickpea (*Cicer arietinum* L.) genotypes flowering and maturity parameters according to amounts irrigation

First flowers appearance date of the chickpea genotypes varies from 48,5 to 58,5 DAS; whereas the 50% flowering date varies from 59,5 to 67,8 DAS (Table 4). Chickpea genotypes, having received 75% EUR amount irrigation underwent drought stress 63 DAS; whereas those having received 50% and 25% EUR amount irrigation, have undergoes drought stress before even the flowering phase (fig. 3). Genotypes Kasseb and FLIP96-114C appear characterized by an early flowering; whereas Bochra, Nayer, Béja1 and ILC3279 have a late flowering. Genotypes Amdoun1 and FLIP88-42C have an intermediate flowering (Table 4). Kumar and Abbo (2001) have reported that time to flowering plays a central role in determining the adaptation and productivity of the chickpea genotypes in short growing environments.

Morizet et al., (1984) showed that genotypic variability for the drought tolerance appears only if the drought stress proceeded during the flowering phase. An early stress does not induce, necessarily, a distinction between the drought tolerant and sensitive genotypes.

Other work of Ouattar et al., (1987) concluded that sifting period for drought stress tolerance could extend until the grain development phase.

Genotypes	EFlDt (DAS)	FlDt (DAS)	FlDr (days)	EMtDt (DAS)	MtDt (DAS)	MtDr (days)
Béja I	**16.5b**	58.5a	64.5abc	84.9ab	85.6abc	**7.1a**
Amdoun I	**22.3a**	52.9ab	62.6bc	85.3ab	87.ab	8.5a
Nayer	18.1ab	**58.7a**	**67.8a**	**87.1a**	**87.7a**	7.8a
Kasseb	20.4ab	**48.5b**	59.5c	81.1b	81.6bc	7.6a
Bochra	19.3ab	59.3a	67.6a	84.1ab	87.4a	**11.4a**
FLIP 96-114 C	20.2ab	50.5b	**61bc**	82b	83abc	7.4a
FLIP 88-42 C	17.7ab	53.8ab	62bc	**80.9b**	**80.7c**	8.5a
ILC 3279	17.6ab	57.5a	64.9ab	84.1ab	83.9abc	7.7a

The values of the same column accompanied by the same letter are not significantly different at 5% level
The values in fat from the same column are extreme values

Table 4. Mean comparisons (Newman-Student and Keuls test at 5% level) of the chickpea (*Cicer arietinum* L.) genotypes flowering and maturity parameters

First flowers appearance date varies, simultaneously, according to the chickpea genotypes and crop water requirement from 39 to 69 DAS (Table 5). Mean comparisons showed that there are three interfered homogeneous groups. The genotype Kasseb presented the earliest flowering date, 39 DAS, with 75% of EUR amount irrigation. On the other hand Béja I formed its first flowers 69 DAS with 25% of EUR amount irrigation (Table 5).

According to Richa, and Singh, (2001), the appearance of the first flowers depends on several factors such as varietals precocity, the sowing date and density and the farming techniques. Singh et al., (1995) indicated that, on the basis of a collection consist of 4165 chickpea genotypes evaluated under drought conditions, they could select only 19 drought tolerant accessions characterized by an early flowering.

The 50% flowering date varies according to the amount irrigation and chickpea genotypes from 54,9 to 73,7 DAS. Mean comparisons showed that there are three interfered homogeneous groups. The earliest flowering date is produced at 55 DAS, by FLIP96-114C with 50% of EUR amount irrigation; while the latest flowering is produced at 74 DAS by Bochra under the same amount irrigation (Table 5). Singh et al., (1995) found that the flowering date of six kabuli chickpea genotypes, led in rainfed conditions, varied from 48 to 54 DAS. Berger et al., (2006) stated that the early chickpea genotypes flowering date varies from 51 to 69 DAS; whereas that of the late genotypes varies from 60 to 93 DAS. Physiological chickpea studies confirm the flowering period importance for the sifting of drought tolerant genotypes (Tollenaar, 1989). Other phenological studies indicated that the chickpea biological cycle and flowering durations are determined by the response of the genotype to the day length, the temperature and photoperiod rise. Subbarao et al., (1995) announced that, chickpea flowering date is the most important component of adaptation to the abiotic stresses such as water deficit and high temperatures. In the semi-arid zones, leguminous flowering date has a great adaptive value for the dryness. It determines the ground water use efficiency for the seeds filling (Or et al., 1999). Saxena et al., (1993)

Amount irrigation	**Genotypes**	EFlDt (DAS)	FlDt (DAS)	FlDr (days)	EMtDt (DAS)	MtDt (DAS)	MtDr (days)
100% EUR	Béja I	54.7abc	61.3abc	14.3bc	81ab	82.4ab	7ab
	Amdoun I	52.3abc	62.1abc	24.7ab	88.7ab	88.6ab	7.7ab
	Nayer	57.7abc	67.6abc	19.3abc	**90.7a**	91.2ab	8.7ab
	Kasseb	49.7abc	58.6bc	23.3abc	81ab	79.6ab	8ab
	Bochra	64.7ab	64.7abc	21abc	85.9ab	89.8ab	12.4ab
	FLIP 96-114 C	49.6abc	61.8abc	22.7abc	81.1ab	82.4ab	9.2ab
	FLIP 88-42 C	52abc	60.9abc	18.7abc	80.2ab	80.9ab	11.1ab
	ILC 3279	58.7ab	63.9abc	17.3abc	79.3ab	78.3ab	12.3ab
75% EUR	Béja I	52.7abc	60.9abc	20.3abc	**77.7b**	**77b**	9.3ab
	Amdoun I	49.7abc	59.3abc	23.3abc	**77.7b**	81.1ab	10.3ab
	Nayer	60.3ab	66.9abc	15bc	87ab	89ab	9ab
	Kasseb	**39c**	59.7abc	**30a**	**77.7b**	82.1ab	13ab
	Bochra	46.7bc	62.6abc	24.7ab	81ab	84.2ab	**16.7a**
	FLIP 96-114 C	49.6abc	61.8abc	25ab	82.8ab	85.4ab	9.5ab
	FLIP 88-42 C	51.3abc	60.4abc	18.7abc	79.3ab	79.6ab	11.7ab
	ILC 3279	54.3abc	62.3abc	16.7abc	82.8ab	82.8ab	7.5ab
50% EUR	Béja I	57.7abc	63abc	21.7abc	**91.7a**	**92.8a**	4.3b
	Amdoun I	54.3abc	63.7abc	22abc	85.8ab	88.1ab	8.2ab
	Nayer	62ab	73.1ab	19abc	86.9ab	86ab	5.4b
	Kasseb	55.7abc	60abc	11bc	83ab	82.2ab	4b
	Bochra	64ab	**73.7a**	17abc	85.9ab	90.9ab	8.1ab
	FLIP 96-114 C	47.3bc	**54.9c**	12bc	80.2ab	79.7ab	**2.8b**
	FLIP 88-42 C	52.3abc	59bc	15.3bc	79.3ab	78.2ab	5.7b
	ILC 3279	57.3abc	65.5abc	17.3abc	85.8ab	85.9ab	5.5b
25% EUR	Béja I	**69a**	72.9ab	**9.7c**	89.1ab	90.2ab	7.8ab
	Amdoun I	55.3abc	65.2abc	19.3abc	89.1ab	90.2ab	7.8ab
	Nayer	55abc	63.7abc	19abc	83.ab	84.6ab	8.3ab
	Kasseb	49.6abc	59.5abc	17.3abc	82.8ab	82.6ab	5.5b
	Bochra	62ab	69.5ab	14.3bc	83.ab	84.6ab	8.3ab
	FLIP 96-114 C	55.3abc	65.5abc	21abc	83.ab	84.6ab	8.3ab
	FLIP 88-42C	59.6ab	67.8abc	19abc	84.8ab	84.2ab	5.5b
	ILC 3279	59.6ab	67.8abc	19abc	88.5ab	88.6ab	5.5b

The values of the same column accompanied by the same letter are not significantly different at 5% level
The values in fat from the same column are extreme values

Table 5. Mean comparisons (Newman-Student and Keuls test at 5% level) of the chickpea (*Cicer arietinum* L.) flowering and maturity parameters according to the interaction (Amount irrigation X Genotype)

concluded that dryness escape resistance is the seedling ability to finish its biological cycle before the exhaustion of the soil water reserves. According to Malhotra and Saxena, (2002), early flowering remains the main component of the chickpea water stress avoidance. This mechanism was largely used, especially through the selection of genotypes for an early flowering. Moreover, genotypes with early flowering are characterized by a high grain yield (Berger et al., 2004); whereas genotypes with late flowering, having suffered the final drought stress, are characterized by poor yield (Thomas et al., 1996). Actually, the delay of chickpea flowering induced by drought stress, increases the potential of drought stress avoidance and generates a reduction of the duration between flowering and pods formation (Berger et al., 2006). On the other hand, Siddique and Khan, (1996) concluded that chickpea genotypes selection with early flowering does not involve necessarily an increase in the production. However, the combination of an early flowering and grain yield improvement alleles were proven at desi chickpea genotypes. Rajin et al., (2003) noticed that chickpea phenologic phases depend on accumulated thermal time. To flower, chickpea genotypes need thermal durations varying from 623 to 808 °C/day. According to the amounts irrigation, flowering phase duration varied from 16,9 to 21,6 days. With amounts irrigation 100%, 75%, 50% and 25% of EUR, flowering phase duration are similar two by two. It appears proportional to amounts irrigation. They are long with amounts 100% and 75% of EUR with respective values 20,2 and 21,6 days and short values with the amounts 50% and 25% of EUR with respective values 16,9 and 17,3 days (Table 3). Flowering phase duration of the chickpea genotypes varied from 16,5 to 22,3 days. Flowering phase of the genotype Béja1 is shortest; whereas that of Amdoun1 is longest. The other genotypes have intermediate flowering durations (Table 4). According to Richa, and Singh, (2001), flowering phase duration varies, according to genotypes, from 30 to 45 days. The early cultivars spread out their flowering phase duration and delay their pods formation period (Abdelguerfi-Laouar et al., 2001). The interaction (Genotype X Amount irrigation) showed that the chickpea genotypes flowering period varied from 9,7 to 30 days. Mean comparisons revealed three interfered homogeneous groups. The longest flowering phase duration is 30 days and is accomplished at 75% of EUR amount irrigation by the genotype Kasseb; whereas, the shortest duration is 9,7 days and is recorded at 25% of EUR amount irrigation by the genotype Béja1 (Table 5). Bonfil and Pinthus, (1995) indicated that the chickpea flowering phase duration is a determining factor of the grain yield. Or et al., (1999) noted that the long flowering period, controlled by early flowering alleles, can increase the grain yield. In fact, cultivars with early flowering enter in hasty fructification and achieve their filling pods before the final dryness advent (Abdelguerfi-Laouar and Al, 2001).

Early flowering date and 50% flowering date are inversely proportional to the flowering phase duration. High amounts irrigation, 100% and 75% of EUR, cause an early flowering over a long duration. Conversely, limited amounts irrigation, 50% and 25% of EUR, delay the flowering phase and shorten its duration (Fig. 5A). Favorable water conditions incited plants to increase their capacities to flower enough early in the season. On the other hand, under severe drought stress conditions plants find difficulties to producing flowers even limited number. Early pods maturity and 50% pods maturity dates depend on the amounts of irrigation and vary respectively from 80,7 to 85,7 and 82,6 to 86,2 DAS (Table 3). Early date pods maturity mean comparison revealed two homogeneous groups. The first is composed of 100%, 50% and 25% of EUR amount irrigation which generated of similar and late pods maturities. The second is consisting of the amount irrigation 75% of EUR which

generated an early pods maturity (Table 3). Mean comparison of 50% pods maturity dates showed only one homogeneous group which shows that all amounts of irrigation have similar effects on 50% pods maturity date (Table 3). Pods maturity date appears inversely proportional to amounts of irrigation. With the amounts 100 and 75% of EUR, 50% pods maturity is hasty, whereas under limited water doses it is, relatively, late (Table 3). These results are in conformity with those obtained by Khanna-Chopra and Sinha, (1987) and Silim, and Saxena, (1993) which noticed moisture supply during the growing period had a strong influence on phenology, that pods maturity date is prolonged by complementary irrigation and reduced by dryness.

Early pods maturity date varies, according to the chickpea genotypes from 80,9 to 87,1 DAS. Mean comparison revealed two interfered homogeneous groups. The first is formed of genotypes Béja1, Amdoun1, Kasseb, Bochra, FLIP96-114C, FLIP88-42C and ILC3279. The second is formed of Béja1, Amdoun1, Nayer, Bochra and ILC 3279 (Table 4).

Chickpea genotypes 50% pods maturity date varies from 80,7 to 87,7 DAS. Mean comparison showed three interfered homogeneous groups. The first group is consisting of Béja1, Amdoun1, Nayer, Bochra, FLIP 96-114 C and ILC 3279. The second is composed of genotypes Béja1, Amdoun1, Kasseb, FLIP 96-114 C and ILC 3279. The thread is consisting of Béja1, Kasseb, FLIP 96-114 C FLIP 88-42 C and ILC 3279 (Table 4). Siddique, et al., (2001) reported that drought avoidance and/or tolerance were observed for the some species (*C. arietinum* and *L. satius*) in the form of delayed senescence and maturity.

Chickpea 50% pods maturity depends jointly on the vegetable material and amounts irrigation. It varies from 77 to 92,8 DAS. Mean comparison showed two interfered homogeneous groups (Table 5). Silim, and Saxena, (1993) reported that, in the Mediterranean basin, chickpea pods maturity date of the spring culture varies from 85 to 101 DAS. However, this culture suffers from thermal and drought stress during flowering, seeds filling and pods maturity phases (Singh et al., 1995). According to Singh et al., (1994), early pods maturity is significantly associated with the dryness tolerance. Other authors claimed that, in the dry zones, escape to drought stress could appear through the early flowering and pods maturity (Berger et al., 2006). Gentinetta et al., (1986) noticed the possibility of sifting for drought stress tolerance during the physiological seeds maturity phase.

Chickpea pods maturity phase duration is proportional to the amounts of irrigation and varies from 5,5 to 10,9 days. With the amounts of irrigation 100 and 75% of EUR, pods maturity phase durations are lengthen with similar respective values 9,5 and 10,9 days. On the contrary, with the amounts 50 and 25% of EUR, they are shortened with respective similar values 5,5 and 7,1 days (Table 3). Maturity duration was extended by high moisture supply and reduced by drought. Irrigation extended reproductive growth duration (Silim, and Saxena, 1993).

Chickpea genotypes pods maturity phase duration varies from 7,1 to 11,4 days. Mean comparison showed that chickpea genotypes have similar pods maturity phase durations (Table 4). Chickpea 50% pods maturity date is inversely proportional to pods maturity phase duration (Fig. 5B). With the amounts irrigation not stressful, in fact 100% and 75% of EUR, 50% pods maturity is hastened and its phase duration is lengthened. On the other hand, limited amounts irrigation, 50% and 25% of EUR, delay the physiological 50% pods maturity and reduce its duration (Fig. 5B). It appears that, under not limited water conditions, the plant

tends to take easily its water requirements. Vegetative development and pods filling phases are shortened in aid of pods maturity phase duration which is lengthened. It may be that pods are sufficiently water gorged and would need enough time to release it. Conversely, under drought stress conditions, vegetative development and pods filling phases are lengthened with the detriment of the pods maturity phase duration which is shortened. With the water scarcity, the plant will spend more time to be able to achieve its vegetative development and pods filling phases. As pods are less water gorged, they will be desiccated more quickly.

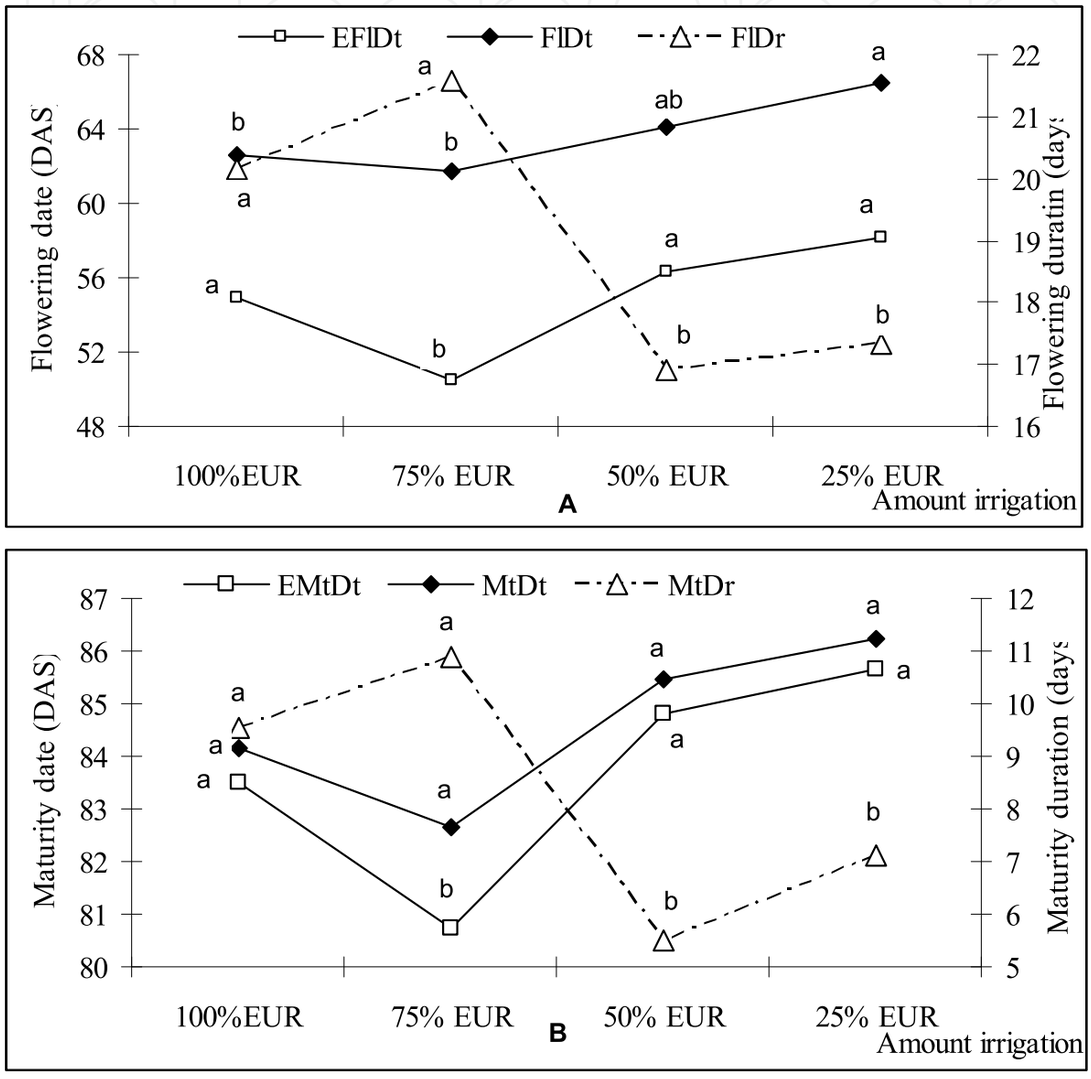

Fig. 5. Comparisons (Student-Newman and Keuls test at 5%) of (A) the flowering dates and durations; (B) maturity dates and durations of the chickpea (Cicer arietinum L) cultures according to the amounts of irrigation

4. Conclusion

Chickpea culture did not suffer from thermal stress and the critical temperature was exceeded only during the pods maturity phase. Water requirement for this culture is

evaluated to 392 mm. Amounts of irrigation 50% and 25% of the EUR induced severe drought stress.

Chickpea flowering and pods maturity dates and durations are controlled by the crop water requirement. The amount irrigation 75% of the EUR induced the hastened flowering and maturity dates with longest durations. Furthermore, according to the amounts of irrigation, flowering and maturity dates were inversely proportional to their durations. The amounts of irrigation 100% and 75% of the EUR hasten flowering and maturity dates and enlarge their durations; while the amounts 50% and 25% of the EUR delay flowering and maturity dates and shorten their durations.

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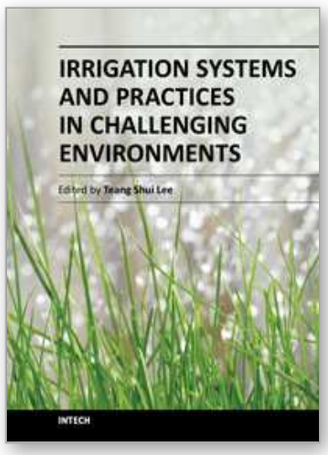

Irrigation Systems and Practices in Challenging Environments
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The book Irrigation Systems and Practices in Challenging Environments is divided into two interesting sections, with the first section titled Agricultural Water Productivity in Stressed Environments, which consists of nine chapters technically crafted by experts in their own right in their fields of expertise. Topics range from effects of irrigation on the physiology of plants, deficit irrigation practices and the genetic manipulation, to creating drought tolerant variety and a host of interesting topics to cater for the those interested in the plant water soil atmosphere relationships and agronomic practices relevant in many challenging environments, more so with the onslaught of global warming, climate change and the accompanying agro-meteorological impacts. The second section, with eight chapters, deals with systems of irrigation practices around the world, covering different climate zones apart from showing casing practices for sustainable irrigation practices and more efficient ways of conveying irrigation waters - the life blood of agriculture, undoubtedly the most important sector in the world.

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