# EVALUATION OF SOME FABA BEAN (*Vicia faba* L.) CULTIVARS FOR DROUGHT RESISTANCE AND WATER CONSUMPTIVE USE: 3- GROWTH STAGES RESPONSE TO RAINFALL AND SUPPLEMENTARY IRRIGATION*

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## ABSTRACT

This experiment was carried out during the growing season of 2004 – 2005 at Horticulture field researches, Agriculture and Forestry College, Mosul University to evaluate five faba bean cultivars for water stress and supplementary irrigations by withholding complementary watering at either vegetative (RWW), flowering (WRW), pod developments and seed fillings (WWR) stage, whereas the check and other treatments were watered whenever 25% soil AWC is depleted to a depth of 25 cm. The results revealed that Pod developments and seed fillings was the most drought susceptible stage where supplementary irrigation should be applied to improve yield and yield quality. However, other stages were less sensitive, particularly the early vegetative stage. The five cultivars were categorized in the following order according to their performance at the most drought susceptible stage: Local Syrian > Aquadulce > Towaytha > Babylon > Taka357. Subsequently, forecasting depending up on cultivar seeds germinations under sub-optimal conditions could not be used as indicator for the approval of drought resistance cultivars. Finally, results confirmed the Taka357 was the most drought susceptible during all stages particularly in seed filling stage.

## INTRODUCTION

The major problem facing faba bean productions in Iraqi north provinces is synchronizing of inadequate rainfall incidences during the most drought susceptible stage of growth and developments (Abdel, 1993). Most studies on faba bean cultivars for improving yield confirmed that pod development and seed filling stages were the most drought sensitive ( Abdel, 1982 and El-Hamadany, 2005. Therefore, attempts were made to improve the yield of faba beans by screening the most suitable cultivars to match with the ambient environments by the application of the lowest supplemental watering required for optimal yield during the most drought susceptible stage.

## MATERIALS AND METHODS

This experiments was conducted during 2004–2005 growing season at the research fields of Horticulture department, Agriculture and Forestry College, Mosul University, to evaluate five faba bean cultivars by withholding complementary watering at either vegetative (RWW), flowering (WRW), pod developments and seed fillings (WWR) stage, while, the check and other treatments were irrigated whenever 25% soil AWC is depleted to a depth of 25 cm.

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A Split Plot with in Factorial Randomized Complete Block Design was used in this experiment. The main plots were withholding supplementary irrigation during either vegetative (RWW), flowering (WRW) and pod developments or seed filling (WWR) , besides the continuous supplementary irrigation whenever 25% soil AWC is depleted (WWW) for check and other treatments. The sub main plot was Aquadulce, Local Syrian, Towaytha, Babylon and Taka357cultivars. Each treatment was replicated 3 times and each replicate was represented by a furrow of (0.75×5m), sown on both sides with 25cm intra plant space.

Seed of faba bean cultivars were obtained from ICARDA, Syria ;Iraqi Atomic Energy, Baghdad and Agricultural research station, Mosul. Field soil was plowed twice the dissected to plots and furrows. Gypsum blocks were settled to a soil depth of 25 cm from furrow tops to truck consumed soil moisture and its substitutions by rainfalls and supplementary irrigations. Diammonium phosphate (DAP) fertilizer was applied at rate of 15 g. $m^{-2}$ then, On December,$4^{th}$ ,2004. Seeds were sown. On January,$10^{th}$ , 2005, hills were thinned to 2 plants in pit. and on March, $3^{rd}$ , 2005, the second dose of 15 g.$m^{-2}$ of DAP fertilizer was broadcasted. On April, $14^{th}$ , 2005 , Malathion insecticides was applied at rate of 2ml.$l^{-1}$ to control aphids. Weed were manually controlled throughout growing season. Treatments of withholding supplemental watering at pod developments and seed fillings (WWR) were harvested on May, $8^{th}$ , 2005. Whereas other treatments were harvested on May, $20^{th}$ , 2005.

Number of branches, leaflet numbers per plant, node numbers on main stem, flower node numbers on main stem, first fruiting node on main stem, fruiting node numbers on main stem, pod numbers on main stem, inflorescence numbers on maim stem, flower number per inflorescence, aborted ovules per pod, aborted seeds per pod were counted. Plant height, leaflet length, leaflet width and pod length, fresh weight of plant, fresh weight of entire plant at harvesting and fresh weight of mature pods were measured. Plants and pods were dried under sun at the field for a week, then plant dry weights and pod dry weights were recorded. Leaf area and leaf area index were calculated from (Abdel, 1994), setting percentage was calculated by dividing pod numbers/ flower numbers per plant multiplied by 100, exceeding (%) = higher value – low value/ low value.

## RESULTS AND DISCUSSION

**Effect of environment on growth and yield of five faba bean cultivars:**

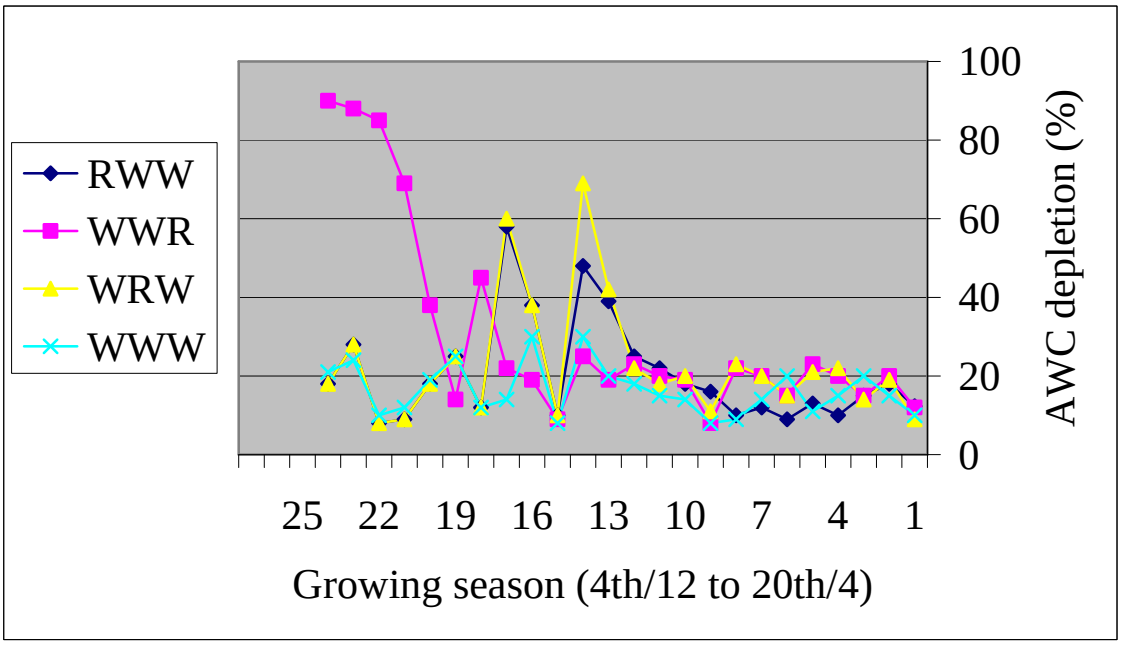
Meteorological data ( table,1 and figure 1a & 1b) revealed that earlier growth stage including seed germinations were synchronized with steady temperature decreases, where the cold stress was being the growth limiting factor. Thus plants were of small size and sustaining very slow rates of growth during this stage. Cold stress adversely affected the hydraulic conductivity of plant roots, especially in term of active transport of water which is highly dependant on respirations (Javot and Maurel, 2002). Low temperature alter the hydrophilic :

hydrophobic equilibrium of cellular membrane, ultimately led to their disintegration and loosing their functions (Turner and Kramer, 1980 and Crowe, *et al*.1989). Photosynthesis inhibition is usually caused by sub optimal temperatures as cold stress tended to close stomata, slow aperture opening and sustains closure of closed stomata (Guye and Wilson, 1987). Rainfalls records manifested that most of this season rainfalls occurred during the vegetative stage where a poor plant ability to utilize it, because of the slow growth rate and lesser extent of plant soil coverage. Therefore, supplemental watering was not required at all, then considerable steady temperature increases were commenced at the beginning of March, where plants started to resume higher growth rates. Thereafter, considerable rainfall was ceased during the higher growth rates creating two severe drought episodes ( table, 1; figure 1), rendering plants depended on the stored soil moisture. Thus, faba bean plants suffered early drought during the most susceptible physiological stages, owing to their shallow roots of 0-30cm soil depth (Ruggiero, 1999). This is the reason why the vegetative stage was less drought susceptible in compassion to other stages, particularly pod developments and seed fillings stage**.**

Table (1): The meteorological data, applied water and irrigation frequencies for faba bean. Mosul, Meteorological station.

| Months | Dec | Jan | Feb | Mar | Apr | May |
|---|---|---|---|---|---|---|
| Min Temp. ºc | 6.5 | 5.1 | 4.1 | 5.7 | 12.3 | 17 |
| Max Temp. ºc | 13.1 | 12.4 | 16.3 | 21.5 | 26.8 | 34.2 |
| R. H. % | 84 | 81 | 68 | 58 | 48 | 34 |
| Rainfalls mm | 82.2 | 88.6 | 62.6 | 20.5 | 71.4 | 3.7 |
| Irrig Freq WWW | 0.0 | 0.0 | 0.0 | 2 | 3 | 2 |
| Irrig Freq RWW | 0.0 | 0.0 | 0.0 | 2 | 3 | 2 |
| IrrigFreq WRW | 0.0 | 0.0 | 0.0 | 0.0 | 3 | 2 |
| Irrig Freq WWR | 0.0 | 0.0 | 0.0 | 2 | 0.0 | 0.0 |

Figure (1): Soil AWC depletion (%) during the growing season.




**Effect of ceasing supplemental irrigation at different physiological stages of five faba bean cultivars:** The obtained results (table, 2) manifested that pod developments and seed filling seemed to be the most water stress susceptible stage (WWR) in relation to other stages. Thus ceasing supplemental watering at this critical period resulted in substantial reductions in water use efficiency (44%), plant height (10.61%), node numbers on main stem (20.4%), number of branches per plant (16.4%), leaflet numbers per plant (28.1%), leaflet area (36.4%), leaf area index (76.8%0, number of flowering nodes on main stem (16.3%), pod length (15%), seed numbers per pod (15%), fresh weight of entire plant at harvesting (41.6%), fresh weight of mature pods (179.9%), weight of dry pods (290.8%), yield of dry seeds (292.4%) and weight of 100 seeds (7%), as compared to continuous watering treatment (WWW). Pod developments and seed fillings stage displayed the highest reductions in most detected parameters, as plants suffered severe drought at this most drought susceptible stage. Most biochemical and biological functions are included in this stage, where continuous vegetative growth, initiation of flower primordial and their developments, seed fillings and pod maturations are all synchronized at this stage. Subsequently, the results suggested that faba bean plants should not be deprived of adequate moisture until the closest pod to the apical of branches are matured. These results in agreements with those obtained by (Stedule, 1998; Manschadi, *et al.* 1998 and Chielewski and Kohn, 1999). Competitions on photosynthetic assimilate were severe at this stage where generations and differentiations of leaves node flowers pod setting, seed developments and pod maturations are proceeds almost to the end of plant life. Similar results were reported by (Chapman and Peat, 1978; Kagure, *et al.* 1978 and El-Far, 1994). Flowering stage (WRW) was slightly less drought susceptible, as compared to the former (WWR) treatment. It significantly increased leaflet area (17.7%), leaf area index (20.6%), pod length (5.6%), seed number per pod (16%), weight of

mature pods (67.9%), weight of dry pods (65.4%), and weight of 100 seeds (18.7%). During the flowering stage (WRW), rainfall incidences were ceased and the first drought episode was started. Therefore, plants utilized the stored soil moisture and some rain showering. They suffered more drought in relation to (RWW) as it resulted in higher reductions in most detected parameters. However, (Abdel, 1993 and El-Hamadany, 2005) results revealed slight reductions in this stage (WRW), which we referred it to the very low rainfall incidence of this season as compared to those of former investigations. Ceasing complementary watering at the vegetative stage (RWW) resulted in the lowest adverse effects of water stress as compared to the above two stages. When a comparison was made to WWR stage , this treatment exhibited substantial increases in water use efficiency (43.9%), plant height (17.6%), node numbers on main stem (17.7%), leaflet numbers per plant (24.6%), leaflet area (17.2%), leaf area index (44.7%), plant fresh weights (18.9%), number of flowering nodes on main stem (48.8%), first fruiting node on main stem (31.5%), pod numbers on main stem (28.8%), pod length (9.3%), fresh weight of entire plant at harvesting (28.5%), fresh weight of mature pods (39.3%), pod dry weights (93.3%) and yield of dry seeds (96%). Moreover, it displayed non-significant difference in relation to continuous supplemental watering treatment (WWW) in terms of plant height, number of branches per plant, node numbers on main stem, leaflet numbers per plant, leaflet area, leaf area index, internode's length, number of flowering nodes on main stem, flower numbers per inflorescence, setting percentage, first fruiting node on main stem, fruiting node numbers on main stem , pod numbers on main stem, pod length, seed numbers per pod and aborted ovules per pod. However, it showed reductions of 19.6, 18.3, 37.1, 19, 19.7, 22.2, and 22% in water use efficiency, plant fresh weight, plant dry weight, fresh weight of entire plant at harvesting, fresh weight of mature pods, pod dry weight and yield of dry seeds, respectively. Whereas, continuous supplementary irrigation, the check treatment showed the highest values in most detected parameters (table, 2). Ceasing supplemental irrigation at the vegetative stage of faba bean growth manifested slight reductions in growth and yield parameters in relation to the other two growth stages, particularly the stage of pod developments and seed fillings which showed the highest reductions in compression to continuous supply of adequate water. The slight reductions observed in the vegetative stage withholding irrigation (RWW) were attributed to the low extent of plant suffering from drought during this early stage where most rainfall incidences occurred (table, 1and figure 1). Furthermore, even if plants suffered real drought at this stage. there were enough juvenility time to recover. Very close results were stated by Sparrow, (1995).

**Cultivar Responses:** Local Syrian appeared to be the most responded cultivar to withholding complementary watering at all growth stages. It significantly exceeded Aquadulce in leaf number per plant (25.8%), leaf area index (20%), pod length (13.2%), seed numbers per pod (21.9%), pod dry weights (9.8%). Moreover it displayed non-significant differences in relation to Aquadulce, the paramount cultivar under continuous watering in all other detected parameters. Aquadulce substantially exceeded Towaytha in water use efficiency (18%), fresh

weight of entire plant at harvesting (12.5%), fresh weight of mature pods (15.3%), weight of dry pods (14.1%) and yield of dry seeds (13.4% ). However, most other traits were non-significantly differed. Towaytha showed the highest values in relation to other cultivars in terms of plant height (67 cm), number of nodes on main stem (18.3), leaf area index (15.6), number of flowers per inflorescence (4.5), pod numbers on main stem (3.25). In addition to that, it significantly exceeded Babylon in plant height (6.9%), number of nodes on main stem (12.3%), leaflet numbers per plant (20.4%), leaflet area (19.1%), leaf area index (45.9%), number of flowering nodes (on main stem (13.5%), pod numbers on main stem (30%), fresh weight of entire plant (10.9%), pod dry weights (12.4%) and yield of dry seeds (14.8%). However, some other traits were not significantly differed. Babylon was the fourth in the cultivar responses sequence. It showed the highest flower numbers per inflorescence (4.5) in relation to other cultivars. When Babylon compared to Taka357, it showed significant increases in water use efficiency (33%), plant height (73.3%), number of nodes on main stem (148.2%), leaflet numbers per plant (73.5%), plant dry weights (95.5%), plant fresh weight (26%), flowering node numbers on main stem (240.3%), flower numbers per inflorescence (63.6%), first fruiting node on main stem (60.5%), pod length (11.5%), seed numbers per pod (52.9%), fresh weight of entire plant at harvesting (15.8%), fresh weight of mature pods (10.8%), pod dry weight (45.1%) and yield of dry seeds (47.3%). Taka357 disability to compete its corresponding cultivars was confirmed by its lowest values in most detected parameters, particularly these related to yield component which is considered as a major production criterion by agriculturist. However, Taka357 showed the highest values in number of branches per plant, leaflet area and setting percentage. Local Syrian and WWR stage interaction revealed the best responses to water stress resistance in relation to other

Table (2).Effect of ceasing irrigation during given growth stages and cultivars.

| Cultivars | WWW | RWW | WRW | WWR | Aqu | Syr | T357 | Tow | Bab |
|---|---|---|---|---|---|---|---|---|---|
| Wue ($g.mm^{-1}$) | 4.1a | 3.3b | 2.3d | 2.8c | 3.7a | 3.9a | 2.1c | 3.1b | 2.8b |
| P h (cm) | 64a | 61.5a | 52.3a | 57.9b | 62.7b | 66ab | 36.2c | 67a | 62.7b |
| B no. /p | 7.6a | 7.6a | 7.1ab | 6.5b | 6b | 6.2b | 12a | 5.8b | 6b |
| node no./s | 17.3a | 16.9a | 14.3b | 14.2b | 17.9a | 19.2a | 6.6c | 18.3a | 16.3b |
| leaflet /p*10 | 41.9a | 40.7a | 32.6b | 31.7b | 39.6b | 44.6a | 20.6d | 43.1a | 35.8c |
| leaflet a ($cm^2$) | 31.4a | 31.8a | 27.1b | 23c | 23.6bc | 25.8bc | 43.3a | 26.6b | 22.4c |
| Leaf area ind. | 16.6a | 16.3a | 11.3b | 9.4c | 12.9b | 15.5a | 12.3bc | 15.6a | 10.7c |
| Inte. L (cm) | 3.9b | 3.9b | 3.8b | 4.5a | 3.5bc | 3.4c | 5.6a | 3.7bc | 3.8b |
| Pdw.$kg.m^{-2}$ | 0.91b | 0.66c | 0.66c | 1.1a | 0.96ab | 0.98a | 0.43c | 0.94ab | 0.83b |
| Pfw.$kg.m^{-2}$ | 1.52a | 1.29b | 1.08c | 1.63a | 1.61a | 1.49a | 1.07c | 1.46ab | 1.28b |
| F nod no/s | 13.3a | 12.8a | 7.7c | 11.4b | 13.5a | 14a | 3.5c | 13.5a | 11.9b |
| Fl no /inf | 4.1a | 3.8a | 4a | 4.1a | 4.5a | 4.2a | 2.8b | 4a | 4.5a |
| Settin % | 8.8a | 9.5a | 8.9a | 10.4a | 5.3b | 5.8b | 24.3a | 6.4b | 5.1b |
| f f node | 4.2ab | 4.3a | 3.7b | 4.1ab | 4.3a | 4.6a | 2.8b | 4.4a | 4.4a |
| no. f nodes | 2.9a | 2.8a | 2.1b | 2.7a | 3.1a | 2.8ab | 2.1c | 2.9ab | 2.4bc |
| Pods/stem | 3.1a | 3a | 2.3b | 2.9a | 3.1ab | 3.1ab | 2.3c | 3.3a | 2.5bc |
| Pod le(cm) | 22.2a | 22.3a | 20.4b | 19.3c | 21bc | 23.8a | 19.2d | 20.1cd | 21.4b |
| Seeds / pod | 4.9a | 5.1a | 4.9a | 4.3b | 5bc | 5.6a | 3.4d | 4.7c | 5.2ab |
| abor seed/p | 0.2a | 0.2a | 0.2a | 0.3a | 0.1b | 0.2ab | 0.4a | 0.1b | 0.2b |
| Abor ovu/p | 0.1a | 0.2a | 0.2a | 0.2a | 0.3a | 0.2a | 0.2a | 0.1a | 0.2a |
| epfw(kg.m-2) | 3.13a | 2.63b | 2.05c | 2.21c | 2.87a | 2.8a | 1.99d | 2.55b | 2.3c |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mpw.kg.m$^{-2}$ | 1.6a | 1.34b | 0.96c | 0.57d | 1.26a | 1.31a | 0.92c | 1.09b | 1.02b |
| Pdw.kg.m$^{-2}$ | 0.86a | 0.7b | 0.36c | 0.22d | 0.61b | 0.67a | 0.38e | 0.54c | 0.48d |
| Yds.kg.m$^{-2}$ | 0.65a | 0.63b | 0.27c | 0.17d | 0.47a | 0.51a | 0.27d | 0.42b | 0.36c |
| 100 sw(g) | 141.8c | 149.4b | 157.4a | 132.6b | 149.9a | 145ab | 139.8b | 148.1a | 143.8ab |

(Wue= water use efficiency);(lwp=leaf water potential);(wsd=leaf water saturation deficit);(ph=plant height);(bno/p=branche numbers/plant);(nodeno/s=node numbers/main stem);(leaflet/p= leaflet numbers /plant);(leafleta=leaflet area);(Leaf area in+leaf area index);(interl=internode length);(pdw=plant dry weight);(pfw=plant fresh weight);(flno/inf=flower numbers/inflorescence);(f node no/s=flowering node numbes /main stem);(ffnod=first fruiting node/mainstem);(nofnodes=fruting node numbers/ main stem).

cultivars at this drought susceptible stage. It manifested the highest water use efficiency (3.4 g.mm$^{-1}$), number of nodes on main stem (17.3), leaflet numbers per plant (398.3), leaf area index (10.95), plant dry weights (1.4 Kg.m$^{-2}$), first fruiting node (5.3), pod length (22.7 cm), seed numbers per pod (5.4), fresh weight of entire plant at harvesting (2.5 Kg.m$^{-2}$) and yield of dry seeds (0.2). Furthermore this cultivar was also superior over other cultivars under sustaining adequate soil moisture throughout the whole growing season (WWW). It showed the optimal responses in water use efficiency (5.52 g.mm$^{-1}$), plant height (73.8 cm), node numbers on main stem (21.7), leaflet numbers per plant (486.7), leaf area index (18.6), number of flowering nodes on main stem (16.3), fresh weight of mature pods (1.99 Kg.m$^{-2}$), pod dry weights 1.18 Kg.m$^{-2}$) and yield of dry seeds (0.88 Kg.m$^{-2}$). On the other hand, Taka357 was the inferior cultivar , it gave the lowest values in most in most detected parameters at all investigated stages (Table 2a). Local Syrian and Aquadulce cultivars were superior over others. They gave the highest values in most of the detected traits. Thus, the results suggested that these two cultivars were the most drought resistance in relation to the others. Furthermore they were also the best responded under adequate irrigation. Towaytha displayed moderate responses as it gave slightly lower values in relation to Aqadulce. Followed by Babylon which showed significant reductions, when was compared to Towaytha cultivar. On the other hand, Taka 357 was the worst cultivar. The five cultivars were ordered as the following according to their performance under the most drought susceptible stage or even under well watering conditions : Local Syrian > Aquadulce > Towaytha > Babylon > Taka 357. The results were not recommended the cultivation of Taka 357 under both rainfalls and supplementary irrigation in Mosul, owing to its very low productivity. Moreover, this cultivar was not contribute to the yield quality as it gave non-distinguished protein percentage or weight of100 seeds and its earliness in maturation are not desired desperately in the production of dry seeds. The determinate faba bean type is grown in low altitude region of China as well as in Japan , it has large number of branches, generally 10 to12. Studies revealed that the determinate plant type has a major sink concentrated in the middle portions of the plant stem where most of the pods are born. The photosynthesis rate of determinate types was high in the pod set area and continued to remain high from pod setting to grain filling (Kagure, 1993).

**تقييم بعض أصناف الباقلاء ( *Vicia faba* L . ) لمقاومة الجفاف والتقنن المائي :**

**٣- استجابة مراحل النمو للأمطار والري التكميلي**

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**الخلاصة**

أجريت هذه التجربة خلال فصل النمو ٢٠٠٤ – ٢٠٠٥ في حقل أبحاث قسم البستنة وهندسة الحدائق ، كلية الزراعة والغابات ، جامعة الموصل لتقييم النمو والحاصل لخمسة أصناف من الباقلاء للأمطار والري التكميلي حيث تم توقيف الري التكميلي في المرحلة الخضرية ( RWW ) والمرحلة الزهرية ( WRW ) ومرحلة تطور القرنات وامتلاء الحبوب ( WWR ) وتم ري المعاملات الأخرى والمقاربة عند استنفاذ ٢٥ % من الماء الجاهز ولعمق ٢٥ سم من التربة . أظهرت النتائج بأن مرحلة نمو القرنات وامتلاء الحبوب ( WWR ) هي أكثر المراحل حساسية للجفاف وعليه يجب استخدام الري التكميلي لتحسين الحاصل كماً ونوعاً . وكانت المراحل الأخرى هي أقل حساسية للجفاف خاصة المرحلة الخضرية . يمكن ترتيب الأصناف حسب قدرتها في النمو والحاصل خلال المرحلة الفسلجية الحساسة جداً للجفاف وكما يلي سوري محلي > كوالجي > تويثة > بابل > طاقة ٣٥٧ .من خلال نتائج تجربة ١ يمكن الاستنتاج بأن الاستدلال على مقاومة الجفاف في الصنف المعين من خلال أداء بذور هذا الصنف تحت الظروف غير المثالية يكون غير دقيق تماماً . كان صنف طاقة ٣٥٧ أكثر الأصناف حساسية للعطش خلال جميع مراحل النمو وخاصة مرحلة نمو القرنات وامتلاء البذور .

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