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Effects of climatic gradient on growth performance, yield components, and chemical composition of lentil legume crop

(*Lens culinaris Medik*)

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Abstract:
The main goals of the present study were to characterize, evaluate, compare and determine the suitability of lentil legume crop (*Lens culinari Medik., var. Baladi*) to different Palestinian agro-ecological locations namely Dora, Al-arroub and Janata. Different morphological traits, yield components and some grain quality parameters were registered. Obtained data were statistically analyzed using MINITAB package system. Results showed highly significant environmental (locations) effects for almost all measured traits. In general, Al-arroub site showed higher morphological and yield values; whereas Janata site presented the lowest values. However, no significant variations were observed for all conducted chemical parameters (dry matter, protein content and ash) among the three examined locations. Drought and the limited water availability are the main factors affecting lentil ontogeny and yield, but not the quality variables. Lentil is not recommended for regions of precipitations lower than 250 mm.

Keywords: Lentil, drought, morphological features, yield component, seed quality.

1. INTRODUCTION:

Legumes are the second largest family (after grasses), in terms of agriculture and economic importance [1]. Among different legume crops, lentil is so early domesticated with vital range of uses as food and feed owing to its protein-rich grains and straw [2]. Statistically, the total world cultivated area of lentil is about 5.11 million hectares producing around 5 million tons of seeds, as it was revealed in the triennium ending of 2014 [3], and interestingly its production is increased over the past decades. In developing countries alone, lentil production and yield rose by 60% [4]. Major production increases have been recorded in India, Turkey and Canada [5].

Economically, lentil is a vital nutritious food legume. The primary product is the seed which has relatively higher contents of protein, carbohydrate and calories compared to other legumes [6]. Because of its high average protein content and fast cooking characteristic, lentils are considered the most desired crops [7], especially in the third world countries. It can be used as a main dish, side dish, or in salads. Seeds can be fried and seasoned for consumption; flour is used to make soups, stews, purees, and mixed with cereals to make bread and cakes; and as a food for infants [8]. Lentil is an important dietary source of energy, fiber, minerals, vitamins and antioxidant compounds, as well as diverse non-nutritional components like protease inhibitors, tannins, α-galactoside, oligosaccharides and phytic acid [9]. Furthermore, its high ability to convert atmospheric nitrogen into nitrogenous compounds which is useful for fertilizing the soil makes it highly important [10].

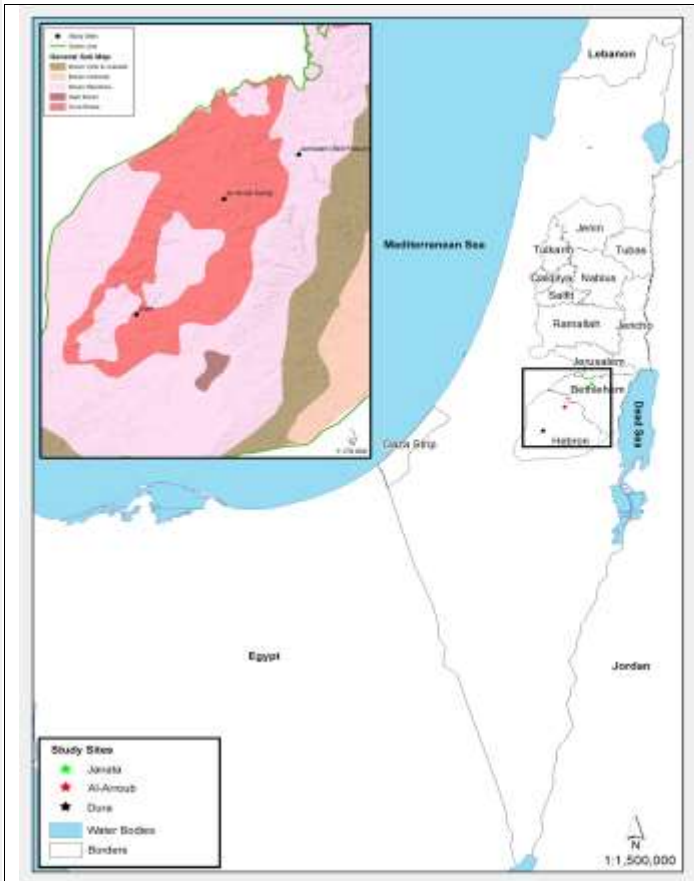
Despite its high values and importance's worldwide, lentil constitute only a small portion of the Palestinian cultivable area, in which currently it covered only an area of about 95.2 hectare compared to 423 hectare 10 years ago [11]. One explanation for such noticeable reduction is the sharp decrease in rainfall and the marked increase in the number of droughts which characterize the region over the last several decades [12], particularly in the southern and eastern slopes of Palestine [13]. Unfortunately, there are forecasts of a further decline in rainfall and increase drought in the region which might negatively affect and devastate the native species of Palestine including lentil as an example [14]. In addition to that, lentil is subjected to either disappearance or deterioration. It also suffers from many other problems such as unsuitable agricultural practices and the lack of literature and scientific knowledge for its suitability, adaptability and productivity to different Palestinian agri-ecological regions. The main goals of the present study were to characterize, evaluate, compare and determine the suitability of lentil legume crop (*Lens culinari* Medik*.,* var. Baladi) to different Palestinian agro-ecological locations namely Dora, Al-arroub and Janata.

2. MATERIALS AND METHODS:

2.1. Plant materials, experimental sites, design and plantation

LENTIL (*LENS CULINARIS* MEDIK., VAR. BALADI), WAS CULTIVATED IN THREE DIFFERENT AGRI-

ecological sites namely Dora, Al-arroub and Janata (Figure 1), using completely randomized design with five replicates with a net plot size of 20 m^2 area (4m*5m) / replicate. To isolate the plots as well as to facilitate the follow-up process (cultural practices, registration, etc), one meter corridors around all the plots were used. Seeds were sowing manually using adoption rate of 300 gram seeds / plot (equivalent to 15 kg/dunum).



- Dora-Hebron (elevation: 660 m; latitude: 31"44; longitude: 34"98), has mountainous topography with Terra Rossa (red) soil, and an average rainfall of about 380 mm.
- Al-arroub-Hebron (elevation: 842 m; latitude: 31"36; longitude: 354"13), has valley topography with Terra Rossa (red) soil, and an average rainfall of about 610 mm.
- Janata-Bethlehem (elevation: 629 m; latitude: 31"67; longitude: 35"24), has hilly with moderate to steep slope topography, with Brown Rendzina soil, and an average rainfall of about 285 mm.

FIGURE 1. MAP OF PALESTINE SHOWING THE THREE EXPERIMENTAL SITES WITH SOME GEOGRAPHICAL AND SOIL TYPES AS WELL AS SOME METEOROLOGICAL DATA.

2.2. Measured and evaluated parameters

Different agro-morphological parameters including: germination date (when 50% of the total germination occurred), flowering period (the period lasts from the beginning of flowering until all plants were flowered), fruit set period (the period lasts from the beginning of fruit set until all the fruit set of all plants were done), maturation and harvesting period (plants considered mature, when 50% of the maturation occurred and when the moisture contents of the seeds reaches 15%), stem length (from the stem base up-to the stem apex in centimeter), number of branching (using randomly one square meter frame-quadrate per plot), and number of grain per pod were registered [15].

At the maturity stage, plants of each plot were harvested manually, and then sub-dried for a week. Continually, total fresh yield was recorded in kilo-gram (kg). Then, each crop was sun dried and then threshed separately. The grain weight of each plot was recorded in kg and hay yield of each plot was calculated by subtracting the grain yield from the total yield. In addition, weight of 100 seeds per crop was registered. Finally, obtained data were subsequently converted into kg/dunum (kg/1000m^2).

For grain quality parameters, representative seed samples were collected from the three sites. Seeds were ground in a Wiley mill, and then stored in sealed jars [16]. Chemical analysis including: Dry matter was determined using an oven at 65°C for 24 hours [17]. Crude protein was determined by estimating nitrogen content using Kjeldahl procedure; percentage of crude protein obtained by multiplying the nitrogen concentration by 6.25 (NX 6.25); and ash content was determined using igniting in muffle furnace at 550 ^{o}C for 8 h [16].

2.3. Data analysis

The data were statistically analyzed using the one-way analysis of variance (ANOVA) and means were separated using the Tukey's pairwise comparisons at a significance level of $p \leq 0.05$ using the MINITAB package system.

3. RESULTS:

3.1. Germination and morphological parameters

As shown in table 1, germination took 10-11 days at Janata and Dora sites; however, it took longer time at Al-aroub site by 14 days. Flowering period was almost similar at the three evaluated sites which last from 6-7 days. Fruit set period lasts 7 days at Janata site, 8 days at Dora site, and 11 days at Al-aroub site. Maturation and consequently harvesting date was earlier at Janata site with 23 days, followed by Dora site 27 days; whereas, maturity stage at Al-arroub site took longer time compared with the other two examined sites.

Significant variation in stem length variable between the three different sites was observed, in which Al-arroub site revealed significantly higher stem length followed by Dora and Janata sites, respectively. In reference to crop branching, Al-arroub and Dora sites revealed higher branching than Janata site. Number of grain per pod showed similar at the three evaluated sites.

Significant variations in the weight of 100 seeds at three different sites were also exhibited. Al-arroub site revealed significantly higher seed weight (7 gram), followed by Dora (6 gram) and Janata (5.56 gram) sites respectively.

TABLE 1. GERMINATION AND MORPHOLOGICAL PARAMETERS OF LENTIL (LENS CULINARIS MEDIK.) CULTIVATED AT THREE DIFFERENTIATES SITES OF SOUTHERN REGION OF PALESTINE.

Morphological Parameters	Site		
	Dora	**Al-aroub**	**Janata**
Germination date	11 days	14 days	10 days
Flowering period	7 days	7 days	6 days
Fruit set period	8 days	11 days	7 days
Maturation and harvesting period	27 days	30 days	23 days
Stem length (cm)	29.56 b±0.961	38.3 a±0.676	27.98bc±1.69
No. of branching	.498±0.157	5.01 ±.0166	.478±.0134
No. of grain / pod	1.00 ±0.00	1.04±0.400	1.00±0.00
Weight of 100 seed (gram)	06.1b±0.105	7.0 a±0.095	5.56c±0.169

* Means within rows using different letters are differ significantly at the P value ≤ *0.05* levels (using one way analysis).

3.2. Yield parameters

Based on the analysis of variance (Table 2), and comparing with the other two sites, lentil crop at Al-arroub site exhibited significantly the highest yield (grain and hay) by 471.2 kg/dunum (1000m^2); however, the lowest yield was presented at Janata site by 288 kg (Table 2). Regarding the total grain production, Al-arroub site presented the highest grain production (43.7 kg), followed significantly by Dora site (18.3 kg), and Janata site with only 4 kilo gram per dunum. Similar trend goes also with the total hay production parameter.

TABLE 2. YIELD PARAMETERS OF LENTIL (*LENS CULINARIS* MEDIK.) CULTIVATED AT THREE DIFFERENTIATES SITES OF SOUTHERN REGION OF PALESTINE.

Yield parameters	Site		
	Dora	Al-aroub	Janata
Total fresh weight (kg/dunum)	439.5 bc±78.2	471.2a ±23.2	292ab±39.4
Grain production (kg/dunum)	18.3b±2.60	43.70a ±1.99	4.00c±2.45
Hay production (kg/dunum)	421.2ab±36.1	427.5a ±21.3	288b±39.4

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

3.3. Chemical composition

Dry matter, protein content, and ash variables of lentil crop presented similar results with those of broad bean and chickpea crops, in which the sites have no significant differences among these examined parameters (Table 3) (http://www.feedipedia.org).

Table 3. Chemical Composition and Quality Parameters of Lentil Crop *(Lens Culinaris Medik.)* Cultivate at Three Differentiates Sites of Southern Region of Palestine.

Parameters	Site			International percentage (feedipedia)	
	Dora	Al-aroub	Janata	MIN	MAX
Dry matter %	90.47±0.604	89.97±0.873	89.70±0.205	87.1	91.0
Protein %	28.08±0.907	27.22±1.44	28.25±0.469	24.6	30.0
Ash %	5.10±0.359	6.18±0.195	6.42±335	2.7	6.8

* Means within rows using different letters are differ significantly at the *P* value ≤ *0.05* levels (using one way analysis).

4. DISCUSSION:

4.1. Germination and morphological parameters

4.1.1. Germination

Germination is a critical phase in plant growth that determines plant establishment and final crop yield [18]. Here, our examined crop showed earlier germination date at Janata, followed by Dora and Al-arroub sites respectively. Since the same genotype was repeated at the three sites with the same cultural practices (sowing), and the first rainfall date occur at the same time, therefore the environmental fluctuation among the three sites might explain the differences in the germination period among the three examined sites. In fact, germination period of any crop is depending on the prevailing different agro-climatic condition, in which temperature and rainfall are the most important factors. The high temperature characterized Janata might be the reason for the early germination at this site. Similar results confirmed by [19], who stated that faster germination temperature occurs at high temperature. Furthermore, [20] indicated that the optimal temperature for seed germination of winter legume crops is about 10–15^{0}C and high germination temperatures are considered to be 22–35^{o}C.

Furthermore, germination is directly related to the amount of water absorbed, in which germination rate and the final seed germination decrease with the decrease of the water movement into the seeds during imbibition period [21].

4.1.2. Flowering, fruit set, and maturation periods

Similar trends goes also with flowering, fruit set, and maturation periods, in which lentil crop presented earlier periods at Janata, intermediate at Dora and late flowering, fruit set and maturation periods at Al-arroub sites. The long flowering, fruit set and maturation periods exhibited at Al-arroub site might be related to the long rainfall and cold season period [22], compared to the drought once at Janata. Accordingly, water stress led to significant decrease in number of days to flowering and maturity stages [23]. This result also in agreement with [24] who found significant differences in days of flowering for some legume cultivars. Furthermore, [25] showed that faba bean legume crop had longer time to flowering when grown under irrigation condition than those grown under rain-fed conditions confirming therefore the significant effects of rainfall period.

Concerning fruit set, it is well documented that there is a significant reduction impact of heat stress on pod-set, filled pods and pod numbers per plant in chickpea legume crop [26].

4.1.3. Stem length

Stem length is genetically and environmentally controlled characteristic. Since same crop genotype is examined at three different locations, therefore the environmental conditions especially water availability probably explained the higher significant values presented at Al-arroub site compared with the other two sites. Consistently, similar results have been confirmed in literature [27] who pointed out that the stem length stage more affected by drought and water stress, in the event of increase drought lead to reduce the stem length (plant height) of any field crop. Interestingly, plant height is considered an important criterion discriminating among different geographic regions [24]. These results were also in agreement with [25], who found that plant height of broad bean genotypes varied significantly under rain-fed conditions.

When we made correlation between stem length and total production, positive relationship was obtained. Similar correlation was found by [28].

4.1.4. Number of branches

No Significant variation was observed in number of branches on the main stem among the three examined sites which imply that this criterion is genetically controlled rather than environmental once. In fact, number of branch per plant and the number of pod per plant were the main constitutes of total plant yield [29].

4.1.5. Number of grain per pod

Environmental factors had little effect on grains per pod of chickpea as a similar legume crop and it is mainly influenced by genotypes [30]. Also, other studies indicated that for any given cultivar of similar faba bean genotype, the average number of seeds per pod is a relatively stable character [31]. Confirming to this assumption, and despite the harsh conditions at Janata site, no significant differences were noticed among the three examined sites for this variable which implying that this variable is more influenced by genetic than environmental factors.

4.2. Yield parameters (weight of 100 seeds, total fresh weight, grain, and hay production).

The significant variations in the weight of 100-seeds observed at three different sites (Table 2), might be attributed either to genotype and/or environmental influences. Some researchers stated that, number of seeds per pod and 100 seed weight is relatively stable trait and did not significantly affected by the environment [32]. However, other studies showed that water deficit during the reproductive growth of legume crops is highly influences seed yield components and causes reduced pods per plant and 100-seed weight affecting thereby the total crop productivity [33]. Indeed, water stress has significant effects on all plant characteristics and especially on seed yield. Means that, despite being strongly genetically determined, seed weight also depends on climatic conditions, such as water availability or temperature regime [34]. These explanations confirmed the significant weight of 100-seeds revealed at Al-arroub site (high average rainfall and longer season) compared with Janata site (drought conditions with low average rainfall and short season).

Similar trends go also with the other yield parameters which showed low yield parameters at Janata site and high once at Al-arroub site. Supporting evidences were reported by many researchers [35], who attributed the reduction in grain yields under water deficit to the reduction in number of pods per plant, number of grain per pod and total grain weight.

In addition to water effects, temperature also played an important role in limiting the final legume production in which high temperature reduces total grain yield. Indeed, high temperature during the grain filling period can reduce the individual seed size at maturity which may lower grain yield per plant [36]. Other studies showed that, average daily temperatures of 20-25°C is required for a proper growth of some legume crops and higher temperatures led to flowers and fruits fall [37], resulting thereby in declining the total yield. Also, in another work, it was reported that heat stress during the reproductive phase in legumes is generally allied with lack of pollination, abscission of flower buds, flowers and pods with substantial yield loss [38]. Hot temperature (> 30 ºC) and dry atmospheric conditions lead to profligate loss of flower buds and open flowers in chickpea [39]. High temperature stress also causes yield losses because of damage to reproductive organs [40], and had reduced total and grain yield during drought [41]. These findings indeed could explain the general trend of low production exhibited at Janata site which characterized by a general harsh conditions in terms of water availability and drought stress.

4.3. Chemical composition

Generally, quantity characteristics are influenced mainly by environmental factors, while the quality once is largely genetically determined [42]. In fact, findings on the nature of genetic control are rather controversial, although all scientists agree that this is undoubtedly a complex subject and one that is difficult to study, due to the strong influence of the environment upon its expression [43]. Concerning protein content parameter, it is well documented that protein content is influenced largely by environmental factors [44]. In our study, its values tended to be rather higher at Janata site but not significant compared with the other two tested sites. Similar results were also registered by [45] who indicated that protein content of legumes such as faba bean tended to increase under water deficit condition. This indeed the case of Janata site (drought conditions) that presented slightly higher protein content. Our finding also confirmed by several researches [46] who reported that water stress can reduce crop yield, but it has no significant effect on seed quality.

Furthermore, the protein content of lentil (27.22 to 28.25) found to be within the general international acceptable lentil average (feedipedia) which is ranged between 24.6 to 28% (Table 3). A similar trend goes also with ash contents for all examined sites in which no significant differences observed.

5. Conclusions:

The present study concluded that drought and the limited water availability are the main factors affecting lentil ontogeny and production, but not the quality parameters (protein content, ash content and dry matter). In addition, lentil could be successfully recommended in the regions with more than 380 mm/year and must exclude in regions of precipitations lower than 285 mm.

References

[1] Lewis G, Schrire B, Mackinder B, Lock, M. (eds.), (2005). Legumes of the world. Royal Botanic Gardens, Kew, Richmond, U.K.

[2] Mishra B.K, Srivastava J.P, Lal J.P, (2018). Drought resistance in Lentil (Lens culinaris Medik.) in relation to morphological, physiological parameters and phenological developments. Int. J. Curr. Microbiol. Appl. Sci. 7: 2288–2304.

[3] FAO, (2019). The Global Economy of Puloses. Rawal V, Navarro D.K., (eds.). Publication of Food and Agriculture Organization of the United Nations, Rome, Italy.

[4] Hulse J.H. (1990). Nature, composition and utilization of grain pulses. p.11-27. In: ICRISAT. Uses of tropical grain pulses: Proceedings of a consultants' meeting, 27-30 Mar, 1989. ICRISAT Center, India, Patancheru, A.P. 502 324. India, ICRISAT.

[5] Ahlawat I.P.S, (2012). Agronomy – rabi crops, Lentil. Division ofAgronomy, Indian Agricultural Research Institute, New Delhi.

[6] Khazaei H, Subedi M, Nickerson M, Martínez-Villaluenga C, Frias J, Vandenberg A, (2019). Seed protein of lentils: Current status, progress, and food applications. Foods (Basel, Switzerland). 8: 391.

[7] Muehlbauer FJ, Cubero JI, Summerfield RJ, (1985). Lentil (Lens culinaris Medic.). p. 266-311. In: Summerfield RJ, Roberts EH (eds.), Grain Legume Crops. Collins, 8 Grafton Str., London, UK.

[8] Williams P.C, and Singh U. (1988). Quality screening and evaluation in pulse breeding. p. 445-457. In: Summerfield R.J. (ed.), World crops: Cool season food legume. Kluwer Academic Publishers, Dordrecht, the Netherlands.

[9] Urbano G, Porres J.M, Fnas J. and& Vidal-Valverde, C. (2007). Nutritional value. p. 47–93. Vol. 3. In: Lentil: An Ancient Crop for Modern Times. Yadav S.S, McNeil D, and Stevenson P.C. (eds.) Berlin: Springer.

[10] Postgate J. (1998). Nitrogen fixation (3rd ed.). Cambridge University Press, UK.

[11] MOA, (2018). Publication of the Ministry of Agriculture, Ramallah, Palestine.

[12] Zhang X, Aguilar E, Sensoy S, Melkonyan H, Tagiyeva U, Ahmed N, Kutaladze N, Rahimzadeh F, Taghipour A, Hantosh TH, Albert P, Semawi M, Karam Ali M, Said Al-Shabibi MH, Al-Oulan Z, Zatari T, Al Dean Khelet I, Hamoud S, Sagir R, Demircan M, Eken M, Adiguzel M, Alexander L, Peterson TC, Wallis T, (2005). Trends in Middle East climate extreme indices from 1950 to 2003. Journal of Geophysical Research: Atmospheres. 110: 1-12.

[13] Basheer-Salimia R, Ward J, (2014). Climate change and its effects on olive tree physiology in Palestine. Review of Research, 3, 1-7.

[14] IPCC, (2012). Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of working groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B. Barros, V. Stocker, T.F. Qin, D. Dokken, D.J. Ebi, K.L. Mastrandrea, M.D. Mach, K.J. Plattner, G.K. Allen, S.K. Tignor, M. and Midgley, P.M. (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp582.

[15] Alsalimiya M, De-Luigi G, Abu-Rabada E, Ayyad H, Basheer-Salimia R, 2018. Adaption of wheat genotypes to drought stress. International Journal of Environment, Agriculture and Biotechnology, 3(1): 182-186.

[16] AOAC (1990). Official methods of analysis of the AOAC, (15th ed). Methods 932.06, 925.09, 985.29, 923.03. Association of official analytical chemists. Arlington, VA, USA.

[17] Ryan J, George E, Abdul R, (2001). Soil and Plant Analysis Laboratory Manual. Second edition. International Center for Agricultural Research in the Dry Areas (ICARDA).

[18] Zeid I.M, (2011). Alleviation of seawater stress during germination and early growth of barley. International Journal of Agriculture: Research and Review. 1: 59-67.

[19] Covell S, Ellis RH, Roberts EH, Summerfield RJ, (1986). The influence of temperature on seed germination rate in grain legumes: I. A comparison of chickpea, lentil, soyabean and cowpea at constant temperatures. Journal of Experimental Botany. 37: 705-715.

[20] Ellis R.H, Covell S, Roberts E.H, Summerfield RJ, (1986). The influence of temperature on seed germination rate in grain legumes: II. Intraspecific variation in chickpea (Cicer arietinum L.) at constant temperatures. Journal of Experimental Botany. 37: 1503-1515.

[21] Welbaum G.E, Bradford K.J, (1990). Water relations of seed development and germination in muskmelon (Cucumis melo L.) : III. Sensitivity of germination to water potential and abscisic acid during development. Plant Physiol. 92: 1038-1045.

[22] Abu-Alhaija E, Ganma I, Alarawy S, (2011). Rainfall Seasonal Report, 2010/2011, General Director of Soil and Irrigation, Ministry of Agriculture, Palestinian National Authority: Ramallah, Palestine.

[23] Ahmed A.K, Tawfik KM, Abd-Elgawad ZA, (2008). Tolerance of seven fava bean varieties to drought and salt stresses. Research Journal of Agricultural and Biological Science. 4: 175-186.

[24] Suso M.J, Moreno M.T, Cubero JI, (1993). New isozyme markers in Vicia faba: Inheritance and linkage. Plant Breeding. 111: 170-172.

[25] Della A, (1988). Characteristics and variation of Cyprus faba bean germplasm, FABIS Newsletter, 21, 9-12.

[26] Krishnamurthy L, Gaur P.M, Basu PS, Chaturvedi SK, Tripathi S, Vadez V, Rathore A, Varshney R.K, Gowda C.L.L, (2011). Large genetic variation for heat tolerance in the reference collection of chickpea (Cicer arietinum L.) germplasm. Plant Genetic Resources. 9: 59-69.

[27] Thomas H, (1997). Drought Tolerance in Plant. In: A. S. Bara and R.K. Bara (Eds.) Mechanisms of Environmental Stress Tolerance in Plant. Academic Puplisher. 1-42.

[28] Younis N, Hanif M, Siddique S, Ghulam A, Jawad M, Ahsanul Haq M, (2008). Estimate as of genetic parameters and path analysis in lentil (Lens culinaris Medik). Pak. J. Agri. Sci. 45: 44-48.

[29] Kumar S, Rajendran K, Kumar J, Hamwieh A, Baum M, (2015). Current knowledge in lentil genomics and its application for crop improvement. Front Plant Sci. 6: 78.

[30] Ghassemi-Golezani K, Mustafavi SH, Shafagh-Kalvanagh J, (2012). Field performance of chickpea cultivars in response to irrigation disruption at reproductive stages. Research on Crops, 13: 107-112.

[31] Agung S, McDonald GK, (1997). Effects of seed size and maturity on the growth and yield of faba bean (Vicia faba L.). Australian Journal of Agricultural Research. 49: 79-88.

[32] Abedlmula A.A, Abuanja I.K, (2007). Genotypic responses, yield stability, and association between characters among some of Sudan's faba bean (Vicia faba L.) Genotypes under heat stress. International Agricultural Research for Development. 1-7.

[33] Jamaati-e-Somarin S, Zabihi-e-Mahmoodabad R, (2013). Selection of resistance and sensitive cultivars of lentil in Ardabil region of Iran under irrigation and nonirrigation conditions. African Journal of Biotechnology. 10: 8380-8387.

[34] Voltas J, Romagosa I, Lafarga A, Armesto AP, Sombrero A, Araus JL, (1999). Genotype by environment interaction for grain yield and carbon isotope discrimination of barley in Mediterranean Spain. Australian Journal of Agricultural Research 50: 1263–1271.

[35] Khamssi N.N, Golezani KG, Salmasi SZ, Abdollah N, (2010). Effects of water deficit stress on field performance of chickpea cultivars. Afr. J. Agric. Res. 5: 1973-1977.

[36] Ong C.K, (1983). Response to temperature in a stand of Pearl Millet (Pennisetum typhoides, S. & H.). Journal of Experimental Botany. 34: 337-348.

[37] Akcin A. (1988). Grain Legumes. Publications of Faculty of Agriculture, Selcuk University, Publication No., 8, Istanbul, Turkey.

[38] Nakano H, Momonoki T, Miyashige T, Otsuka H, Hanada T, Sugimoto A, Nakagawa H, Matsuoka M, Terauchi T, Kobayashi M, Oshiro M, Yasuda K, Vanichwattanarumruk N, Chotechuen S, Boonmalison D, (1997). "Haibushi", a new variety of snap bean tolerant to heat stress. Japan International Research Center for Agriculture Science Journal. 5: 1-12.

[39] Sinha S.K. (1977). Food legumes: distribution, adaptability and biology of yield. FAO Plant Production and Protection, Paper no: 3., pp 124, Rome, Italy..

[40] Anyia AO, Herzog H, (2004). Genotypic variability in drought performance and recovery in cowpea under controlled environment. Journal of Agronomy and Crop Science. 190: 151-159.

[41] Leport L, Turner NC, Davies SL, Siddique KHM, (2006). Variation in pod production and abortion among chickpea cultivars under terminal drought. European Journal of Agronomy. 24: 236-246.

[42] Edward M. (2010). Morphological features of wheat grain and genotype affecting flour yield, PhD thesis, Southern Cross University, Lismore, NSW.

[43] Nachit M.M, Sorrels M, Labhilili M, Baum M, Asbati A, Azrak M, Baalabaki M. (1995). Durum wheat improvement, grain quality. Cereal T 1995 Program. Ann. Report, pp. 102-105.

[44] Ceyhan E, Harmankaya M, Avcı MA, (2008). Effects of sowing dates and cultivars on protein and mineral contents of bean (Phaseolus vulgaris L.). Asian Journal of Chemistry. 20: 5601-5613.

[45] Ibrahim S.A, Kandil H. (2007). Growth, yield and chemical constituents of soybean (Glycin max L.) plants as affect by plant spacing under different irrigation intervals. Res. J. Agric. Biol. Sci., (36): 657-663.

[46] Ghassemi-Golezani K, Mousabeygi T, Raey Y, Aharizad S, (2010). Effects of water stress and pod position on the seed quality of chickpea (Cicer arietinum L.) cultivars. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 38: 114-118.