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Comparative Study of Five Legume Species under Drought Conditions

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ABSTRACT

Background: Vegetative, reproductive and grain-filling phases are critical developmental stages determined legume's yield and grain quality. Drought is the key factor affecting legumes ontogeny and production. The main goal of the present study is to compare growth, yield and seed quality of different legume species grown under drought conditions.

Methods: Completely randomized design were used in this experiment with five local legume species including faba bean, chickpea, lentil, common vetch and bitter vetch, with five replicates using a net plot size of 20 m^2 area (4m*5m) / replicate. Plants were grown at the eastern slopes of Bethlehem governorate (Latitude 31″67, Longitude, 35″24, Altitude of 629 m, with hilly-moderate to steep slope topography) under drought conditions (average rainfall is 260 mm). Growth performance (germination, flowering, fruit set, maturation, harvesting, stem length and branching), yield components (weight of 100-seeds, fresh weight, seed and hay production) and seed quality traits (percentages of dry weight, protein and ash) were evaluated.

Result: Significant morphological, yield and grain quality parameters among the evaluated legume genotypes were registered. Positive correlation between branching and total yield was obtained. For economical and sustainable legume grain production, bitter vetch and common vetch could be successfully recommended under drought conditions, whereas faba bean and chickpea cultivation should be excluded from severe drought regions. Significant higher protein content in common vetch, faba bean and lentil was obtained, meanwhile the proximate analysis (dry matter, protein and ash) of the five examined crops found to be slightly high but within the documented international percentage range. Drought seems to be the main factor affecting legumes ontogeny and production, but not the quality parameters.

Key words: Drought, Grain quality, Growth, Legumes, Yields.

INTRODUCTION

Legume production has been increasing worldwide especially in the last ten years (FAOSTAT, 2020). This growing trend is mainly attributed to its high demand for food and nutrition security, animal feed, generation of income, soil fertility improvement through biological nitrogen fixation, soil erosion control, water conservation and source of fuel (Kebede, 2020). Recently, there has been also a growing interest toward the potential utilization of legume by-products in food industry, mainly related to the presence of high amounts of proteins which could be exploited to create meat analogs for vegetarian/vegan diets and more generally in the formulation of functional food for human consumption (Kumar *et al*., 2017). This of course has led to an increase in the demand for alternative sources of food proteins mainly coming from legumes and their processed products (Tassoni *et al*., 2020).

Despite its global upward growing and multiple benefits; climate change, water scarcity and drought stress are a serious threating challenges facing legume production and productivity not only for todays but also it is predicted to increase in the future (Anjum *et al*., 2017). Undoubtedly, most of legume crops exhibit high sensitivity to drought stress among their growth, development and reproductive stages (Nadeem *et al*., 2019), restraining therefore the total crop yield (Farooq *et al*., 2016) and causing global food insecurity.

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In Palestine, legumes are among the eldest grown crops (Basheer-Salimia *et al*., 2013), in which the ancient seeds of faba bean as an example were found in Jericho and date as far back as 6250 BC (Mc-Vicar *et al*., 2008). Genetically, most planted legume species are landraces, with some minor recently introduced commercial cultivars grown almost all over the country and are typically located on marginal areas, in which faba bean, chickpea, lentil, bean, pea, common vetch and bitter vetch are the main cultivable legume crops. However, sever decline in legume production and productivity were clearly noticeable during the last years.

Reasons behind such decline might related to the detectable climate change in the region including lower average precipitation rate, more marked changes in the distribution of precipitation from one year to the next, with winter getting shorter and extensive (Alsalimiya *et al*., 2018), particularly in the southern and eastern slopes of Palestine (Basheer-Salimia and Ward, 2014). Unfortunately, there are forecasts of a further decline in rainfall and increase drought in the region which will negatively affect and devastate the native species of Palestine (IPCC, 2012), including the local legume seeds resulting thereby in seed disappearance and/ or deterioration. In addition to drought, the lack of literature and scientific knowledge for their suitability, adaptability and productivity under drought conditions are still a challenge. The aim of the present study is to compare growth performance, yield components and quality traits of five legume species grown under semi-arid condition as well as to evaluate which of these crops could respond and perform well for sustainable future plantation of legumes.

MATERIALS AND METHODS

The experiment was conducted at the eastern slopes of Bethlehem governorate (Latitude 31″67, Longitude, 35″24, Altitude of 629 m, with hilly-moderate with steep slope topography). The area is classified as semi-arid with average annual rainfall and relative humidity of 260 mm and 60%, respectively (LRC, 2018). Before planting, soil was analyzed at the laboratories of Hebron University. Soil analyses presented neutral pH (pH 7.26), clay loam texture (with 34.76% clay content), low organic matter content (1.38%), low salinity (EC= 0.249 ds/m). Also, the analysis revealed low content of total Nitrogen (0.119%) and phosphorus (8.19 ppm) and high content of potassium (291.43 ppm).

Completely randomized design was used in this experiment with five local legume species including faba bean (*Vicia faba*), chickpea (*Cicer arietinum*), lentil (*Lens culinaris*), common vetch (*Vicia sativa*) and bitter vetch (*Vicia ervilia*), with five replicates using 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, measurements, *etc*), one meter corridors around all the plots were used.

Four cubic meter of well decomposed cow dung was added and then, lands were plowed and well prepared for plantation. For lentil, common vetch and bitter vetch crops, adoption rate of 300 gram seeds / plot (equivalent to 15 kg/ dunum) were used. In addition, 200 gram seeds / plot (equivalent to 10 kg/dunum) were used for faba bean and chickpea crops. All of the necessary cultural practices such as weed control, two times spraying for aphids, *etc*, were conducted throughout the growing season.

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) and number of branching (using randomly one square meter frame-quadrate per plot) were registered. At the maturity stage, plants of each replicate 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 replicate 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 converted into kg/dunum (kg/1000m^2). For grain quality parameters, representative seed samples were collected from each crop and transferred to the laboratories of Hebron University. Seeds were ground in a Wiley mill and then stored in sealed jars (AOAC, 1990). Chemical analysis including: Dry matter was determined using an oven at 65°C for 24 hours (Rayan *et al*., 2001). Crude protein was determined by estimating nitrogen content using Kjeldahl procedure according to (AOAC, 1990). Percentage of crude protein obtained by multiplying the nitrogen concentration by 6.25 (NX 6.25) according to (Peter and Young, 1980; AOAC, 1990). Ash content was determined using igniting in muffle furnace at 550°C for 8 h).

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.

RESULTS AND DISCUSSION

Morphological parameters

Vegetative, reproductive and grain-filling phases of any crop are critical developmental stages determined by interactions between genetic and environmental factors and are responsible for adaption and yield generation (Reynolds *et al*., 2012). Since our examined five legume species were planted at the same location under identical environmental and cultural conditions (water, temperature, soil, sowing depth, *etc*), therefore the obtained variations (Table 1) comprising germination, flowering period, fruit set, maturation time, stem length, branching, *etc*; are probably related to the genetic makeup of the examined species rather than the environmental settings. Comparably, large seeded crops (faba bean and chickpea) presented late germination, slightly early flowering, late fruit set period and less branches compared with the small-seeded genotypes (lentil, common vetch and bitter vetch). These results are also in line with the works of Kaya and Day (2008) as well as Mut and others (2010), who found that the speed of germination in small-seed crops was faster than large-seed size.

As shown in Table 1, common vetch and faba bean presented significantly the highest stem length compared to the other legumes. Indeed, plant height response to drought is varied among the crops; in the event that increase drought leads to reduce stem length in faba bean (Al-Rifaee, 2004), maize (Khan *et al*., 2015) and *Pueraria javanica* (Sinamo, *et al*., 2018). Thus, the existing variation is perhaps linked to the genetic features of each crop. The observed significant number of branches on the main stem among the tested legume crops (Table 1) was also genetically controlled rather than environmentally determined. This finding is confirmed by (Silim and Saxena, 1992), who found that legume genotypes were different on the number of branches. Similar results also registered by Malhotra *et al*. (1997), stating that number of primary and secondary branches of chickpea was not affected by irrigation (Malhotra *et al*., 1997), confirming that branching trait is genetically controlled. Here, positive significant correlation was obtained between number of branches per plant and total hay production as well as total yield. Similar correlation was also confirmed by Younis *et al*. (2008).

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

In general, total yield of the five examined legume crops exhibited low values compared with the world average legume productivity (Table 2). In fact, drought stress in the targeted area caused remarkable production losses, in the event that drought reduced germination, stunted growth, caused serious damage to the photosynthetic apparatus, decreased the net photosynthesis and nutrient uptake (Nadeem *et al*., 2019). Furthermore, drought affects the leaf development, activity of enzymes, ion balance and ultimately leads to yield reduction (Anjum *et al*., 2017). Here, seed weight found to be varied considerably among the legume genotypes (ranged from 5.56 gram in lentil to 45.5 gram in faba bean), which is in line with the finding of Della (1988). In fact, the 100 seed weight is relatively stable trait and was not significantly affected by the environment (Kambal, 1968). This fact might explain the dissimilarity of the obtained seed weights throughout the five examined legume crops.

Concerning yield components (total yield, grain weight, hay production), common vetch crop revealed significantly the highest total yield (306 kg/dunum), whereas faba bean genotype presented significantly the lowest value of only 41kg/dunum (Table 2). Despite being strongly genetically determined, yield component also depends on climatic conditions, such as water availability and temperature regime (Calderini *et al*., 1999). Toward this end, our study site is indeed suffering from both challenges (water and temperature stresses) in which the inadequate available moisture is the largest constraint for faba bean production (Xia, 1994) and its sensitivity to water stresses, is probably due to combination of its shallow root system (Day and Legg, 1983), as well as to its little osmo-regulation (Bond *et al*., 1994). Other studies recorded also the temperature effects on faba bean wherein high temperatures leads to lack of pollination (Nakano *et al*., 1998), abscission of flowers, flower buds and fruits (Akcin, 1988), damage to reproductive organs (Anyia and Herzog, 2004), reduce the individual seed size at maturity especially at the grain filling period (Ong, 1983), resulting thereby in declining the total grain yield. For these reasons, faba bean is often grown under irrigation in many parts of the world; except with some regions in Mediterranean-type environments having high rainfall (ICARDA, 1994). A similar trend for low production of faba bean goes also with chickpea crop (Table 2), however the remaining legume crops (common vetch, lentil and bitter vetch), presented a great production in terms of total yield, grain and hay production except for lentil which revealed high fresh and hay weight allied with the lowest grains (only 5.56 kg/dunum). Nevertheless, lentil is highly subjected to drought that delayed its phenology (Erskine and Saxena, 1993), reduced the root shoot ratio (Dabbagh and Nasab, 2011), affected blossoming and harvesting period (Naroui *et al*., 2010), reduced branching/sprouting fraction (Tahir *et al*., 2019) and produced poor seed yields (Shrestha *et al*., 2005). Based on these finding, we may confidently assume that the yield component variations are genetically controlled rather than environmentally, however some genotypes behaved differently under the tested climatic condition.

Grain quality traits

Seed quantity characteristics are influenced mainly by environmental factors, while the quality ones are largely genetically determined (Edwards, 2010). In fact, findings on the nature of genetic control are rather controversial, although 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 (Nachit *et al*., 1995). Here, the three examined quality parameters

Table 1: Morphological parameters of five legumes cultivated at the eastern slopes of Bethlehem.

Morphological parameters	Fababean	Chickpea	Lentil	Common vetch “Bekia”	Bitter vetch “Kersana”
Germination date (days)	14	16	10	10	12
Flowering period (days)	5	5	6	6	6
Fruit set period (days)	9	8	7	6	6
Maturation and harvesting period (days)	27	16	23	16	17
Stem length (cm)	33.86a±2.75	29.56b ±1.61	27.98c±1.69	35.10a±3.36	27.80c±1.79
No. of branching	03.30c±0.69	02.78d±0.14	04.78b±0.13	05.70a±0.22	05.01b±0.40

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

Table 2: Yield parameters of five legumes cultivated at the eastern slopes of Bethlehem.

Yield parameters	Fababean	Chickpea	Lentil	Common vetch "Bekia"	Bitter vetch "Kersana"
Weight of 100 seed (gram)	44.50a±0.20	32.26b±0.35	05.56c±0.17	07.13c±0.08	06.90c±0.19
Fresh weight (kg/dunum)	130c±23.7	189b±31.6	292a±39.4	306a±61.9	280a±33.7
Grain production (kg/dunum)	39b±13.5	41b±30.20	4.00c±2.45	41b±7.95	57.5a±11.6
Hay production (kg/dunum)	91d±22.1	148c±24.5	288a±39.4	265a±54.1	222b±42.0

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

Table 3: Proximate analysis of five legume seeds (*Vicia faba*) cultivated at the eastern slopes of Bethlehem.

Parameters	Fababean	Chickpea	Lentil	Common Vetch "Bekia"	Bitter vetch "Kersana"
Dry matter %	**90.36a±0.59**	**89.69a±01.34**	**89.70a±0.21**	**90.66a±0.35**	**90.43a±0.15**
Min. to Max. according to the International percentage (feedipedia)	(83.4 to 89.6)	(87.6 to 90.8)	(87.1 to 91)	(75 to 91)	(75 to 91)
Protein %	**28.90a±0.45**	**24.98b ±0.42**	**28.25a±0.47**	**29.92a±1.99**	**26.95ab±0.08**
Min. to Max. according to the International percentage (feedipedia)	(25.4 to 33.5)	(18.5 to 25.7)	(24.6 to 30)	(14.7 to 35.8)	(14.7 to 35.8)
Ash %	**3.77c±0.39**	**3.46c±0.18**	**6.42a±0.30**	**4.47b±0.79**	**4.78b±0.78**
Min. to Max. according to the International percentage (feedipedia)	(3.3 to 4.6)	(3 to 3.9)	(2.7 to 6.8)	(2.4 to 7.5)	(2.4 to 7.5)

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

(dry matter, protein content and ash) found to be slightly high and somehow near the maximum (Table 3), but still within the world general legume averages (Table 3). Similar results were also registered by Duc *et al*. (2015) who indicated that protein content of legumes tended to increase under water deficit condition which indeed similar to our conditions. Our finding also confirmed by Ghassemi-Golezani (2010) who reported that water stress can reduce crop yield, but it has no significant effect on seed quality.

Comparatively, protein content, ash and dry matter were significantly lower in chickpea genotype (24.98%; 3.46%; 89.69% respectively), compared with the other examined crops (Table 3). Similar result was also accomplished by Kahraman *et al*. (2015), in a field experiment conducted on 10 chickpea genotypes under particular drought conditions and showed a very low protein and ash percentage ranged only from 19.71 -19.80% and 2.81-2.86%, respectively. Thus, we could assume that the main quality parameters of chickpea genotype are more sensitive to drought than other evaluated legume crops.

CONCLUSION

Drought is the main factor affecting legumes ontogeny and production, but not the quality parameters. For economical and sustainable production, common vetch and lentil crops could be successfully recommended for hay production rather than for grain; however bitter vetch and common vetch for grain production; and common vetch for both hay and grain production. Faba bean and chickpea are highly sensitive to drought; therefore its cultivation should be excluded from any future plantation in intermediate and severe drought regions.

REFERENCES

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

AL-Refaee, M., Turk, M. and Tawaha, A. (2004). Effect of seed size and plant population density on yield and yield components of local faba bean (*Vicia faba* L. Major), International Journal of Agriculture and Biology. 2: 294-299.

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.

Anjum, S.A., Ashraf, U., Zohaib, A., Tanveer, M., Naeem, M., Ali, I., Tabassum, T., Nazir, U. (2017). Growth and developmental responses of crop plants under drought stress: A review. Zemdirbyste-Agriculture. 104: 267-276.

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

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.

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

Basheer-Salimia, R., Shtaya, M., Awad, M., Abdallah, J. and Hamdan, Y. (2013). Genetic diversity of Palestine landraces of faba bean (*Vicia faba*) based on RAPD markers. Genetic and Molecular Research. 12(3): 3314-3323.

Bond, D.A., Jellis, G.J., Rowland, G.G., Guen, J., Robertson, L.D., Khalil, S.A. and Li-Juan, L. (1994). Present status and future strategy in breeding faba beans (*Vicia faba* L.) for resistance to biotic and abiotic stresses. Euphytica. 73: 151-66.

Calderini, D.F., Abeledo, L.G., Savin, R., Slafer, G.A., (1999). Final grain weight in wheat as affected by short periods of high temperature during pre- and post-an thesis under field conditions. Australian Journal of Plant Physiology. 26: 453-458.

Dabbagh, A. and Nasab, M. (2011). Effects of water potential on germination and seedling growth of two varieties of lentil (*Lens culinaris Medik*.). Int. Agricrop. Sci. 3: 61-64.

Day, W. and Legg, B.J. (1983). Water Relations and Irrigation Response. In: The Faba Bean (*Vicia faba* L.). A Basis for Improvement. [Hebblethwaite, P.D. (Ed.)], Butterworths, London, U.K. pp: 217-31.

Della, A. (1988). Characteristics and Variation of Cyprus Faba Bean Germplasm, FABIS Newsletter. 21: 9-12.

Duc, G., Agrama, H., Bao, S., Berger, J., Bourion, V., De Ron, A. M. (2015b). Breeding annual grain legumes for sustainable agriculture: New methods to approach complex traits and target new cultivar ideotypes. Crit. Rev. Plant Sci. 34: 381-411. doi: 10.1080/07352689.2014.898469.

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

Erskine, W. and Saxena, M.C. (1993). Problems and prospects of stress resistance breeding in lentil. In: Breeding for stress tolerance in cool-season food legumes. [(Eds) K.B. Singh, M.C. Saxena](John Wiley and Sons: Chichester, UK). pp. 51-62.

FAOSTAT (2020). Food and Agriculture data. Available online: http://www.fao.org/faostat/en/#home.

Farooq, M., Gogoi, N., Barthakur, S., Baroowa, B., Bharadwaj, N., Alghamdi, S.S. (2016). Drought stress in grain legumes during reproduction and grain filling. J. Agron. Crop Sci. 203: 81-102.

Ghassemi-Golezani, K., Mousabeygi, T., Raey, Y and Aharizad, S. (2010). Effects of water stress and pod position on the seed quality of chickpea (*Cicer arietinum* L.) cultivars. Not. Bot Hort. Agrobot. Cluj, 38: 114-118.

ICARDA, (1994). Response of and Genotypic Differences in Food and Feed Legumes to Drought. In: Legume Program Annual Report for 1993, International Centre for Agricultural Research in Dry Areas, Aleppo, Syria, pp. 172-200.

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.

Kahraman, A., Ceyhan, E., Harmankaya, M. (2015). Nutritional variation and drought tolerance in chickpeas (*Cicer arietinum* L.). Journal of Elementology. 20(2): 331-341. DOI: 10.5601/jelem.2014.19.2.674.

Kambal, A.E. (1968). A study of agronomic characters of some varieties of (*Vicia faba* L.). Journal of Agric. (Cambridge). Sci. 72: 359-363.

Kaya, M.D. and Day, S. (2008). Relationship between seed size and NaCl on germination, seed vigor and early seedling growth of sunflower (*Helianthus annuus* L.). African Journal of Agricultural Research. 3: 787-791.

Kebede, E. (2020). Grain legumes production and productivity in Ethiopian smallholder agricultural system, contribution to livelihoods and the way forward. Cogent Food and Agriculture. 6(1): 1-20.

Khan, M.B., Hussain, M., Raza, A., Farooq, S., Jabran, K. (2015). Seed priming with $CaCl_2$ and ridge planting for improved drought resistance in maize. Turk. J. Agric. For. 39: 193-203.

Kumar, P., Chatli, M.K., Mehta, N., Singh, P., Malav, O.P., Verma, A.K. (2017). Meat analogues: health promising sustainable meat substitutes. Crit. Rev. Food Sci. Nutr. 57: 923-932.

LRC, (2018). Land Research Center data base. Hebron, Palestine.

Malhotra, R.S., Singh, K.B. and Saxena, M.C. (1997). Effect of irrigation on winter-sown chickpea in a Mediterranean environment. J. Agron. Crop Sci. 178: 237-43.

Mc-Vicar, R., Panchuk, K., Brenzil, C., Hartley, S., (2008). Faba Bean in Saskatchewan. Saskatchewan Ministry of Agriculture. Available at [http://www.agriculture.gov.sk.ca/adx/aspx/adxGetMedia.aspx?DocID=1070,335,185,81,1, Documents and Media ID=5743 and Filename=Faba+Bean+ in+Saskatchewan+-+Printer+Friendly.pdf].

Mut, Z., Akay, H. and. Nevzat, A. (2010). Effects of seed size and drought stress on germination and seedling growth of some oat genotypes (*Avena sativa* L.). African Journal of Agricultural Research. 5(10): 1101-1107.

Nachit, M.M., Sorrels, M., Labhilili, M., Baum, M., Asbati, A., Azrak, M. and Baalabaki, M. (1995b). Durum wheat improvement, grain quality. Cereal Improvement Program. Ann. Report. pp. 102-105.

Nadeem, M., Jiajia, Li., Muhammad, Y., Alam S., Chuanxi, Ma., Naroui, R., Ghasemi, M.R.,A., Arjmandinejad, A. (2019). Study of limit irrigation on yield of Lentil (*Lens culinaris*) genotypes of national plant gene bank of Iran by drought resistance indices. J. Agric. and Environ. Sci. 7 (2): 238-241.

Nakano, H., Kobayashi, M., Terauchi, T. (1998). Sensitive stages to heat stress in pod setting of common bean (*Phaseolus vulgaris* L.). Japanese Journal of Tropical Agriculture. 42: 72-84.

Naroui, R.M.R., Ghasemi, A., Arjmandynejad, A.R. (2010). Study of limit irrigation on yield of lentil (*Lens culinaris*) genotypes of national plant gene bank of Iran by drought resistance indices. American-Eurasian J. Agric Environ Sci. 7(2): 238-241.

Ong, C.K. (1983). Response to temperature in stand of pearl millet (*Pennisetum typhoides*) II. Reproductive development. Journal of Experimental Botany. 34: 337-348.

Peter, L.P. and Young, V.R. (1980). Nutritional Evaluation of protein Foods. P.8. The United Nations University, Japan.

Reynolds, M.P., Pask, A.J.D. and Mullan, D.M. (eds.) (2012). Physiological Breeding I: Interdisciplinary Approaches to Improve Crop Adaptation. Mexico, D.F.: CIMMYT.

Ryan, J., George, E., Abdul, R., (2001). Soil and Plant Analysis Laboratory Manual (2nd ed.). International Center for Agricultural Research in the Dry Areas (ICARDA).

Shrestha, R., Siddique, K.H.M., Turner, N.C., Turner, D.W., Berger, J. (2005). Growth and seed yield of lentil (*Lens culinaris Medikus*) genotypes of West Asian and South Asian origin and crossbreds between the two under rain-fed conditions in Nepal. Australian Journal of Agricultural Research. 56: 971-981. doi: 10.1071/AR05050.

Silim, S.N. and Saxena, M.C. (1992). Comparative performance of some faba bean (*Vicia faba* L.) cultivars of contrasting plant types-2 growth and development in relation to yield. Journal of Agricultural Science. 118: 333-342.

Sinamo, V., Nevy, D.H., Tri, H.W. (2018). Legume plant growth at various levels of drought stress treatment. Indonesian Journal of Agricultural Research. 1(1): 9-19.

Tahir, A., Masood, Q., Rabia, S., Saira, S., Sidra, T. (2019). Morphological and yield response of pulses against drought stress: a review. Turkish Journal of Agriculture - Food Science and Technology. 7(2): 202-208.

Tassoni, A., Tullia, T., Chiara, Z., Ilaria, M.C., Janos-Istvan, P., Óscar, R., Simona, N., Annamaria, C., Laura, S., Patrizia, C., Francesca, S., Georgios T., Marika, B., Stefanie, V., Geert, B., Philippe, C. (2020). State-of-the-Art Production Chains for Peas, Beans and Chickpeas-Valorization of Agro-Industrial Residues and Applications of Derived Extracts. Molecules. 25: 1383; doi:10.3390/molecules 25061383

Xia, M.Z. (1994). Evict of soil drought during the generative development phase of faba bean (*Vicia faba*) on photosynthetic characters and biomass production. J. Agric. Sci.-Camb. 122: 67-72.

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.