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EVALUATION OF TERMINAL WATER STRESS EFFECT ON MORPHOLOGICAL, PHYSIOLOGICAL PARAMETERS, YIELD AND REMOBILIZATION OF ASSIMILATES IN TWO TYPES OF LENTILS CULTIVARS (*Lens culinaris* Medik *culinaris ssp.*) UNDER ALGERIAN CONDITIONS

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ABSTRACT

Lentil (*Lens culinaris* Medik *culinaris*) is the main important food legume worldwide and in the Mediterranean areas, it is faced to terminal drought coinciding with its reproductive period and inducing yield losses. The present investigation was conducted on microsperma (Syrie229) and macrosperma (Metropole) varieties of Lentil to evaluate differences in drought tolerance regarding to some morpho- physiological parameters, productivity, seed N and K remobilization. A field Trial was carried out under Rain fed and irrigated conditions using two Lentil varieties (small and large seeds). Results indicated that terminal drought effected all studied parameters, the variety factor was significant only for INN, LA, FSW, NC and KC. The highest grain yield was obtained under irrigated treatment, however, GY depend on environmental conditions and the (water regime× varieties) interaction either on the variety factor or the type of plants. Results showed also the superiority of microsperma type in accumulating more Nitrogen and Potassium to developing seeds.

Keywords: Lentil microsperma and macrosperma varieties; terminal drought; morpho-physiology; yield.

INTRODUCTION

Lentil is the most important food legume grown worldwide, the main producers are: Canada, the USA, Australia, Turkey, India and Syria [1].

Lentil, among other food legumes, plays a significant role in human and animal nutrition and in soil fertility improvement. Its cultivation enriches soil nutrient status by adding Nitrogen, Carbon and Organic matter which promotes sustainable cereal –based crop production in the regions [1,2]. Lentil crop is a source of protein especially for poor who cannot afford animal products, minerals, vitamins, fiber and carbohydrates for balanced nutrition [1,3].

Lentil cultivars have been subdivided into two groups on the basis of seed size. The first group is the microsperma type with small seeds (2 – 6 mm) and a hundred kernel weight less than 4 g which dominate in Indian sub-continent, the countries of the Middle East and East of Africa. The second group dominating in North Africa, Mediterranean regions, Europe and America is characterized by a large seeds (6 – 9 mm) and a hundred kernel weight exciding 4.5 g (macrosperma) [4,5,6].

The lentil production areas in Algeria are located in the interior plains and highlands of Mila, Constantine, Guelma, Tiaret: sersou plain, Medea and Setif [7]. In the highlands and Sersou regions of Tiaret province (Algeria), the microsperma type is mostly cultivated and largely preferred by the farmers of these regions for its high productivity, its earliness and its resistance to drought, but the yields obtained do not exceed 7 quintals in a rainy year. [4]. The decline in grain yield is the result of many factors including non-performing plant material, low competitiveness of lentil against weeds (reduction in yield reaches 84%), cultivation practices and many biotic and abiotic stresses [8,9,10]. Among these constraints, the terminal drought is very frequent (March-April) and coincide with the reproductive period of the crop (flowering and grain filling stages) when temperatures are increasing and rainfall is declining [11,12,13,9,14] affecting all water relations of plants including relative water content and turgor, inducing stomatal closure which limits gas exchange and reduces transpiration, it effect negatively nutrition absorption and transport [15,16,17,18] and seriously altering yield development and hindering the expression of lentil productive potentialities [13,19] and consequently lens productivity. Therefore it will be necessary to develop a strategy to adapt and reduce the effect of terminal drought. According to Fellahi, Serghal and Hassani [8,13,20], the selection of drought tolerant plants appears to be one of the most effective solutions to mitigate the effect of these constraints. This strategy is based on the knowledge of mechanisms developed by plants to adapt to environmental conditions [18].

Drought adaptation is the ability of plants to maintain optimum productivity through environments where drought periods, their durations and their intensities are fluctuating [21,12,13].

Plants have involved many mechanisms for drought stress tolerance including a number of physiological, morphological and biochemical processes such as maintaining of water-use efficiency, reducing transpiration, reducing plant height and leaf areas and accumulating osmoregulators [12,6,13,18].

The objective of this work is a comparative study between two varieties of Lentil (*Lens culinaris* Medik, Culinaris ssp) belonging to two groups (macrosperma and microsperma) through the study of some morphological and physiological responses to water deficit, to highlight the contribution of the genotypic factor and the type of the plant to improve lentil tolerance to terminal drought and its consequence on the remobilization of nitrogen and potassium to seeds.

MATERIALS AND METHODS

Plant Material and Experimental Design

The plant material studied consist of two varieties of lentil which have been selected at the stations of the technical institute for arable crops (ITGC) (Algeria) and are adapted to Mediterranean climate. This include two types of plants, the first with small grains (microsperma) represented by Syrie 229 variety originating from Syria and the other one macrosperma type with large grain: Metropole (France) which differ in their productivity and their sensitivity to drought.

The field experiment was conducted at the farm of the technical institute of field crop ITGC of Sebaine, eastern Algeria (35°21’N latitude, 1°28’E longitude and 1023 m altitude) during 2015/2016 crop season from December to June.

The experiment was carried out on a silty clay soil (0-20 cm) with 7.98 of pH, no salty, with 1.40% of organic matter, 0.07% of Nitrogen, 6.35 ppm of available phosphor and 270 ppm of exchangeable potassium.

The climate of the experimental site was characterized by a heavy rainfall in winter and a little rainfall for the rest of the year. Monthly maximum, minimum temperatures and Rainfall were monitored by a weather station located at the experimental site (Table 1).

The experiment was carried out as a factorial design with two factors and two levels each one, water regimes (Irrigated: IRR and Rain fed: RF) and varieties (Syrie229 and Metropole) with three replications.

The land was prepared by a disc ploughing followed by laddering to break up clods, then levelled with a power harrow. Fertilizers were applied at 100-50-40 Kg/ha using triple super phosphate (TSP), Potassium sulfate (K_2O) and Urea.

The two varieties of Lentil were previously treated with a fungicide to prevent disease infestations then sown manually at a depth of 4 cm using a seeding density of 200 grains/m^2 on 12 December 2015. Each elementally plot had 12 m^2 (2.4 mx5 m) with 8 sewing rows /variety separated by 30 cm. Sewing was followed by rolling to ensure good soil and seed adherence. A hand weeding was done when is necessary. To ensure homogenous germination, the two plots were irrigated after sewing (December was mostly dry, 00 mm of Rainfall received).

In the irrigated plots, Irrigation was started at the beginning of flowering (when the first flower appears) with 3 water supply per week and stopped at seed filling stage. The irrigation was done using aspers.

Harvest was done manually on 7 of June 2016 then manually threshed. Seeds were dried in an oven at 65°C for 72 hours then powdered to a fine flower used for Nitrogen and Potassium essay.

Table 1. Weather data at the experimental site during 2015-2016 crop season

Months	Dec	Jan	Feb	Mar	April	Mai	June
Rainfall (mm)	00.00	39.60	62.70	28.30	24.60	26.70	6.50
Mini –Temp (°C)	0.74	2.25	3.41	2.32	5.63	8.56	12.90
Max – Temp (°C)	16.21	14.79	13.89	13.68	19.90	24.27	30.40

Fig. 1. The field experiment

Measurements

Morphological parameters

Morphological measurements concerned plant height (PH cm), Internode number (INN) and leaf area (LA cm^2). Data for plant height (PH cm) were recorded from the measurement of the height of twenty five lens plants randomly selected at the end of flowering stage from the basal part of the plant to the last leaf with a graduated ruler. The inter node number (INN) or foliar layers was counted on the main stem from the basal part of the plant to the last leave. The leaf area (LA) was directly measured by an Automatic area meter (model AAM-8) and expressed in cm².

Physiological parameters

The relative water content

It was determined according to Barrs and Weatherley [22] method by the next formula:

$$RWC\% = [(Wf - Wd)/(Wt - Wd)] \times 100$$

Where Wf is the fresh weight measured immediately after excising the leaves. Wt is the turgid weight obtained after 24 hours of immersion of the leaves in test tubes containing distilled water and placed in the dark at 4°c and Wd is the dry weight obtained by passing the leaves in oven for 48 hours at 80°C.

The rate of water loss

It was evaluated according to Clark and Mcaig [23] method. The leaves were excised at their base and placed in test tube at 4°C in the dark for 12 hours, after full turgidity , they were wiped and weighed to give the full turgidity weight (WF). Then they were kept erect at laboratory temperature for 60 min and the W60min was done after this time. The Leaf area was measured on the same samples. The rate of water loss was estimated by the next equation:

$$RWL((mg/(\mathrm{cm2}) * 60\mathrm{min}) = (WF - W60)/(LA * 60)$$

Foliar specific weight

It was determined by the ratio of leaf dry matter to the corresponding leaf area. The foliar specific weight is obtained by the following relation:

$$SFW(g/cm2) = Wd/LA$$

The chlorophyll determination

The chlorophyll a and chlorophyll b pigments were determined by Arnon [24] method used by [25]. 100 mg of leaves fresh matter were introduced in test tube in the presence of 10 ml of 95% acetone at 4°C in the dark for 24 hours. The absorbance was read at 663, 645 and 470 nm by an OPTIZEN spectrophotometer. Chlorophyll content was expressed on an FW basis (mg/ml) using the following formula:

$$Chlorophyll\ a\ (mg/ml) = (9.78 \times A663) - (0.99 \times A645)$$

$$Chlorophyll\ b\ (mg/ml) = (21.42 \times A645) - (4.65 \times A663)$$

Nitrogen determination

The nitrogen content of the seeds was analyzed according to The Kjeldahl method (Kjeltek 1002, Manuel part N° 1000 1535, Técator AB).

Dosage of potassium content K

Potassium was determined according to the Method described by [26]. 500 mg of dried and ground grains were put in porcelain crucible and placed in muffle furnace at 500°C for 5 hours, after complete calcinations, The obtained ashes were moistened with 02 ml of absolute HNO_3 nitric acid. The whole was placed in a sand bath in order to evaporate the nitric acid. Then 1 ml of hydrochloric acid HCL (6N) was added. The resulting mixture was filtered through ash-free (wattman) filter paper into 50 ml volumetric flasks. The dosage was done by the flame spectrometer (JUNWAY) and the optical densities were converted according to the mass of the sample and the dilution volume, Potassium (KC) content was expressed as ppm.

Statistical Analysis

Collected data were statistically analyzed using STAT BOX Software version 8.40. Newman Keuls test at 5% of probability was used to compare means values.

RESULTS

Morphological Parameters

Our results showed that the water regimes treatment had a significant effect on the plant height, the internode number and the leaf area parameters (Table 2). The plant height of irrigated plants was higher than that of stressed ones with a values ranging between 25.07 cm and 22.03 cm respectively. The two varieties tested registered a neighboring values under both water regimes. The internode number was lower in stressed plants than of the irrigated ones, the values oscillated between 13.46 and 14.71 respectively. The reduction in INN in Metropole (macrosperma) was of lesser magnitude as compared to Syrie229 (microsperma) with a respective rate of reduction ranged between 5.06% and 11.37%. Thus, the leaf area parameter experienced a significant and remarkable decrease under Rain fed conditions, indeed, it was mostly influenced by both the variety factor and the interaction, and the two varieties differed in their perception of the effect of water stress. The reduction in leaf area in stressed plants as compared to irrigated ones was more in Metropole than in Syrie229. The rate of reduction was of 18.7% in Metropole (macrosperma type) compared to 9.5% in Syrie229 (microsperma) (Fig. 2a, 2b, 2c).

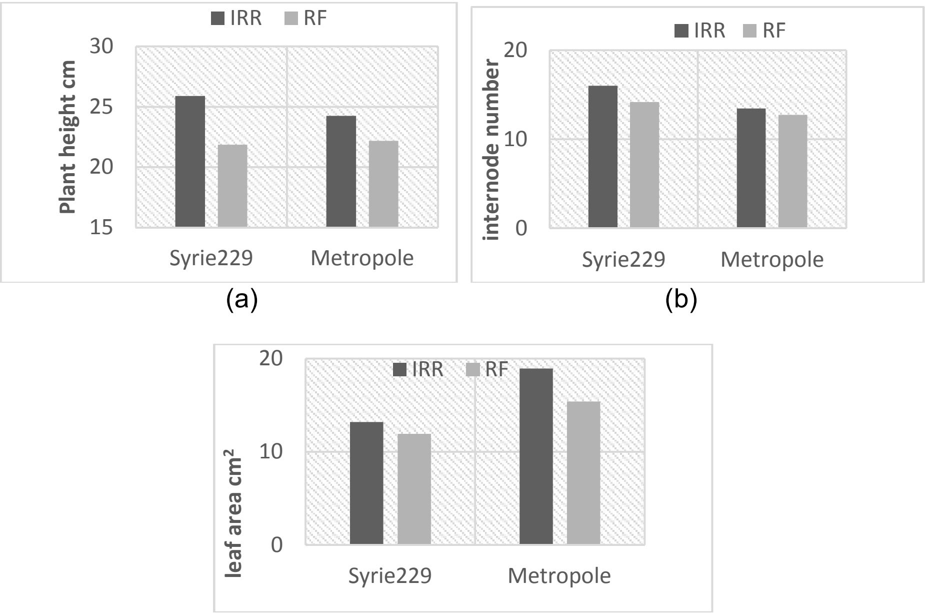
Physiological Parameters

Relative water content

The analysis of variance reveals a significant effect of water regime on the relative water content (RWC) and a no influence of variety factor and the interaction (water regime*varieties) (Table 2). The relative water content decreases under Rain fed conditions and it was of 71.31% while under irrigated situation (irrigation+ Rainfall), the RWC was higher (80.79%) (Fig. 3a).

The rate of water loss RWL

The rate of water loss excised by leaf is represented essentially by stomata transpiration carried out after 60 minutes. Statistical analysis (Table 2) indicated that the RWL parameter was not influenced by both the varieties factor and the interaction while the effect of water regime was mostly significant. The results (Fig. 3b) indicated that the loss of water is higher in the leaves of irrigated plants than of stressed plants.



(a) (b) (c)

Fig. 2. (a) Plant height (cm), (b) internode number, (c) leaf area (cm^2) in microsperma and macrosperma lentil varieties under IRR and RF conditions

Foliar specific weight FSW

The Specific foliar weight was strongly influenced by the water treatment and variety factors. The interaction had not any significant effect on the variation of this parameter (Table 2). There was an increase of 32% in SFW means values of stressed plants in comparison with irrigated ones (Fig. 3c). The increase in FSW was higher in Syrie229 (microsperma) (45.9%) than in Metropole (macrosperma) (27.41%).

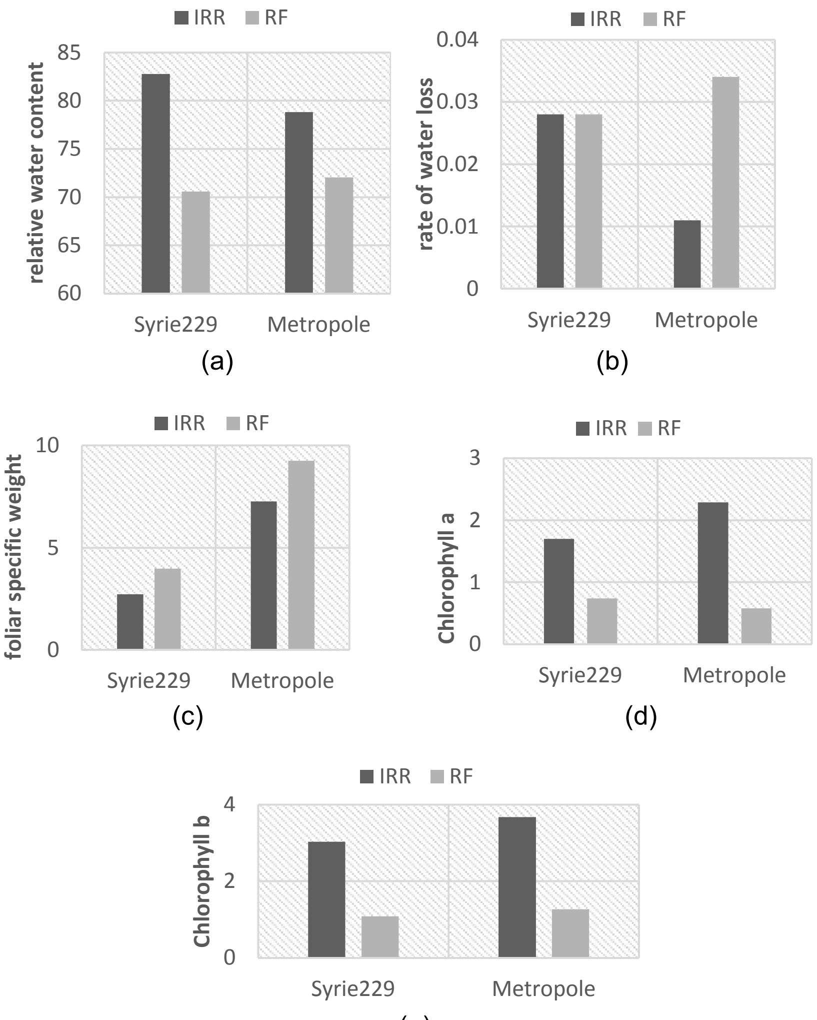
Chlorophyll a and chlorophyll b pigments

The statistical analysis of chlorophyll a variance showed a very highly significant influence for the water regime at 5% level of probability, the variety factor and the interaction (water regimes x varieties) effects on the chlorophyll a content were no significant (Table 2). The chlorophyll a content decreased under water stress conditions, the rate of reduction was of 65.07% as compared to irrigated conditions. Under Rain fed conditions, Syrie229 variety registered a rate of CHLL a of 1.08 mg.ml^{-1} and Metropole marked a value of 1.26 mg.ml^{-1}, while under watered situation, the CHLL a oscillated between 3.03 mg.ml^{-1} in microsperma variety and 3.67 mg.ml^{-1} in macrosperma variety (Fig. 3d).

The statistical data of CHLL b showed a very highly significant effect for the water treatment factor and a significant influence for the interaction, a no significant effect was observed for the variety factor (Table 2). The water stress induced had reduced the chlorophyll b with a rate of 67.33%, the highest value of chlorophyll b was recorded in the irrigated plants with the Metropole variety (2.28 mg.ml^{-1}) while under Rain fed conditions, Syrie229 variety marked the highest level of CHL b with a value of 0.73 mg.ml^{-1} (Fig. 3e).

Nitrogen content (NC)

The obtained results showed that the expression of seed Nitrogen content is under a highly significant influence of the water treatments, the nature of varieties tested as well as the interaction (Table 3). In both varieties, the NC was more important in drought stressed plants than in irrigated ones. The mean results indicated that under irrigated conditions, Metropole variety



(a) (b) (c) (d) (e)

Fig. 3. Variation in (a) RWC, (b) RWL, (c) FSW, (d) CHLL a, (e) CHLL b of two lentil varieties under Irrigated and Rain fed conditions. RWC= relative water content, RWL= rate of water loss, FSW=foliar specific weight, CHLL a = chlorophyll a, CHLL b= chlorophyll b

Table 2. Results of variance analysis of morphological and physiological traits of lentil varieties under irrigated and Rain fed conditions

S.V	WR effect	V effect	WR*V effect	CV%	LSD
PH	0.0005***	0.2775^{ns}	0.1214^{ns}	4.91	1.31
INN	0.0123*	0.0008***	0.1935^{ns}	5.71	0.91
LA	0.000***	0.0000***	0.0120*	4.98	0.53
RWC	0.0009**	0.5514^{ns}	0.1970^{ns}	5.12	4.41
RWL	0.0021**	0.0000***	0.3180^{ns}	18.04	0.035
FSW	0.0014**	0.0000***	0.3180^{ns}	12.16	0.799
CHLL a	0.0000***	0.1674^{ns}	0.4292^{ns}	24.44	0.626
CHLL b	0.0000***	0.2014^{ns}	0.0374*	23.27	0.349

S.V: sources of variations, PH= plant height in cm, INN= internode number, LA= leaf area (cm^2), RWC= relative water content %, RWL= Rate of water loss (mg/cm^2.60mn), FSW= foliar specific weight mg.(cm$^{2)-1}$, CHLL a= chlorophyll a (mg.ml^{-1}), CHLL b= chlorophyll b (mg.ml^{-1}).
*WR= water regime, V= varieties, WR*V= Interaction water regime*varieties, * = Significant, ** = Highly Significant, *** = very highly significant, ns: not significant, CV%: Co variance, LSD: low significant difference*

Table 3. Effect of water treatments, varieties and their interaction on nitrogen, potassium contents and grain Yield in microsperma and macrosperma varieties

S.V	NC	KC	GY
WR	0.0000***	0.0061**	0.0002***
V	0.0000***	0.0086**	0.4220^{ns}
WR*V	0.0023**	0.0200*	0.0455*
CV%	2.82	8.62	26.66
LSD	0.12	74.77	1.51

*SV= sources of variations, NC= nitrogen content %, KC= potassium content (ppm), GY= grain yield (Qx.ha^{-1}). WR= water regime, V= varieties, WR*V= interaction water regime*varieties, * = significant, ** = highly significant, *** = Very highly significant, ns= not significant, CV%= Co variance, LSD= low significant difference*

recorded a high content in nitrogen of 4.32% whereas Syrie229 registered a level of 2.96%. Under Rain fed conditions, the microsperma type recorded the highest content of Nitrogen with a rate of 4.1% while the macrosperma type registered a level of nitrogen content of 3.63% (Fig. 4a).

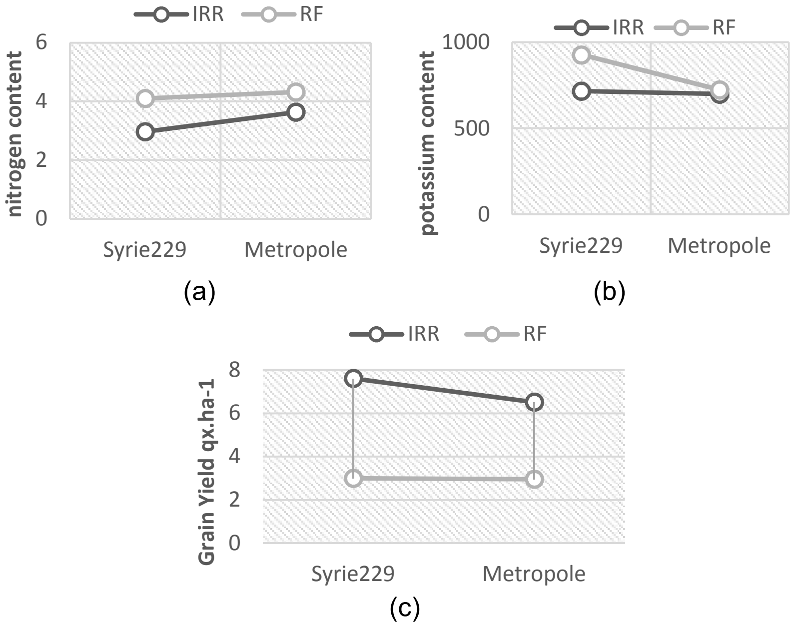
Potassium content

The analysis of the results obtained from the measurement of this characteristic showed that their elaboration is dependent on the water regime as well as the variety factor and the interaction (Table 3). In the absence of irrigation, the potassium content increased significantly and it was of 825.44 ppm while in watered conditions (irrigation + Rainfall), the potassium content exhibited a value of 707.91 ppm. In terms of the variability tested, The Syrie229 variety externalized a very marked increase in potassium content in comparison with the irrigated plants evaluated at 29.30% (926.66 ppm) and Metropole variety recorded 3.57% rate of increase (724.16 ppm) (Fig. 4b).

Table 4. Correlation matrix between morphological, physiological, GY, NC and KC in microsperma and macrosperma lentil varieties

Plant traits	**PH**	**INN**	**LA**	**RWC**	**RWL**	**FSW**	**CHLL a**	**CHLL b**	**NC**	**KC**	**GY**
PH	1										
INN	**0.58**	1									
LA	**0.67**	**0.56**	1								
RWC	**0.56**	0.46	**0.59**	1							
RWL	**0.70**	0.22	**0.78**	**0.75**	1						
FSW	-0.41	**0.84**	**0.72**	-0.30	-0.11	1					
CHLLa	**0.70**	0.33	**0.43**	**0.79**	**0.83**	-0.13	1				
CHLLb	**0.72**	0.31	**0.68**	**0.63**	**0.74**	-0.17	**0.94**	1			
NC	**0.84**	**0.72**	0.21	**-0.77**	**-0.66**	**0.62**	**-0.67**	**-0.63**	1		
KC	0.28	-0.10	0.36	**-0.50**	**-0.50**	-0.20	-0.49	-0.43	0.27	1	
GY	**0.82**	**0.58**	**0.87**	**0.67**	**0.73**	0.43	**0.71**	**0.76**	**-0.82**	-0.41	1

*PH: plant height (cm), INN: internode number, LA: leaf area (cm^{2}), RWC= relative water content %, RWL= Rate of water loss (mg.cm-^{2}*60mn), FSW: foliar specific weight (mg.cm-^{2}), CHL a: chlorophyll a (mg.ml^{-1}), CHl b: chlorophyll b (mg.ml^{-1}). NC: nitrogen content%.*
KC: potassium content (ppm), GY: grain yield (Qx ha^{-1})



(a) (b)

(c)

Fig. 4. (a) Nitrogen content, (b) Potassium content, (c) Grain yield of two lentil varieties under IRR and RF conditions

Grain yield

Lentil Yield was more influenced by the water situation adopted than of the variety factor. The interaction of the two factors was also responsible of the variation of this parameter (Table 3). The highest yield was obtained under irrigated conditions with 7.05 quintals.ha^{-1} whereas under Rainfed conditions, the grain yield realized was of 2.97 quintals.ha^{-1}. The decrease in grain yield under terminal drought stressed conditions was higher in Syrie229 (microsperma) (60.65%) than in Metropole (macrosperma) (54.6%) (Fig. 4c).

DISCUSSION

The effects generated by the terminal drought on the behavior and productivity in plant species are the result of the sum of the actions of this stress on the various fundamental functions governing these complicated processes. Among these functions, the different morphological and physiological parameters hold an important part, which determine the reactions of the plant to the actions exerted by the abiotic environment. Plant tolerance to water deficit is a function in which the variables are diverse and sometimes with minor effects that are difficult to detect.

The finding of the present investigation indicated that drought stress affected all plant growth parameters (PH, INN and LA) in all tested varieties. Plant height is a trait highly affected by environmental conditions, thus, a reduction in plant height, internodes numbers and in leaf area parameters was observed. Metropole (macrosperma type) exhibited the highest values of PH and LA as compared to Syrie229 variety under Rain fed conditions while the microsperma type

(Syrie229) showed the highest value for the INN parameter. A decrease in morphological parameters may be due to the impairment of cell division, cell enlargement caused by loss of turgor or inhibition of various growth metabolisms [6]. Indeed, the reduction in leaf area parameter is according to many authors, the immediate response of plant to abiotic stresses, it contributes to the conservation of water resources which allows the survival of plants and a form of adaptation to water stress by reducing water losses by transpiration but it causes a decrease in yields due to the reduction of photosynthesis [27]. Similar results are found on Lentils cultivars [28,29,30] and Rice [31]. According to Gosgrove [32], reduction in growth is a programmed response of plants to anticipate the effect of severe water deficit.

Among the physiological parameters studied, foliar RWC, CHLa and CHLb decreased significantly in lentil varieties under Rain fed conditions. Both macrosperma and microsperma varieties maintained a neighboring values of RWC. A high relative water content appears to be a common trait in drought resistant species, plants with high RWC are considered to be relatively drought resistant [33]. It is an effective criterion for evaluating the effect of water deficit on plant functioning and the selection of genotypes that are tolerant to this stress [34]. The RWC is the main early predictor of water deficit declaration. Our results were confirmed by numerous works carried out in this field which show that any deficiency in water supply perceptible by the plant is expressed by a decrease in the water content of the vegetative organs, essentially its leaf system [6,32,33,35,36].

In drought conditions, the regulation of exchanges between the vegetative organs and the environment is of crucial importance in the preservation of the latter's hydration levels. This is confirmed by the clear relationship established between estimated transpiration through water loss from the excised leaf (RWL) and the relative moisture content (r=0.75**). This indicates that the intensification of the transpiration acuity is the source of an excessive loss of leaf water content. RWL, essentially representing stomata transpiration, is insensitive to the water regime applied to plants. This result indicates that stomata movements and the regulation of stomata transpiration is carried out regardless of the development history of the plant. The water loss is directly related to the sweating area (r=0.59**), larger is the leave area; higher is the rate of water loss [37,38,39], which confirm our results.

Another parameter is also a determining factor in the water status of the plant which is the specific weight of the vegetative organs, in particular the leaves. This physiological characteristic is greatly reduced by the application of irrigation (r=0.66**). This result is essentially expressed through the reduction in leaf area and the thickening the leaf to achieve equivalent photosynthetic yield under drought conditions. These hypotheses converge with the work of Morgil [12] which indicates that the selection of tolerant genotypes to water deficit is more efficient with the increase in the specific weight of the plant's assimilating organs.

The Chlorophyll a and Chlorophyll b contents of stressed plants decreased compared to those carried out under irrigated (irrigation + Rainfall) conditions (r=-0.88** and r=-0.8** respectively) (Table 4).Thus, The decrease in chlorophyll b values was greater than in chlorophyll a values for all genotypes and Syrie229 (microsperma) has relatively higher content in CHLL a and lower content in CHLL b than

Metropole under Rain fed conditions. Maintaining a high level in chlorophyll pigments allows to lentil varieties to resist drought efficiently. Such findings are in accordance with earlier reports of Bousba [40] on durum wheat and Hirreche [41] on Medicago sativa which indicated that the decline in chlorophyll content as a response to drought is probably the result of the combination of various factors: Reduction in stomata opening which limits water loss through evapo-transpiration, increasing resistance and the decrease in atmospheric CO_2 input required for photosynthesis.

Indeed, Drought stress is reported to hamper N accumulation, its efficient partitioning in various plant parts and towards seeds [13,41], Our results showed that Nitrogen content in seeds had increased under drought applied at reproductive period. The Syrie229 variety showed a high N accumulation capacity (38.5%) in regards to its efficient partitioning to seeds under drought than Metropole (19%). The nitrogen content in seed after harvest derived from nitrogen translocation from sources tissues, it was stored in stem and leaves and accumulated during vegetative period before declaration of drought [42]. Our results are in agreement with previous findings of [42,43,44,45,46].

The content in Potassium ion marked an increase under Rain fed conditions during our experiment, It was higher in microsperma type (Syrie229) than in macrosperma plants, This inorganic ion play a key osmoregulatory role in guard cells and in the maintenance of turgor in plant cells during water stress [47]. Through seed development of lentil, Potassium is remobilized to seeds from sources. According to Erchidi [48], the translocation of assimilates participates in the filling of grains when the environment becomes constraining.

In terms of the productivity of lentils crop, the results of the present work showed that lentil yield elaboration was mostly influenced by environmental conditions and the (genotype × environment) interaction either than of the type of plant, the yield is an intrinsic characteristic to the plant. Among tested varieties, Syrie229 (microsperma) and Metropole (macrosperma) displayed similar GY under drought conditions(Rain fed) but the reduction in yield as compared to irrigated conditions was greeter in microsperma type (60.7%) than in macrosperma (54.7%). The results are in agreement with the finding of Morteza [49] and Idrissi [50] on Lentil and Liliane [46] on soy bean.

CONCLUSION

The results obtained from the focused study indicated that all morphological (PH, INN, LA) and physiological (RWC, RWL, FSW, CHLL a and CHLL b) parameters were significantly affected by drought stress in both macrosperma and microsperma varieties. The variety effect was significant only for INN, LA and FSW. We conclude that irrigation at flowering and filling stages increased lens productivity, the highest yield was obtained under irrigated conditions, thus, GY depend mainly on environmental conditions and the interaction environment*variety either on the type of plants. The accumulation of assimilates (N and K) in lentil seeds increased as a response to terminal drought, the rate of accumulation was greater in microsperma variety.

CONPETIN INTERESTS

Authors have declared that no competing interests exist.

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