



Registration of ‘Krib’ new lentil variety in Tunisia

Ali Ouji · Moez Amri · Mariem Bouhadida ·
Noura Omri · Khalil Khamassi · Dorra Sfayhi ·
Shiv Kumar · Mohamed Kharrat

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Abstract In Tunisia, lentil (*Lens culinaris* subsp. *culinaris* Medik.) is cultivated in arid and semi-arid areas. Terminal drought and heat stresses during the end of cycle causes significant yield losses. Selection of short cycle varieties could be the best option to escape the effect of pre cited abiotic factors. ‘krib’ was developed using both modified pedigree and bulk methods by INRAT in collaboration with ICARDA. It’s a selection from an advanced F9 line, FLIP2012 196L, which was derived from a cross of ILL590 (early-maturing genotype) with ILL8113 (drought tolerant). During the three consecutive cropping

seasons (2014–2017), the increase in yield of ‘krib’ above that of the local checks was about 13 and 15% for ‘kef’ and ‘Boulifa’, respectively. ‘Krib’ is an early-flowering (on average ~93 d) and early-maturing (on average ~138 d) variety. It’s therefore, the earliest variety among the previously released varieties. Its dehulled seed has a protein content of 26.8% which was above that of ‘Kef’ (23.9%). ‘Krib’ showed good agronomic performance under drought conditions and large adaptation for the Tunisian environments. Tested as ILL11171, ‘Krib’ was approved for release and registered in the Tunisian Official Catalogue of Plant Varieties in 2019, based on the superior performance, by the DG/PCQPA, Tunisia. The availability of ‘Krib’ variety to farmers could increase lentil production and offers the producer profitable benefit in their cropping systems.

A. Ouji (✉)
Regional Research/Development Office of Agriculture
in Northwest Semi-Arid, Le Kef, Jendouba University,
Jendouba, Tunisia
e-mail: ouji_ali@yahoo.fr

A. Ouji · M. Bouhadida · N. Omri · K. Khamassi ·
D. Sfayhi · M. Kharrat
Field Crop Laboratory, National Institute for Agricultural
Research of Tunisia, Ariana, Carthage University, Tunis,
Tunisia

M. Amri
Plant Physiology and Crop Improvement Program
(PPCI), African Integrated Plant and Soil Research
Group (AIPLaS), AgroBioSciences (AgBS), University
Mohammed VI Polytechnic11 (UM6P), Lot 660, Hay
Moulay Rachid, 43150 Ben Guerir, Morocco

S. Kumar
International Center for Agricultural Research in the Dry
Areas, Avenue Hafiane Cherkaoui, 10112 Rabat, Morocco

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Introduction

Lentil (*Lens culinaris* subsp. *culinaris* Medikus.) is an excellent source of protein, dietary fiber and essential minerals and therefore, has the potential to be used as a staple food crop for destroying the hidden hunger (Gautam et al. 2018). Furthermore, lentil contributes to the fertility of soil structure and to the improvement of the productivity of cropping systems

via the fixation of atmospheric nitrogen through the symbiotic relationship with the bacterium *Rhizobium leguminosarum*. In Tunisia, lentils are cultivated during autumn or winter in arid and semi-arid areas. In these areas, with low rainfall, this crop could represent one of the cultural option for enhancing the value of the farm's land. Over the last decade, lentil average yields fluctuated greatly between years, reaching a peak of 1077 kg/ha in 2015 (FAO stat 2015). The average yield of this specie is low, fluctuating and insignificant. These fluctuations in yields are attributed to abiotic constraints which decrease its development, in particular water deficit during the end of cycle which is more frequent and which causes significant yield losses. Shrestha et al. (2006) reported that the Mediterranean environment is to face, episode of intermittent drought during the vegetative growth and terminal drought during the reproductive period when temperatures are ever increasing and rainfall is waning. Singh et al. (2003) reported that drought is responsible to leaf area and plant growth decrease, root functioning, cell membrane stability, variation in biomass and nitrogen distribution in different plant parts. Selection of short cycle lines could be a good solution to escape the effect of heat and drought during the end of cycle. Considering the importance of lentil in the nutrition, the Ministry of Agriculture of Tunisia paid attention to this crop and enhanced a breeding program at INRAT in collaboration with ICARDA since early Eighty (1980s). Consequently, this crop acquires importance in the national legume improvement program by developing high yielding lentil varieties adapted to wide regions of Tunisia. Furthermore drought tolerance, nonlodging, good seed quality are the most required traits for Tunisian farmers. Therefore, the present investigation was undertaken to develop early and drought-tolerant lentil variety with the potential to realize high yields in severe climatic conditions. The release of this new variety named, 'Krib' is the product of a long-term collaborative research between ICARDA and the National Institute for Agricultural Research of Tunisia (INRAT). Since 'Krib' was developed through the cross made at ICARDA, between ILL590 (early-maturing genotype) and ILL8113 (drought tolerant) it has numerous of beneficial agronomic characteristics such as high yields, the precocity and drought tolerance in addition to large adaptation to Tunisian environments. Developed by using both modified

pedigree and bulk methods, 'Krib' was approved for release in 2019 (JORT 2020).

Material and methods

Breeding and line selection

'Krib' was developed through the cross made at ICARDA, between ILL590 (early-maturing genotype) and ILL8113 (drought tolerant). After testing in a non-replicated preliminary screening nursery and replicated preliminary and advanced yield trials between 2006 and 2009, it was entered into the international testing program in 2012 as promising line in the Drought Tolerance lentil nursery (LIEN-DT). The line was entered into the Lentil Germplasm Catalog as accession ILL11171. An advanced line, FLIP2012-196L, derived from the cross was introduced as an F9 breeding line to INRAT, Tunisia, from ICARDA breeding program, through its international nursery trials in 2015 (LIENDT-2015). The line was tested at Kef research station (where the national lentil program is mainly conducted). FLIP2012-196L was selected for higher podding intensity, early flowering and maturity characters. Based on these good characters, the line was advanced to preliminary yield. Subsequently, the promising line was tested in advanced yield trials in two contrasting locations in Tunisia (Kef and Béja sites) for studying its adaptation to Tunisian environment. After seed multiplication the selected line was proposed for registration in the official catalog of plant varieties.

Experimental design

ILL11171 was tested in replicated yield trials at kef site (Semi-arid region, a relatively dry site with an annual average rainfall of 350 mm and clay soil type with latitude 36°07' N and longitude 8°43'E) for three consecutive cropping seasons (2014–2017) and at Béja site (Sub-humid region, with an annual average rainfall of 560 mm and vertisol soil type with latitude 37°44'05"N and longitude 9°13'35"E) during 2016/2017 cropping season, undertimely (TS) and late sowing (LS) dates. The design adopted was a randomized complete block with three replications for preliminary and advanced yield trials. Each line was planted in four rows of 4-m length with 0.5 m

row spacing. Agronomic and phenological parameters were measured. The standard descriptor for lentil (UPOV 2015) was used as guidelines in the phenotypic characterization of krib variety. Seed protein content was determined by multiplication of total nitrogen in whole seeds as assayed by Kjeldahl method (AOAC 2003) using the conversion factor of 6.25. Statistical analyses were performed by using ANOVA procedure with Statistix software.

Results

Evaluation in replicated yield trials

During the 2014–2015 cropping season, the lentil crop was affected by drought at kef station (because rainfall was unevenly distributed) so seed yields were very low. During this season, ILL11171 performed well compared to the local checks ('kef' and 'Boulifa' varieties). It produced 376.3 kg ha⁻¹ which was significantly superior to that of 'kef' and 'Boulifa' varieties which produce 190 and 210 kg ha⁻¹

respectively. During 2015–2016 and 2016–2017 cropping seasons, seed yields of ILL11171, at kef station, were 2235.7 and 1147.7 kg ha⁻¹ respectively. These yields were superior to that of 'Boulifa' which produce 2130 and 1074 and 'kef' which produce 2216 and 1066.7 kg ha⁻¹, respectively in 2015–2016 and 2016–2017 cropping seasons. During 2016–2017 cropping season, seed yields of ILL11171 at Béja station were 1548.3 and 1183 kg ha⁻¹ in timely and late sowing dates, respectively. These yields were superior to that of 'Boulifa' variety which produce 1204 and 986 kg ha⁻¹ and 'kef' variety which produces 1264.7 and 991.3 kg ha⁻¹ in timely and late sowing dates, respectively. On average, 'krib' produced 1298.2 kg ha⁻¹ seed yield compared with 1120.8 kg ha⁻¹ for 'Boulifa' and 1145.7 kg ha⁻¹ for 'Kef'. The increase in yield of 'Krib' above that of the local checks was about 15 and 13% for Boulifa and kef varieties, respectively (Table 1). 'Krib' plant height can reach of 38.3 cm and the lowest pods grow at about 15 cm above soil level, which reduces harvest losses. 'Krib' is suitable for mechanical harvest.

Table 1 Comparison of plant height (PH), 100 seeds weight (100SW), flowering date (FD), maturity date (MD) and seeds yield (SY) of 'Krib' and local checks ('Kef' and 'Boulifa') at INRAT-kef and CRRGC-Béja Experimental Stations in Tunisia

	Site	Year/ precipitations	PH (cm)	100 SW (g)	FD (days)	MD (days)	SY (kg ha ⁻¹)
Krib	Kef	2014–2015 (401.2 mm)	22.3a	5.6a	76a	118.3a	376.3a
		2015–2016 (355.2 mm)	29.3a	5.3ab	113.3a	161.7a	2235.7a
		2016–2017 (283.5 mm)	33.7a	5.1b	99a	142a	1147.7a
	Beja	2016–2017 (TS)*(437 mm)	38.3a	5.1a	105.3a	147a	1548.3a
		2016–2017 (LS)**(437 mm)	30ab	5.3a	73a	121.3a	1183a
		Mean	30.7a	5.3a	93.3a	138.1a	1298.2a
Kef	Kef	2014–2015(401.2 mm)	22a	4.5b	79b	120b	190b
		2015–2016(355.2 mm)	24.3a	5.8a	117b	163.7b	2216a
		2016–2017(283.5 mm)	31a	5.3a	105b	149b	1066.7a
	Beja	2016–2017 (TS)*(437 mm)	33.3b	5.0b	108.7a	152b	1264.7b
		2016–2017 (LS)**(437 mm)	28.3b	5.1b	75.7b	123.3b	991.3b
		Mean	27.8a	5.2a	97.1a	141.6a	1145.7a
Boulifa	Kef	2014–2015(401.2 mm)	22a	4.5b	78b	119ab	210ab
		2015–2016(355.2 mm)	29.7a	4.7b	116b	167c	2130a
		2016–2017(283.5 mm)	33a	4.8c	107c	148b	1074a
	Beja	2016–2017 (TS)*(437 mm)	33.3b	4.9b	109.7a	150.3ab	1204b
		2016–2017 (LS)**(437 mm)	35a	4.8c	77.7b	124b	986b
		Mean	30.6a	4.8b	97.7a	141.7a	1120.8a

For each year, cultivars with the same letters are not significantly different at $p < 0.05$

*TS: Timely sowing date, **LS: Late sowing date

Regarding the phenological parameters over three cropping seasons (2014–2017), ‘Krib’ variety flowers, on average, in ~93 d. The time to maturity of ‘Krib’ (on average, ~138 days) was shorter than that of ‘Boulifa’ (141.7 days) and ‘Kef’ (141.6 days). ‘Krib’ matures 4 d earlier than ‘Boulifa’ and ‘Kef’. Its dehulled seed has a protein content of 26.8% compared with 23.9% for ‘kef’ variety (Kharrat et al. 2007), measured by the Kjeldhal method.

Characteristics

‘Krib’ is the earliest-maturing variety among the previously released varieties. It had a good seed yield under drought condition. ‘Krib’ has good vigor and strong stem, providing lodging resistance. It had a semi erect habit and medium seed weight (5–5.5 g per 100 seeds), which is greater than ‘Boulifa’. This variety is also recognized by the orange-red color of its cotyledon, the greenish yellow of the seed coat, the strong intensity of ramification, the light intensity of green color of the leaves, the medium size of the flower, the blue color of flower standard.

Conclusion

With an increasing effect of climate change resulting in rainfall shortage and bad distribution of precipitation especially in the dry areas, lentil becomes an excellent alternative to build sustainability of production systems in these areas. During these last decades the Tunisian lentil breeding program has invested a lot of efforts through hypothesis-driven research activities that tackle the major priorities for the crop. High yielding, resistance to drought and high temperature and good nutritional quality seeds were defined the main objective of the Tunisian lentil breeding program. Data from long-term field trials highlight the potential of the new variety: early flowering and maturity, drought tolerance, good standing ability, red color of their cotyledon and high grain yield, higher than ‘Kef’ and ‘Boulifa’ checks varieties. The availability of this variety to farmers could increase lentil production and offers the producer a profitable benefit in their cropping systems. Taking into consideration the advantageous characteristics, ‘krib’ has been recommended to be grown across all the lentil-growing regions of Tunisia.

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Data Availability Seed of ‘Krib’ is maintained by the Food legume Improvement Program of INRAT, Tunisia, and at the Integrated Gene Management Program of ICARDA, and is available in small quantities for research purposes. Therefore, plant variety protection will not be sought for ‘Krib’ lentil.

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Declarations

Conflict of interest The authors declare no conflict of interest.

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