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The Preliminary Study of Camelina Compatibility as a New Oil Crop in the Temperate Region of Fars Province

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ABSTRACT

In the last two decades, climate change led to a reduction in the quantity and quality of water resources in Iran. Several efforts have been done to deal with these problems such as the introduction of new plant resources that tolerate drought or salinity. *Camelina sativa* is a plant with low water and nutritional requirements, tolerates low temperatures and is resistant to the majority of pests and diseases. The objective of this study was to evaluate the plant compatibility and approximate determining its appropriate planting date in the temperate region of Fars province. Plant seeds of Soheil cultivar were sown on two planting dates; 16-December-2019 and 25-February-2020 at Zarghan Agricultural Research Station. The field on both planting dates was watered with effective rain that occurred immediately after planting. No pesticides or chemical fertilizers were used during the growing season. Plants were harvested on May 20 and June 15 on the first and second planting dates, respectively. The grain yield of the first date after threshing and cleaning the seeds was about one ton per hectare. Due to the high environmental temperature during the flowering stage, plants had fewer lateral shoots, fewer plant pods and a considerable percentage of pods were seedless, another had the smaller size of seeds on the second planting date, so grain yield was negligible. Results of the present study showed that camelina is a cold-resistant plant and can tolerate below zero degrees temperatures, even in the seedling stage. The December planting date is very suitable for camelina grain production. So it could be considered as a winter oil crop in the temperate region of Fars province with 300 mm rainfall with no need for irrigation events.

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1. Introduction

Reduction of precipitation and the excessive use of water and soil resources in Iran have caused a gradual decrease in the water and soil qualities and Fars province has similar conditions (Ghamarnia *et al.*, 2020).

In addition, due to the drying up of several rivers in recent years, a large number of regions such as Korbal that were previously planted with some crops such as rice have become unusable, either in the Marvdasht region, the lands that were irrigated from Kor and Sivand rivers or Dorodzan dam due to the reduction of water resources have been abandoned, or after planting, due to lack of water and rainfall in the pre-flowering stages, they face severe stresses and dry up, so many local farmers have lost their jobs. In these situations crop diversification and the introduction of new crops suitable for dry farming are necessary. On the other, diversification enhances soil health and fertility, breaks the chain of pests and diseases and reduces environmental stresses and dry farming with crop diversification provides an alternative means of enhancing farmer's income-led to prevent their migration to cities (Ghamarnia *et al.*, 2020; Mirmoeini *et al.*, 2021).

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Camelina (*Camelina sativa*) has been identified as a promising new crop for oil production. This plant has a short growth period (80–100 days), low requirements and tolerates low temperature and drought stresses (Zanetti *et al*., 2013; Ghorbani *et al*., 2020; Soorni *et al*., 2021). It is also known as gold-of pleasure, false flax, Dutch flax, German sesame, or Siberian oilseed in European countries (Putnam *et al*., 1993). In Europe and Russia, camelina was cultivated before World War II and up to the 19th century but then replaced by high-yielding plants. In Iran, the cultivation of *C. sativa* has been recommended as a new medicinal-oil plant in rainfed conditions in Kermanshah Province (Kahrizi *et al*., 2015). Bakhshi et al. (2021) also reported regarding the appropriate tolerance of the plant to environmental stresses, camelina can be considered a highly beneficial crop for agricultural systems in warm and dried regions of Iran especially in rotation with cereals. In the different regions of Iran including Ardebil, Hamedan (as cold climates), Rasht, Ilam, Kermanshah, Karaj, Mashhad (as temperate climates), Ahvaz and Bushehr (as warm climates) Provinces, Raziei et al. (2018) concluded that due to high percentage of unsaturated fatty acids in the cold climates, camelina should be cultivated in cold provinces for nutritional purposes and tropical provinces for industrial and sanitary purposes. Re-cultivation of this plant was considered due to the need for new sources of essential fatty acids, especially omega-3 (Waraich *et al*., 2013; Lawrence *et al*., 2016; Kahrizi *et al*., 2015; Ahmadian Kooshkghazi *et al*., 2021; Piravi-vanak *et al*., 2021). Camelina has a high yield in favorable environments and high levels of oil (40%) and protein (30%) compared to other Brassicaceae crops (Vollmann and Eynck, 2015). Camelina oil contains 12-25% Oleic acid, 10-20% Linoleic acid, 20-40 α- Linolenic acid and 3% Erucic acid (Hurtaud and Peyraud, 2007; Lawrence *et al*., 2016; Paula *et al*., 2019). Camelina seed oil could be utilized as a promising alternative biofuel for the impressive, renewable and green production of biodiesel (Rahimi *et al*., 2021). Dietary supplementation with camelina seed increased the oxidative stability of milk samples and showed that a grass-silage-based diet supplemented with camelina seed results in milk of better quality for human consumption (Mierlita and Vicas, 2015).

The seeds are also a good source of vitamins such as vitamin B1, B3, B5 and gamma-tocopherol (vitamin E) and minerals such as iron, manganese and zinc (Waraich *et al*., 2013). In regard, much attention has been paid to the oil of this plant for the production of medical, health and cosmetic products (Hurtaud and Peyraud, 2007). Camelina seeds have a high nutritional value and have a canola-like amino acid balance. The plant contains significant amounts of alpha, gamma and delta-tocopherol, plastochromanol and phenolic compounds with a high antioxidant role (Waraich *et al*., 2013; Paula *et al*., 2019).

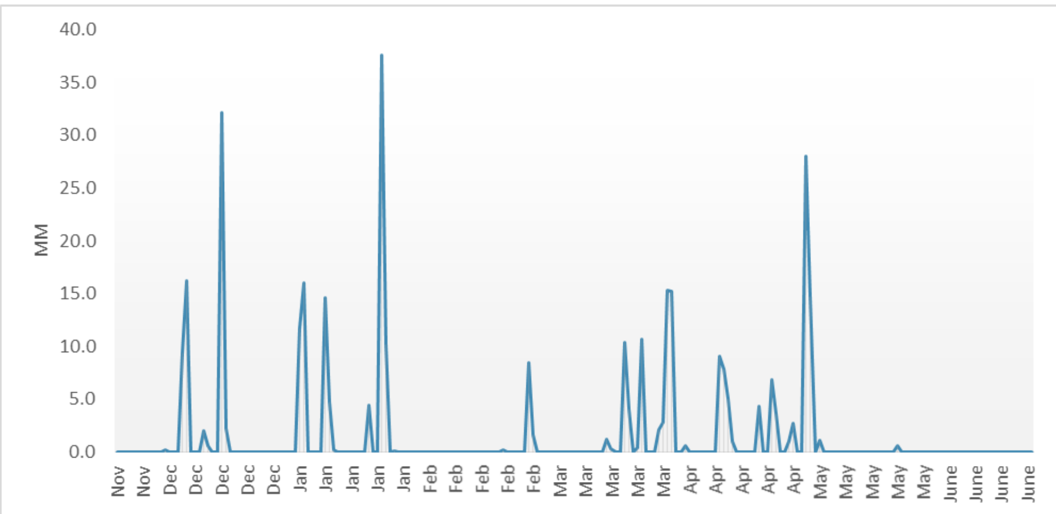

Figure 1. The amount of rainfall during the growing season (2019-2020)

The height of the plant stem reaches up to 1 meter and its seed pods are similar to the flax plant. A thousand kernels weigh of the plant are about 2 grams with no dormancy (Ehrensing and Guy, 2008). Due to these advantages, the plant was cultivated in the Zarghan Agricultural Research Station, Fars Agricultural and Natural Resources Research and Education Center, for the following purposes:

1. As a suitable crop for dryland conditions
2. Use of the plant as a new oil plant in the country
3. If tolerate cold, it could replace rapeseed in areas where early planting is not possible due to lack of water.
4. To determine the appropriate planting date

2. Materials and methods

Camelina seeds of Soheil cultivar obtained from Biston Shafa Co, Kermanshah, Iran were planted in rows of 50 cm apart on two planting dates in Zarghan Agricultural Research Station, Fars Agricultural and Natural Resources Research and Education Center. Half a kilogram of Camelina seeds was used for each planting date. Before planting, plowing, disc and leveler operations were performed. The planting dates were 16 December 2019 and 25 February 2020. The first irrigation was done with rainwater in both planting dates immediately one day after planting (Fig. 1). After emergence, the plants were thinned at a distance of about 6 to 8cm on the row, so the density of plants varied between 250000 to 330000 per hectare. The experiment was carried out as observational in clay loam soil. The climate of the region was temperate. Irrigation was done only once for the first planting date on 1st May and twice for the second planting date on 1st and 20th May. No herbicides or pesticides were used and weeds were mechanically controlled.

Flowering and maturity dates were assumed as when 50% of the plants reached these stages. The farm was harvested on 20 May and 15 June on the first and second planting dates, respectively and grain yield of total area from each planting date was measured separately.

3. Results and discussion

Flowering and maturity dates and the other recorded traits of both planting dates are given in Table 1.

Table 1. Collected data from camelina field at Zarghan station in 2019-2020

Planting date	16-Dec	25-Feb
The amount of seed consumed	0.5 Kg	0.5 Kg
Field area	1400 m^2	1000 m^2
Planter	Manual	Manual
Planting bed preparation operation	customary	customary
Herbicide	Not use	Not use
Cultivar	Soheil	Soheil
Weed	*Convolvulus arvensis - Sorghum halopense – Echinochloa crus-galli –Alhagi comelorun – Carthamus tinctorius – Fumaria officinalis- Descurainia sophia*	
weed control	Hand weeding	Hand weeding
Pest and disease	Not seen	Not seen
Irrigation	One time (1 May) About 140 m^3	Two times (1 and 20 May) about 200 m^3
Flowering date	04-Apr	10-May
Maturity date	15-May	10-Jun
Harvesting date	20-May	15-Jun
Yield (after seed cleaning)	140 Kg	30 Kg

Minimum of daily air temperature during the growing season were taken from Zarghan Meteorological Station very close to the experiment site. From Mach 2020 to the end of the growing season, there was no air temperature below plus three degrees and therefore not shown in the corresponding graph (Fig. 2).

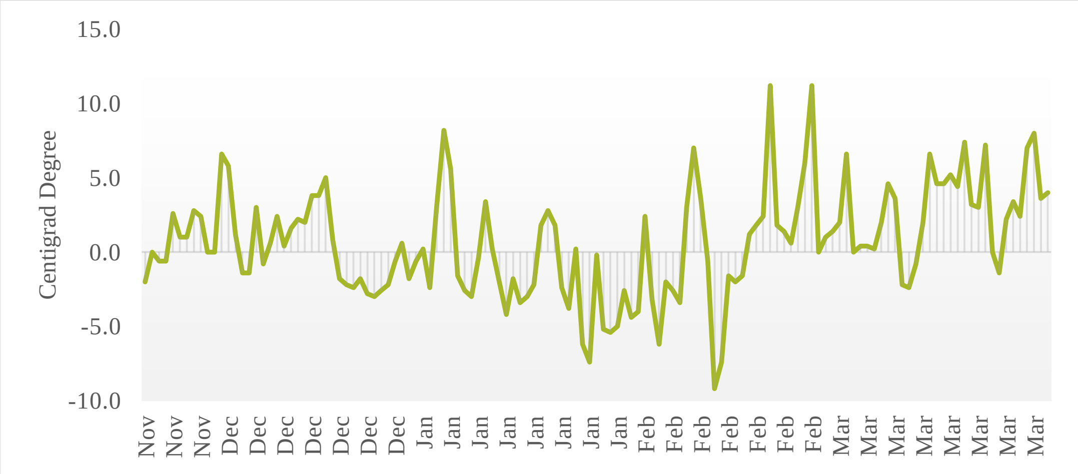

Figure 2. Minimum daily temperature from November 2019 to March 2020 at Zarghan Agricultural Research Station

As shown in Fig. 2 the minimum air temperature has dropped to minus three degrees after late December and although the plants of the first planting date were in the two-leaves stage or seedling stage (Fig. 3-a), they could tolerate zero and below zero temperatures, easily and without any symptoms of frost or chilling.

The total number of days (nights) with a minimum temperature of below zero degrees until the end of March was 48 days and the lowest temperature was about -10 °C on February 12 (Fig. 2). Plants of first planting date in this time (Feb) were in the rosette stage (Fig. 3-b) and so in this stage, they tolerated the cold and frost easily and without damaging the plants and after the cold ended, they grow naturally.

In general, in December 2019 and January 2020, the minimum daytime temperature has often reached below zero degrees and even down to -3 °C.

a

b

Figure 3. Left: Two leaves stage of camelina in the late December of first planting date; Right: Camelina rosette stage

On the growing season of the second planting date, the daily (nightly) temperature rarely dropped below zero degrees, so the plants grew faster and the length of the growing season became shorter. When the plants of the second planting date were in the initial 2-leaf stage, the first planting date was at the end of the rosette stage and before stem elongation (Fig. 4-A). Weed control was performed at this stage. Plant thinning was done at this stage and plant density reached 300,000 plants per hectare. Although the density of plants decreased to about 250000 to 300000 per hectare on both dates, due to the height of the plants (maximum one meter) and the inability of tillering in plants, it can be planted with a higher density. It is necessary to determine the optimum planting density for the best products in the different regions and conditions.

As the weather warmed up from early March to the next months, the plant grew faster and therefore, the first planting date of the field was at the stem elongation phase on March 20 (Fig. 4-B). Plants reached late stem elongation very quickly in early April (Fig. 4-C) and the field entered the flowering stage on April 10 (Fig. 4-D). The height of plants at the beginning of flowering was about 50 cm and increased about 80-100 cm at the complete flowering stage.

Figure 4. A: First planting date of the field before stem elongation (15 March 2020); B: First planting date of the field in stem elongation phase after weeding and thinning (20 March 2020); C: First planting date of the field at the end of stem elongation phase (1 April 2020); D: First planting date of the field in the flowering stage start (10 April 2020); E: The finishing of the flowering stage in the first planting date of the field (Up) and rosette stage in the second planting date field (Down), (Mid-April); F: First planting date of the field in podding start stage (27 April 2020).

Field flowering was ended around Mid-April on the first planting date (Fig. 4-E). At this time, the second planting date of the field was in the early and rosette growth stages. So the field of the first planting date reached to rosette stage about two months after planting, but this stage for the second planting date was happened one month after planting. This means that air temperature changes have a direct effect on plant growth rate and growth stage duration. The different growth stages in the first planting date were longer than the second planting date.

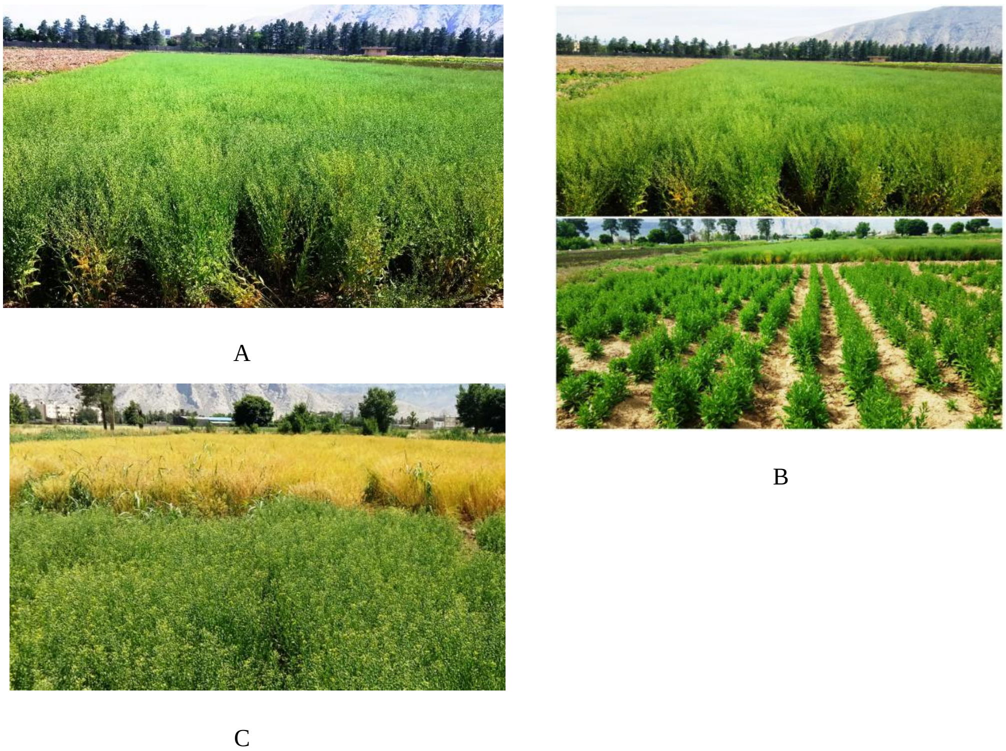

Figure 5. A: First planting date of the field in grain filling stage (5 May 2020); B: First planting date in grain filling stage (Up) and second planting date in stem elongation (Down) on 5 May 2020; C: First planting date in maturity stage (Up) and second planting date in flowering end-stage (Down) on May 23

Although no-tillers were formed in the plant on both planting dates, each plant had a number of sub-branches. The number of sub-branches in the first planting date was more than the second planting date. As shown in Figs. 4-F and Fig. 5-A, on the first planting date, the pod sheathing stage started in late April and the grain filling stage was performed in May gradually.

As the plants on May 5 were in the grain filling period on the first planting date, plants on the second planting date were in stem elongation stage and then the flowering stage began a few days later (Fig. 5-B). Finally, in late May, maturity happened on the first planting date when the second planting date was at the end of the flowering stage (Fig. 5-C).

The plants went through the flowering and grain filling period much faster on the second planting date. At this time air temperature was rising, so high temperature and high growth rate shortened the period of grain filling and pods formation, produced fewer lateral shoots, fewer plant pods and smaller size of grains than the first planting date and so the number of grains in each pod, the number of pods per plants and grains weight decreased. Plants on this planting date were entered to ripening stage in late June. Grains shedding were very severe due to the small size of the seeds on this planting date and the impossibility of adjusting the harvester. In general, fewer seeds were produced on this planting date. The amount of grain yield on the first planting date was about 1000 kg ha^{-1}. This amount for the second planting date regarding 30% grain losing and short-grain filling stage was about 300 kg ha^{-1}.

Thus, the first planting date, i.e. December 16, is well recommended for camelina planting in the temperate region of Fars province for the following reasons:

1. The crop could easily tolerate sub-zero temperatures even in the seedling stage.
2. Due to rainfall events in December, the crop does not need to irrigate at this planting date in temperate regions of the Fars province
3. In years with normal rainfall due to the continuous rainfall in winter and early spring, the crop could enter the seed maturity stage without any need for irrigation.

4. Camelina could be considered as a new option for producing oilseeds in the planting pattern of the region.
5. The crop could be cultivated by farmers who do not grow rapeseed due to limited water resources.
6. Due to production more yield on the first planting date, plant autumnal sowing is recommended than spring, in terms of less water consumption as well as more grain yield.
7. Lack of synchronization of plant harvest on the first planting date with other crops such as barley, wheat, rapeseed and safflower could prevent harvesting traffic and machine shortages.

4. Conclusion

This experiment showed that Camelina can be produced as an oil plant in temperate regions with minimum water consumption if planted on suitable planting date. So it can be recommended that:
1. Recommendation and extension of the plant cultivation as an oil crop in the planting pattern of the region for using rainfall in the autumn and winter (Green water).
2. Growing the crop as rainfed, especially in years with 300 mm precipitation and appropriate distribution.
The following researches are suggested to complete the study of this plant:
1. Analysis of plant oil to determine its composition.
2. Investigating the proper planting density for the highest grain yield and oil quality.
3. Investigation of the use of crop shoots and straw as forage in animal feed.
4. Determination of crop salt tolerance.
5. Release of high-yielding cultivars with diversification in its germplasms and common breeding methods.
6. Investigation of irrigating the crop in warm, cold and temperate conditions of the Fars province.
7. Investigation of rain-fed planting in cold and hot areas of the province.

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References

Ahmadian Kooshkghazi M. E., Madandoust M., Mohajeri F., Kahrizi D. 2021. Study of different dates of planting Camelina (*Camelina Sativa* (L.) Crantz). International Journal of Modern Agriculture 10 (1): 361-365.

Bakhshi B., Rostami-Ahmadvandi H., Fanaei H.R. 2021. Camelina, an adaptable oilseed crop for the warm and dried regions of Iran. Central Asian Journal of Plant Science Innovation 1(1): 39-45.

Ehrensing D.T., Guy S.O. 2008. Camelina. Oregon State University. Ext. Sev., Corvallis. (EM 8953-E).

Ghamarnia H., Kahrizi D., Rostami-Ahmadvandi H. 2020. Camelina; a low input and compatible plant. Razi University press Press (in Persian). ISBN: 9786003930025. P.120.

Ghorbani M., Kahrizi D., Chaghakaboodi Z. 2020. Evaluation of Camelina sativa doubled haploid lines for the response to water-deficit stress. Journal of Medicinal Plants and By-product 9(2): 193-199.

Hurtaud C., Peyraud J.L. 2007. Effects of feeding camelina (seeds or meal) on milk fatty acid composition and butter spreadability. Journal of Dairy Science 90 (11): 5134-5145. https://doi.org/10.3168/jds.2007-0031

Kahrizi D., Rostami-Ahmadvandi H., Akbarabadi A. 2015. Feasibility cultivation of Camelina (*Camelina sativa*) as medicinal-oil Plant in Rainfed Conditions in Kermanshah-Iran's first report.

Lawrence R. D., Anderson J.L., Clapper J.A. 2016. Evaluation of camelina meal as a feedstuff for growing dairy heifers. Journal of Dairy Science 99 (8): 6215-6228. https://doi.org/10.3168/jds.2016-10876

Mierlita D., Vicas S. 2015. Dietary effect of silage type and combination with camelina seed on milk fatty acid profile and antioxidant capacity of sheep milk. South African Journal of Animal Science 45(1): 1-11. https://doi.org/10.4314/sajas.v45i1.1

Mirmoeini T., Pishkar L., Kahrizi D., Barzin G., Karimi N. Phytotoxicity of green synthesized silver nanoparticles on Camelina sativa L. Physiology and Molecular Biology of Plants. 2021 Feb;27(2):417-27. https://doi.org/10.1007/s12298-021-00946-y

Paula E.M., da Silva L. G., Brandao V.L.N., Dai X., Faciola A.P. 2019. Feeding Canola, Camelina, and Carinata meals to ruminants. animals 9 (10): 704. https://doi.org/10.3390/ani9100704

Piravi-vanak Z., Azdmard-Damirchi S., Kahrizi D., Mooraki N., Ercisli S., Savage G.P., Ahmadvandi H.R. and Martinez F. 2021. Physicochemical properties of oil extracted from camelina (*Camelina sativa*) seeds as a new source of vegetable oil in different regions of Iran. Journal of Molecular Liquids, p.117043. https://doi.org/10.1016/j.molliq.2021.117043

Putnam D.H., Budin J.T., Field L.A., Breene W.M. 1993. Camelina: a promising low input oilseed. In: Janick, J., Simon J.E. (eds) New Crops. Wiley, New York 314-322.

Rahimi T., Kahrizi D., Feyzi M., Ahmadvandi H.R., Mostafaei M. 2021. Catalytic performance of MgO/Fe2O3-SiO2 core-shell magnetic nanocatalyst for biodiesel production of Camelina sativa seed oil: Optimization by RSM-CCD method. Industrial Crops and Products 159. 113065. https://doi.org/10.1016/j.indcrop.2020.113065

Raziei Z., Kahrizi D., Rostami-Ahmadvandi H. 2018. Effects of climate on fatty acid profile in *Camelina sativa*. Cellular and Molecular Biology 64(5): 91-96. https://doi.org/10.14715/cmb/2018.64.5.15

Soorni J., Kazemitabar SK., Kahrizi D. et al. 2021. Genetic analysis of freezing tolerance in camelina [*Camelina sativa* (L.) Crantz] by diallel cross of winter and spring biotypes. Planta. 253, 9. https://doi.org/10.1007/s00425-020-03521-z

Vollmann J., Eynck C. 2015. Camelina as a sustainable oilseed crop: contributions of plant breeding and genetic engineering. Biotechnology Journal 10 (4): 525-535. https://doi.org/10.1002/biot.201400200

Waraich E.A., Ahmed Z., Ahmad R., Ashraf M.Y., Saifullah U., Naeem M.S., Rengel Z. 2013. *Camelina sativa*, a climate proof crop, has high nutritive value and multiple-uses: a review. Australian Journal of Crop Science 7(10): 1551-1559.

Zanetti F., Monti A., Berti M.T. 2013. Challenges and opportunities for new industrial oilseed crops in EU-27: a review. Industrial Crops and Products 50: 580-595. https://doi.org/10.1016/j.indcrop.2013.08.030

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