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Research Application Summary

Safflower the Climate Smart Crop for Arid and Semi-arid Lands

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Abstract

Safflower (*Carthamus tinctorius* L.) is a neglected and underutilized multipurpose oil seed crop that is climate smart. The crop is drought, saline, and extreme temeprature (-14-43°C) tolerant. Safflower is the most drought tolerant oilseed crop that can produce good seed yield containing high quality cooking oil in arid and semi-arid lands (ASALs) affected by salinity and exacerbated by scarcity of rainfall due to climate change. Global warming is predicted to increase the frequency of droughts, floods, and heat waves. Climate change may also affect the habitat range of pests and pathogens, and high temperatures may increase pathogen spread, therefore requiring development of new crop cultivars or growing crops that are adaptable to various climatic conditions such as safflower. Safflower is a multipurpose crop grown to produce natural dyes, high-quality edible and industrial oil, pharmaceuticals, biodiesel, and biogas. The crop can further be used as a cut flower, leafy vegetable, and livestock feed. The objective of this study was to elucidate safflower genotypes performance under the ASAL conditions of southern Botswana. The results showed that genotypes and growing season significantly ($P < 0.05$) influence yield components, seed yield and seed oil content of safflower. The results also showed that safflower can be grown in the arid and semi-arid conditions of Botswana, and planting can be coincided with the rain season for dryland farming. It was concluded that safflower has the potential to become an industrial crop that can improve food security, incomes, livelihoods, and alleviate poverty of many people in ASALs if effective and specific support policies, technological inputs, and pricing and marketing systems are put in place.

Keywords: Botswana, climate change, drought, multipurpose oil crop, salt and heat tolerant crop, safflower

Le carthame (*Carthamus tinctorius* L.) est une culture oléagineuse polyvalente négligée et sous-utilisée qui est pro-climatique. Cette culture tolère la sécheresse, la salinité et les températures extrêmes (-14-43°C). Le carthame est la culture oléagineuse la plus tolérante à la sécheresse qui peut produire un bon rendement en graines contenant une huile de cuisson de haute qualité sur les terres arides et semi-arides (ASAL) affectées par la salinité et exacerbées par la rareté des précipitations due au changement climatique. Il est prévu que le réchauffement de la planète augmentera la fréquence des sécheresses, des inondations et des vagues de chaleur. Le changement climatique peut également avoir une incidence sur l'habitat des ravageurs et des agents pathogènes, et les températures élevées peuvent favoriser la propagation des agents pathogènes. Il est donc nécessaire de développer de nouveaux cultivars adaptés à diverses conditions climatiques, comme le carthame. Le carthame est une culture polyvalente qui permet de produire des colorants naturels, des huiles comestibles et industrielles de haute qualité, des produits pharmaceutiques, du biodiesel et du biogaz. Cette culture peut également être utilisée comme fleur coupée, légume à feuilles et aliment pour le bétail. L'objectif de cette étude était d'élucider les génotypes de carthame dans les conditions ASAL du sud du Botswana. Les résultats ont montré que les génotypes et la saison de croissance ont significativement (P < 0,05) influencé les composants du rendement, le rendement en graines et la teneur en huile des graines de carthame. Les résultats ont également montré que le carthame peut être cultivé dans les conditions arides et semi-arides du Botswana, et que la plantation peut coïncider avec la saison des pluies pour l'agriculture en zone sèche. Il a été conclu que le carthame a le potentiel de devenir une culture industrielle qui peut améliorer la sécurité alimentaire, les revenus, les moyens de subsistance, et réduire la pauvreté de nombreuses personnes dans les ASALs si des politiques de soutien efficaces et spécifiques, des intrants technologiques, et des systèmes de prix et de marketing efficaces sont mis en œuvre par les gouvernements.

Mots-clés: Changement climatique, sécheresse, culture oléagineuse polyvalente, tolérance a la salinité et au stress thermique, carthame

Introduction

Safflower (*Carthamus tinctorius* L.) is an ancient neglected and underutilized crop with several uses (Emongor, 2010; Zohary *et al*., 2012; Emongor and Oagile, 2017; FAO, 2019). It is a multipurpose crop grown to produce natural dyes, high-quality edible and industrial oil, pharmaceuticals, biodiesel, and biogas (Emongor, 2010; Zohary *et al*., 2012; Emongor and Oagile, 2017; FAO, 2019). The crop can further be used as a cut flower, leafy vegetable, and livestock feed (Emongor and Oagile, 2017). Safflower oil contains a high proportion of unsaturated fatty acids linoleic (polyunsaturated) and oleic (monounsaturated) in the range of 79.2-93.5% (Khalid *et al*., 2017; Katkade *et al*., 2018; Moatshe, 2019). The health benefits correlated with the use of safflower oil include prevention and treatment of hyperlipidemia, arteriosclerosis, coronary heart disease, blood pressure, osteoporosis, diabetes, cancer, and mineral metabolism (Pongracz *et al*., 1995; Herbel *et al*., 1998; Abidi, 2001; Weiss *et al*., 2005; Fasina *et al*., 2006).

Apart from increasing world population, many factors threaten enough future world production of food from crops. Available arable land is significantly decreasing due to non-sustainable farming, soil erosion and degradation, and climate change (IPCC, 2007; Schlenker and Roberts, 2009; Challinor *et al*., 2014; Hussain *et al*., 2016; Zhao *et al*., 2017). It is predicted that droughts, storms, floods, heat waves, and rise in sea level will occur more frequently, suggesting that salinity will be a problem in ASALs.

Safflower (*Carthamus tinctorius* L.) is grown in many parts of the world due to its adaptability to different environmental conditions such as tolerance to drought, extreme temperatures, salinity, and low nutrient application (Pussain *et al*., 2016; Emongor and Oagile, 2017). The high root density and aggressive root structure of safflower can penetrate up to 2-3.5 m deep into the soil than for many other crops, enabling it to utilise surplus water from deep in the soil profile, and making it thrive in regions receiving annual precipitation as low as 250 mm provided the rainfall is equally distributed through the cropping cycle (Engel and Bergman, 1997; Emongor and Oagile, 2017; Moatshe, 2019). Drought is unpredictable in reference to incidence, severity, timing and duration (IPCC, 2007). Safflower is a potential alternate crop in ASALS because of its growth potential under water stress without a substantial reduction of oil and seed yields (Hussain *et al*., 2016; Moatshe, 2019). Therefore, the objective of this study was to elucidate safflower genotypes performance under the ASAL conditions of southern Botswana.

Materials and Methods

Four field experiments were conducted in the Botswana University of Agriculture and Natural Resources content farm, located at latitude 59^{o} 24'S, 95^{o} 25'E and 993 m above sea level. The experimental design was a randomised complete block design with three replications. The treatments were five safflower genotypes (Kiama Composite, Sina, Gila, PI537636 and PI527710). The spacing was 40 cm x 25 cm. Basal fertilizer application was done at 80 and 20 kg/ha nitrogen and phosphorus, respectively. The dependent variables determined were capitula number/plant, seed number/capitulum, 1000-seed weight, seed yield, and oil seed content. The oil content was determined in accordance with AOACS (2004) standard procedures. The data collected were subjected to analysis of variance (ANOVA) using the SAS (Statistical Analysis System, 2021) program's general linear models (Proc GLM). The Least Significant Difference (LSD) test was used to separate treatment means at P = 0.05.

Results and Discussion

The results of the current study showed that genotypes significantly (P < 0.05) influenced yield components (capitula number/plant, seed number/capitula, and 1000-seed weight) (Table 1), seed yield and seed oil content (Table 2) of safflower grown in both winter and summer. The yield components, seed yield and oil content were also significantly (P < 0.05) influenced by the growing season (Tables 1 and 2). The seed yield and seed oil content varied between 3666-5653 kg/ha and 30.3-64.0%, depending on genotype and growing season. The genotype 'Sina''consistently had significantly (P < 0.05) higher yield components, seed yield and seed oil content than other genotypes evaluated in the study. The differences in yield components, seed yield and seed oil content among genotypes was attributed to genetic differences. The differences in seed yield among the safflower genotypes was also explained by the corresponding differences in yield components. Significant genetic variation of safflower genotypes on capitula number/plant, seed number/capitulum, 1000-seed weight and biological yield has been reported in literature (Camas *et al*., 2007; Hamza, 2015; Killi *et al*., 2016; Moatshe, 2019).

Table 1. Effect of safflower genotypes on yield components

Genotype	Capitula number/plant		Seed number/capitulum		1000-seed weight (g)	
	Winter	Summer	Winter	Summer	Winter	Summer
Kiama Composite	135b	53d	73b	56d	43.8c	32.3c
Sina	163a	99a	87a	74a	56.7a	43.8a
Gila	103d	53d	61c	56d	34.8e	35.1b
PI537636	106c	78c	57e	63c	42.0	31.2d
PI527710	107c	88b	59d	66b	45.2b	35.5b
Significance	****	****	****	***	****	***
LSD	1.89	1.31	0.9	1.0	0.08	0.84

***, ****Significant at P = 0.001,0.0001, respectively. Means separated using the Least Significant Difference at P = 0.05; means within column(s) followed by the same letter(s) are not significantly different

Table 2. Effect of safflower genotypes on seed yield and seed oil content

Genotype	Seed yield (kg/ha)			Oil Content (%)	
	Winter	Summer		Winter	Summer
Kiama Composite	4844bc	3666d		30.3c	31.0b
Sina	5653a	5023a		61.7b	61.6a
Gila	3994d	3718d		30.0c	29.3b
PI537636	4596c	4485c	62.1ab	61.2a	
PI527710	5054b	4734b	64.0a	60.7a	
Significance	**	**	****	****	
LSD	301	145	2.0	1.9	

**, ****Significant at P = 0.01, 0.0001, respectively. Means separated using the Least Significant Difference (LSD) at P = 0.05; means within column(s) followed by the same letter(s) are not significantly different

Conclusion

The results of the current study show that safflower can be grown commercially in the arid and semi-arid conditions of Botswana under irrigation or planting be done at the start of the rain season for dryland farming. Safflower has the potential to become an industrial crop that can improve food security, incomes, livelihoods, and alleviate poverty of many people in ASALs if effective and specific support policies, technological inputs, and pricing and marketing systems are implemented.

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References

Abidi, S. 2001. Chromatographic analysis of plant sterols in foods and vegetable oils. *Journal of Chromatograph A* 935(1): 173-201.

AOACS. 2004. Association of Official Analytical Chemists Society. Official methods and recommended practices of the AOCS. The American Oil Chemists Society, Methods, additions and revisions, pp. 1-2.

Camas, N., Cuneyt, C. and Enver, E. 2007. Seed yield, oil content and fatty acid composition of safflower (*Carthamus tinctorius* L.) grown in northern Turkey conditions. *Journal of Faculty of Agriculture OMU* 22 (1): 98-104.

Challinor, A. J., Watson, J., Lobell, D. B., Howden, S.M., Smith, D.R. and Chhetri, N. 2014. A meta-analysis of crop yield under climate change and adaptation. *Nature Climate Change* 4: 287-291.

Emongor, V. E. 2010. Safflower (*Carthamus tinctorius* L.) the underutilized and neglected crop: A Review. *Asian Journal of Plant Science* 9 (6): 299-306.

Emongor, V. E. and Oagile, O. 2017. Safflower Production. Impression House Publication, Botswana, ISBN 978-99968-0-607-0. 62pp.

Engel, R. and Bergman, J. 1997. Safflower seed yield and oil content as affected by water and nitrogen. *Fertilizer Facts* 14: 1-3.

FAO. 2019. Crop production data. Food and Agriculture Organization of the United Nations, Statistics Division online database. http://www.fao.org/faostat/.

Fasina, O. O., Hallman, H., Craig, S. M. and Clements, C. 2006. Predicting temperature dependence viscosity of vegetable oils from fatty acid composition. *Journal of the American Oil Chemists' Society* 83 (10): 899-903.

Hamza, M. 2015. Influence of different plant densities on crop yield of six safflower genotypes under Egyptian newly reclaimed soils conditions. *International Journal of Agriculture and Crop Sciences* 8 (2): 168-173.

Herbel, B. K., Mcguire, M. K., Mcguire, M. A. and Schultz, T. D. 1998. Safflower oil consumption does not increase plasma conjugated linoleic acid concentration in humans. *American Journal of Clinical Nutrition* 67 (2): 332-337.

Hussain, M.I., Lyra, D., Farooq, M., Nikoloudakis, N. and Khalid, N. 2016. Salt and drought stresses in safflower: a review. *Agronomy for Sustainable Development* 36 (4): 3-31.

IPCC. 2007. Climate change synthesis report in UN and other languages. An Assessment of the Intergovernmental Panel on Climate Change, 52pp. http://www.ipcc.ch/site/assets/uploads/2018/06/ar4_syr.pdf/.

Katkade, M. B., Syed, H. M., Andhale, R. R. and Sontakke, M. D. 2018. Fatty acid profile and quality assessment of safflower (*Carthamus tinctorius* L.) oil. *Journal of Pharmacognosy and Phytochemistry* 7 (2): 3581-3585.

Khalid, N., Khan, S. R., Hussain, M. I., Farooq, M., Ahmad, A. and Ahmed, I. 2017. A comprehensive characterization of safflower oil for its potential applications as a bioactive food ingredient: A Review. *Trends in Food Science and Technology* 66: 176-186.

Killi, F., Kanar, Y. and Tekeli, F. 2016. Evaluation of seed and oil yield with some yield components of safflower varieties in Kahramanmaras (Turkey) conditions. *International Journal of Environmental and Agriculture Research* 7 (2): 136-140.

Moatshe, O. G. 2019. Genotype and plant density effects on growth, yield, and oil composition of safflower (*Carthamus tinctorius* L.). PhD Thesis, Botswana University of Agriculture and Natural Resources. 302pp.

Pongracz, G., Weiser, H. and Matzinger, D. 1995. Tocopherol, Antioxidation. *Journal of Natural Fatty Acid Science and Technology* 97: 90-104.

Schlenker, W. and Roberts, M.J. 2009. Nonlinear temperature effects indicate severe damages to U.S. crop yields under climate change. http://www.pnas.org/content/pnas/106/37/15594.

Weiss, L. A., Barrett-Connor, E. and von Mühlen, D. 2005. Ratio of n-6 to n-3 fatty acids and bone mineral density in older adults: the Rancho Bernardo study. *The American Journal of Clinical Nutrition* 81 (4): 934-938.

Zhao,1., Liu, B., Piao, S., Wang, S., Lobell, D.B., Huang, Y., Huang. M, Yao, Y., Bassu, S., Ciais, P., Durand, J., Elliott, J., Ewert, F., Janssens, I. A., Li, T., Lin, E., Liu, Q., Martre P., Müller, C., Peng, S., Peñuelas, J., Ruane, A.C., Wallach, D., Wang, T., Wu, D., Liu, Z., Zhu, Y., Zhu, Z. and Asseng, S. 2017. Temperature increase reduces global yields of major crops in

four independent estimates. http://www.pnas.org/cgi/doi/10.1073/pnas.1701762114.
Zohary, D., Hopf, M. and Weiss, E. 2012. Dye crops. pp. 33-34. In: Domestication of Plants in the Old World: The Origin and Spread of Domesticated plants in Southwest Asia, Europe, and the Mediterranean Basin. Oxford University Press.