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Research Application Summary

# Evaluation of safflower genotypes under the semi-arid conditions in Botswana

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## Abstract

Safflower (*Carthamus tinctorius* L.) is a multipurpose oil seed crop that is drought, heat, cold and saline tolerant, but minor and neglected despite its many uses. However, recently there is renewed interest in safflower due to its drought tolerance and the suitability of its oil for nutritional or industrial purposes. Under semi-arid conditions of Botswana, farmers have difficulty in increasing crop productivity and diversity in crop rotations due to unfavourable conditions imposed by high and cold temperatures, inadequate rainfall and very high evapotranspiration rate and saline soils in some parts of the country. In such conditions, safflower appears a promising alternative crop. Therefore, the objective of this study was to evaluate the adaptability of safflower genotypes to the semi-arid conditions of Botswana. Nine safflower genotypes were evaluated during the rainy seasons of September to December 2014 and January to April 2015 in a randomized complete block design (RCBD) with three replications in the Botswana University of Agriculture and Natural Resources, Notwane Farm under sandy loam soils. The results of the study showed that safflower genotypes differed significantly ($p < 0.05$) in agro-morphological traits, growth habit, maturity date, seed yield and yield components, oil content and oil yield. The seed yield, oil yield and oil content significantly ($p< 0.05$) varied between 888-3113 kg/ha, 226-1313 kg/ha and 26-42%, respectively, depending on genotype. The safflower genotype PI537598-SINA-USA out performed all the other safflower genotypes including the local cultivar Kiama Composite. This research showed that safflower has a big potential as an oilseed crop in semi-arid Botswana.

Key words: Botswana, *Carthamus tinctorius*, oil yield, seed yield

## Résumé

Le faux safran (*Carthamus tinctorius* L.) est une culture à graine d'huile à usage multiple qui est tolérante à la sécheresse, la chaleur et la fraîcheur et la salinité mais négligée malgré ses nombreux usages. Néanmoins, il y a eu récemment un renouvellement d'intérêt sur le faux safran à cause de sa tolérance envers la sécheresse et le fait que son huile soit convenable sur le plan nutritionnel et industriel. Dans les conditions semi-arides du Botswana, les fermiers ont de difficulté à accroitre la productivité et la diversité des cultures lors de la rotation à cause des conditions défavorables imposées par des températures élevées et faibles, de pluies inadéquates et un taux très élevé d'évapotranspiration et la présence de sols salins dans certaines parties du pays. Dans de telles conditions, le faux safran apparaît comme une culture alternative prometteuse. L'objectif de cette étude était donc d'évaluer l'adaptabilité des génotypes de faux safran aux milieux semi-arides du Botswana. Neuf génotypes de faux safran étaient évalués au cours des saisons pluvieuses de Septembre à Décembre 2014 et Janvier à Avril 2015 dans un dispositif de bloc aléatoire complet avec trois réplications à l'Université d'Agriculture et de Ressources Naturelles du Botswana, la ferme Notwane sur du sol à terreau sableux. Les résultats de l'étude montrent que les génotypes de faux safran diffèrent significativement (p<0.05) au niveau des traits agro-morphologiques, mode de croissance, date de maturité, le rendement en grains ainsi que les composantes du rendement, la teneur et le rendement en huile. Les traits comme le rendement en grains, le rendement en huile et la teneur en huile ont varié significativement (p<0.05) entre 888-3113 kg/ha, 226-1313 kg/ha et 26-42% respectivement dépendant du génotype. Le génotype PI537598-SINA-USA a plus produit que tous les autres génotypes de faux safran y compris la variété locale Kiama Composite. Cette recherche a montré que le faux safran a une grande potentialité en tant que culture à graine d'huile dans les milieux semi-arides du Botswana.

Mots-Clés : Botswana, *Carthamus tinctorius*, rendement en huile, rendement en grain

## Background

Safflower (*Carthamus tinctorius* L.) belongs to the family Compositae or Asteraceae, grown mainly for its seed, which is used as edible oil and as birdseed (Dordas and Sioulas, 2008; Istanbulluoglu, 2009, Emongor, 2010). Safflower is also grown as a vegetable crop, cut flower, fodder crop, medicinal plant, a dye crop for the textile industry, and used in the manufacture of high quality paint ((Dajue and Mündel, 1996; Emongor, 2010; Emongor, 2015). Safflower is a drought, heat, cold and saline tolerant crop (Bassil and Kaffka, 2002; Khalili *et al.,* 2014; Emongor *et al.,* 2015). It is the most drought tolerant oilseed crop and can produce good seed yield in semi-arid regions, while its salt tolerance is a valuable asset as the area affected by some degree of salinity increases world-wide (Weiss, 2000). The safflower crop also tolerates a wide range of temperatures from -7 to 40°C, provided there is no frost during the elongation and flowering phases of growth and development (Mündel *et al.,* 1992; Emongor; 2010; Emongor *et al.,* 2013). Alive and non-alive stresses are the factors limiting crop production, however, drought stress is the most important in agricultural systems in arid and semi-arid regions (Mollasadeghi *et al.,* 2011). Drought adversely affects the already fragile food and agricultural situation in the arid and semi-arid regions and seriously impairs the rural economy and socio-cultural structures. Due to the erratic, unreliable, and poorly distributed rainfall, plus high temperatures, water becomes the most limiting factor to agricultural production in arid and semi-arid countries (Emongor, 2009). In the arid and semi-arid regions loss of yield is the main the concern of crop scientists. Therefore, growing a multipurpose, drought, saline and temperature tolerant crop such as safflower could mitigate the effects of climate change in a semi-arid country such as Botswana. The objective of this study was to evaluate the adaptability of safflower genotypes to the semi-arid conditions of Botswana.

**Study description**

Two field experiments were conducted at the Botswana University of Agriculture and Natural Resources Content Farm, situated at Notwane, Sebele (240 35' S: 250 58' E) at an altitude of 998 m above sea level. The experimental site has an average maximum and minimum temperature varying between 33.1– 34.7 $^0$C and 19.2 – 19.5 $^0$C, respectively in summer. However, during the coldest months April and September the average maximum and minimum temperatures ranges between 26 -34$^0$C and 7-16$^0$C, respectively. The soils are deep sandy loam. The rainfall amount varies between 250 - 600 mm per annum.

The experimental design was a randomized complete block design with three replications. The experiment was blocked because the land where the experiment was done had a slope of about 1%. The treatments were nine safflower genotypes Kiama Composite (control-local cultivar), PI-537632-1038-USA, PI-30441-BJ-2621-IRAN, PI-537598-SINA-USA, PI-407616-BJ-2131-TURKEY, PI-537634-1040-USA, PI-537668-BJ-1085-USA, PI-314650-MILUTIN-114-KAZAKISTAN and PI-306830-BJ-1632-INDIA. The treatments were randomized within the experimental blocks. Safflower seeds were planted in single rows at a spacing of 45 cm between rows and 25 cm within rows and at depth of 6 mm. The experimental units measured 5 m x 5 m. The dependent variables determined were days to emergence, days in the rosette phase, leaf morphology, flower colour, plant height, leaf area, leaf length, leaf blade diameter, leaf chlorophyll a and b contents, total leaf chlorophyll content, percent establishment, number of branches per plant, days to flowering, number of capitula per plant, capitula diameter, number of seed per capitula, 100-seed weight, seed yield, oil content and oil yield. The data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS, 2015) programme. Where a significant F- test was observed, treatment means were separated using the fisher's protected Least Significant Difference (LSD) test at $p < 0.05$.

**Results and discussion**

The results of the study showed that safflower genotypes differed significantly ($p < 0.05$) in their agro-morphological traits, growth habit, maturity date, seed yield and yield components, oil content and oil yield. The vegetative growth variables varied significantly with safflower genotype (Table 1). The seed yield, oil yield and oil content also varied significantly ($p<0.05$) between 888-3113 kg/ha, 226-1313 kg/ha and 26-42%, respectively, depending on genotype (Table 1). The safflower genotype PI-537598-SINA-USA out performed all the other genotypes including the local cultivar Kiama Composite. The differences in seed yield could be explained by the differences among genotypes in leaf area, branch number/plant, capitula number/plant, capitula head size and seed number/capitula. Samanci and Ozkaynak (2003), Camas *et al.* (2007) and Hamza (2015) reported significant differences in safflower seed yield and oil content due to different genotypes. There was positive and significant correlations between oil content and seed yield and oil yield, respectively (Table 2). There were also positive and significant relationships between seed yield and oil content and oil yield, respectively (Table 2). However, the relationship between plant height and seed yield was negative (Table 2). El-Lattief (2012) reported positive and significant relationships between seed oil content of safflower with seed yield and oil yield.

Table 1. Effect of genotype on growth, yield and yield components, oil content and oil yield of safflower

| Genotype | Plant height (cm) | Leaf area ($cm^2$) | Branch number/ plant | Seed number/ capitula | Seed yield (kg/ha) | Oil content (%) | Oil yield (kg/ha) |
|---|---|---|---|---|---|---|---|
| Kiama Composite | $129.6^a$ | $57.24^b$ | $12.0^b$ | $28.0^b$ | $913^c$ | $33.27^b$ | $302^d$ |
| PI-537632-1038-USA | $98.4^b$ | $62.42^b$ | $17.0^a$ | $28.7^b$ | $1693^b$ | $40.97^a$ | $692^b$ |
| PI-30441-BJ-2621-IRAN | $123.7^a$ | $64.47^b$ | $10.3^b$ | $29.3^b$ | $900^c$ | $26.13^c$ | $226^d$ |
| PI-537598-SINA-USA | $98.7^b$ | $74.20^a$ | $17.0^a$ | $37.5^a$ | $3113^a$ | $42.17^a$ | $1313^a$ |
| PI-407616-BJ-2131-TURKEY | $111.0^a$ | $61.41^b$ | $13.3^b$ | $34.1^a$ | $888^c$ | $26.40^c$ | $236^d$ |
| PI-537634-1040-USA | $94.2^b$ | $70.09^b$ | $20.7^a$ | $42.7^a$ | $1062^c$ | $33.17^b$ | $357^{bc}$ |
| PI-537668-BJ-1085-USA | $87.7^b$ | $59.82^b$ | $19.3^a$ | $43.7^a$ | $926^c$ | $34.93^b$ | $326^d$ |
| PI-314650 -MILUTIN-114 -KAZAKISTAN | $102.5^b$ | $91.29^a$ | $15.3^a$ | $38.1^a$ | $1691^b$ | $36.50^b$ | $550^{bc}$ |
| PI-306830-BJ-1632-INDIA | $83.9^b$ | $38.03^c$ | $20.0^a$ | $37.1^a$ | $1889^b$ | $32.00^b$ | $605^b$ |
| Significance | ** | ** | ** | * | **** | **** | **** |
| LSD | 25.6 | 19.58 | 6.11 | 10.24 | 598 | 4.97 | 200 |

*, **, **** Significant at p = 0.05, 0.01, 0.0001. Means within columns were separated using the Least Significant Difference at p = 0.05.

Table 2. Regression equations and relative contribution ($R^2$) for response of dependent variables(Y) for independent variables (X) of safflower genotypes.

| Independent variables (X) | Dependent variables (Y) | Regression equation | R2 |
|---|---|---|---|
| Oil content | Seed yield | Y = 79.148X-1234.3 | 0.3747* |
| Oil content | Oil yield | Y = 42.355X-926.04 | 0.5325** |
| Seed yield | Oil content | Y = 0.0047X+27.072 | 0.3747* |
| Seed yield | Oil yield | Y = 0.4361X-121.63 | 0.9439*** |
| Plant height | Seed yield | Y = -18.541X+3368.1 | 0.1494NS |

*, **, ***, NS significant at p = 0.05, 0.01, 0.001 or not-significant, respectively.

## Conclusion

The safflower genotype PI537598-SINA-USA out performed all the other safflower genotypes including the local cultivar Kiama Composite in most of the variables investigated. There is a positive linear response of safflower oil yield as the seed yield increased. This results suggest that safflower has a big potential as an oilseed crop in semi-arid Botswana.

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