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Research Application Summary

Evaluation of nutritional quality of safflower for use as animal feed

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Abstract

Safflower (*Carthamus tinctorius* L.) is an annual oil seed crop adapted to arid and saline regions of the world. It is potentially a novel food and medicine source, which has not been fully explored in the last century. Safflower's ability to forage for sub-soil moisture with its vigorous tap root, tolerance to salinity, adaptability to a wide range of temperatures, improved oil content and its versatility to produce oil high in linoleic and oleic fatty acids makes it a viable alternative to current crops grown in the more marginal cropping areas around the world. This study was carried out to determine the nutritional quality of the safflower forage, seed and cake as an animal feed. Nine safflower genotypes were evaluated from September to December 2014 and January to April 2015 in a completely randomized block design with three replications in the Botswana University of Agriculture and Natural Resources, Notwane Farm under sandy loam soils. Results of the study showed that safflower genotypes significantly ($p < 0.05$) differed in their oil content, seed, leaf and cake after oil extraction, neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and ash. The seed oil content significantly ($p < 0.05$) differed and varied between 26-42%. The leaf NDF, ADF, ADL and ash varied between 20.5-26.2%, 26.5-32.7%, 6.7-10.7% and 0.89-1.08%, respectively depending on genotype. Seed NDF, ADF, ADL and ash were also significantly ($p< 0.05$) affected by genetype and varied between 43.3-50.3%, 42.8-48%, 15.3-20.7% and 0.95-1.41%, respectively. This research showed that safflower has a big potential as an oilseed crop and source of animal feed in semi-arid Botswana.

Key words: Animal feed, ash, *Carthamus tinctorius*, nutritional potential, oil content

Résumé

Le carthrame (*Carthamus tinctorius* L.) est une culture annuelle de graines oléagineuses adaptée aux régions arides et salines du monde. C'est une nouvelle source potentielle de nourriture et de médicaments, qui n'a pas été entièrement explorée au cours du siècle dernier. La capacité du carthrame à produire de fourrage en condition de l'humidité du sous-sol avec sa racine pivotante vigoureuse, sa tolérance à la salinité, son adaptabilité à une large gamme de températures, sa teneur en huile améliorée et sa polyvalence pour produire de l'huile riche en acides gras linoléiques et oléiques fait de lui une alternative durable aux cultures présentement cultivées dans les zones culturales les plus marginales du monde. Cette étude a été réalisée pour déterminer la qualité nutritionnelle du fourrage de carthame, des graines et des tourteaux de cathrame en tant que aliments pour animaux.

Neuf génotypes de carthame ont été évalués de septembre à décembre 2014 et de janvier à avril 2015 dans un dispositif de blocs aléatoire complets avec trois répétitions à l'Université d'Agriculture et des Ressources Naturelles du Botswana, dans la ferme de Notwane, sur des sols limono-sableux. Les résultats de l'étude ont montré que les génotypes de carthame diffèrent significativement ($p < 0,05$) de part leurs teneur en huile, leurs graines, leurs feuilles ; leurs tourteaux après l'extraction de l'huile, leurs fibres détergentes neutre (FDN), leurs fibres détergente acide (FDA), leurs lignine détergente acide (LDA) et les cendres. La teneur en huile des graines sont significativement ($p < 0,05$) différent et ont varié entre 26 et 42%. FDN, FDA, LDA et les cendres issues des feuilles ont varié respectivement entre 20,5-26,2%, 26,5-32,7%, 6,7-10,7% et 0,89-1,08% ; et ceci en fonction du génotype. NDF, ADF, ADL et les cendres issus des graines ont également été significativement ($p < 0,05$) ont varié en fonction du génotype considéré, respectivement entre 43,3-50,3%, 42,8-48%, 15,3-20,7% et 0,95-1,41%. Cette recherche a montré que le carthame a un grand potentiel en tant que culture oléagineuse et source d'aliments pour les animaux dans la zone semi-aride du Botswana.

Mots clés: Aliments pour animaux, cendres, *Carthamus tinctorius*, potentiel nutritionnel, teneur en huile

Background

Safflower (*Carthamus tinctorius* L.) is more drought tolerant than other oilseed crops and can produce good yields in semi-arid and arid regions of the world (Weiss, 2000). Safflower's salt tolerance is a valuable trait as the areas affected by salinity increases world-wide (Weiss, 2000). Traditionally, safflower was grown for its seeds, for colouring and flavouring foods, as medicines and for making red and yellow dyes, especially before cheaper aniline dyes became available (Weiss, 2000). Safflower oil has been produced commercially and for export for about 50 years, first as an oil source for the paint industry, now for its edible oil for cooking, margarine and salad oil (Dajue and Mündel, 1996; Weiss, 2000; Emongor, 2010; Aghamohammadreza *et al.,* 2013).

Safflower is one of humanity's oldest crops, with its use in China reported over 2,200 years ago. Safflower seeds are reported in Egyptian tombs over 4,000 years ago. However, safflower cultivation remained a backyard crop for personal use and as a result it remained minor and neglected. World seed production of safflower in 1989 was estimated at 908,000 tons (Rowland, 1993; Gyulai, 1996). However interest in cultivation of safflower has increased because of increased demand for vegetable oil for biodiesel and edible oil (Mailer *et al.,* 2008). Interest in cultivating safflower as source of edible oil has further been stimulated since establishment of safflower oil as a rich source of polyunsaturated essential fatty acid linoleic acid (70-87%) and monounsaturated fatty acid oleic acid (11-80%) (Murthy and Anjani, 2008; Aghamohammadreza *et al.,* 2013). Linoleic acid has been shown to offer nutritional and therapeutic benefits such as prevention of coronary heart disease, arteriosclerosis, high blood pressure and hyper lipaemia (Wang and Li, 1985; Cosge *et al.,* 2007). Safflower can also be used as animal fodder or meal

(Landau *et al.,* 2004). Grazed safflower has been shown to satisfactory sustain growth rates in Australian steers (French *et al.,* 1999). Safflower fodder has been reported to improve fertility in Canadian ewes, in comparison to alfalfa-grass hay (Stanford *et al.,* 2001). Safflower hay, given *ad libitum,* has successfully been used as the only food for late-pregnant dairy cows (Landau *et al.,* 2004). Safflower meal can either be dehulled or hulled. The quality of the safflower meal is variable and depends on the amount of hulls and the extent of the oil extraction (Jacob, 2015). The objective of this study was to evaluate the nutritional potential of safflower forage, seed and cake to be used as animal feed with the aim of mitigating the effects of drought and climate change, improve food security, increase income and social welfare of farmers, and to reduce reliance on food importation in Botswana.

Study description

Two field experiments were conducted at the Botswana University of Agriculture and Natural Resources Content Farm, situated at Notwane, Sebele, (24^0 35’ S: 25^0 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. Rainfall amount varies between 250 - 600 mm per annum.

The experiment was designed as a randomized complete block with three replications. The treatments were nine safflower genotypes, i.e., Kiama Composite, 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-KAZAKSTAN and PI-306830-BJ-1632-INDIA. 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 water and dry matter contents, seed oil content, NDF, ADF, ADL and ash of leaves, whole seed and cake after oil extraction. The dependent variables were determined using standard procedures. Data collected were subjected to analysis of variance (ANOVA) using statistical analysis system (SAS) programme. Where a significant F- test was observed, treatment means were separated using the Least Significant Difference (LSD) at $P \leq 0.05$.

Results and discussion

The ADF value refers to the cell wall portions of the forage that are made up of cellulose and lignin. These values are important because they relate to the ability of an animal to digest the forage. As ADF increases the ability to digest or the digestibility of the forage decreases. On the other hand the NDF value is the total cell wall which is comprised of the ADF fraction plus hemicellulose. The NDF values are important because they reflect the amount of forage the animal can consume. As NDF percent increases, the dry matter intake generally decreases (Van Soest *et al.,* 1991). The results of the study showed that safflower genotypes significantly ($P \leq 0.05$) differed in seed oil content, and leaf and seed NDF, ADF, ADL and ash contents (Table 1, 2). The seed oil content significantly ($P \leq 0.05$) varied between 26.13-42.17%, depending on genotype (Table 1). The seed NDF, ADF, ADL and ash significantly ($P \leq 0.05$) varied between 43.3-50.3%, 42.8-48%, 15.3-20.7% and 0.95-1.41%, respectively (Table 1). The leaf NDF, ADF, ADL and ash varied between 20.5-26.2%, 26.5-32.7%, 6.7-10.7% and 0.89-1.08%, respectively, depending on genotype (Table 2). Range (2004) reported dry matter of 92.8, ash 9.9%, crude protein 22.0%, 49.5% NDF, and 36% ADL in safflower forage, while Dixon *et al.* (2003) reported 63.4% of NDF, 44.5% ADF and 15.5% of lignin in safflower forage, futher showing the high variability in this crop.

Table 1. Effect of genotype on seed oil content and seed NDF, ADF, ADL and ash of safflower

Genotye	Oil content (%)	NDF (%)	ADF (%)	ADL (%)	Ash (%)
Kiama Composite	33.27	49.0	48.0	19.5	1.00
PI-537632-1038-USA	40.97	48.0	46.0	14.0	1.23
PI-30441-BJ-2621-IRAN	26.13	46.0	47.3	19.3	1.28
PI-537598-SINA-USA	42.17	47.7	44.5	19.6	1.10
PI-407616-BJ-2131-TURKEY	26.40	47.3	44.3	17.5	1.13
PI-537634-1040-USA	33.17	43.3	47.3	18.7	1.41
PI-537668-BJ-1085-USA	34.93	50.3	46.7	20.7	0.95
PI-314650-MILUTIN-114-KAZAKISTAN	36.50	49.3	42.8	17.4	0.95
PI-306830-BJ - 1632-INDIA	32.00	48.7	43.3	15.3	1.05
Significance	****	**	*	***	*
LSD 0.05	4.97	3.23	4.04	2.82	0.35

*, **, **** 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. Effect of genotype on leaf NDF, ADF, ADL and ash of safflower

Genotye	NDF (%)	ADF (%)	ADL (%)	Ash (%)
Kiama Composite	25.8	30.5	9.6	0.94
PI-537632-1038-USA	23.3	29.8	7.3	1.08
PI-30441-BJ-2621-IRAN	23.3	27.8	7.9	0.86
PI-537598-SINA-USA	21.8	26.5	6.7	0.83
PI-407616-BJ-2131-TURKEY	20.5	30.0	10.7	1.07
PI-537634-1040-USA	25.2	32.0	9.9	0.92
PI-537668-BJ-1085-USA	23.9	31.8	8.6	0.89
PI-314650-MILUTIN-114-KAZAKISTAN	26.2	32.7	7.3	0.89
PI-306830-BJ- 1632-INDIA	24.0	30.2	8.1	0.98
Significance	*	*	*	*
LSD 0.05	4.51	5.56	2.29	0.15

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

Conclusion

According to the results, there were significant genotype effects ($p \leq 0.05$) on seed oil content, seed and leaf NDF, ADF, ADL and ash. Based on the low NDF, ADF, ADL and moderate ash content values, safflower has a big potential as an oilseed crop and source of animal feed in semi-arid Botswana.

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