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Research Application Summary

The influence of nitrogen and phosphorus fertilisation on seed yield and oil content of safflower in southern Botswana

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Abstract

Safflower (*Carthamus tinctorius* L.) is a versatile crop used as edible oil, vegetable, livestock feed, biofuels, textile, and medicinal purposes. Soil fertility is one of the factors that limit crop production in Botswana. The objective of this study was to determine the influence of nitrogen (N) and phosphorus (P) on the seed yield and oil content of safflower. The experiment was a split-plot laid in randomized complete blocks with three replications. The treatments were N application at 0,40,80 and 120 kg/ha allocated to main-plots and P application at 0, 25, 50 and 50 kg/ha allocated to sub-plots. Nitrogen was supplied as calcium ammonium nitrate (28% N) and phosphorus as single super phosphate (8.3 % P as P_2O_5). The results revealed that nitrogen and phosphorus interactions at 40 kg N/ha + 25 kg P/ha and 40 kg N/ha + 50 kg P/ha significantly ($P < 0.0001$) increased the seed number per capitulum and seed yield of safflower, respectively. There was no significant interaction of N and P on seed oil content, but application of N and P independently significantly ($P < 0.05$) increased safflower seed oil content, with maximum oil content of 46.4 and 46.1% obtained through application of 120 and 25 kg/ha of N and P, respectively.

Key words: Botswana, *Carthamus tinctorius* L, nitrogen, phosphorus, soil fertility

Résumé

Le carthame (*Carthamus tinctorius* L.) est une culture polyvalente utilisée comme huile comestible, légume, aliment du bétail, biocarburant, textile et à des fins médicinales. La fertilité du sol est l'un des facteurs qui limitent la production végétale au Botswana. Cette étude a été conduite afin de déterminer l'influence de l'azote (N) et du phosphore (P) sur le rendement en graines et la teneur en huile du carthame. L'expérience était un split-plot disposé en blocs complets randomisés avec trois réplications. Les traitements étaient l'application de N à 0, 40, 80 et 120 kg/ha sur les parcelles principales et l'application de P à 0, 25, 50 et 50 kg/ha sur les parcelles secondaires. L'azote a été fourni sous forme de nitrate d'ammonium de calcium (28 % N) et le phosphore sous forme de superphosphate simple (8,3 % P sous forme de P2O5). Les résultats ont révélé que les interactions entre l'azote et le phosphore à 40 kg N/ha + 25 kg P/ha et 40 kg N/ha + 50 kg P/ha ont augmenté de manière significative ($P < 0,0001$) le nombre de graines par capitule et le rendement en graines du carthame, respectivement. Il n'y a pas eu d'effet significatif de l'interaction entre N et P sur la teneur en huile des graines, mais l'application de N et de P indépendamment a augmenté significativement ($P < 0,05$) la teneur en huile des graines de carthame, avec une teneur maximale en huile de 46,4 et 46,1% obtenue par l'application de 120 et 25 kg/ha de N et P,

respectivement.

Mots clés : Botswana, *Carthamus tinctorius* L, azote, phosphore, fertilité du sol

Introduction

Safflower (*Carthamus tinctorius* L.) is an annual oilseed that is a member of the Asteraceae family. It can grow in semi-arid environments. It is drought tolerant due to its extensive root system that reach depths of 2-3 m enabling it to extract water at depths most cereals and other oil crops cannot (Berglund *et al*., 2007; Emongor, 2010). It has shown potential utility in medical, pharmaceutical, food, animal feed, and cosmetic applications worldwide (Emongor, 2010). Safflower, like every other crop requires mineral nutrition for optimal growth. Nitrogen (N) and phosphorus (P) have been reported to be essential for safflower growth (Golzarfar *et al*., 2016). Soils in Botswana are deficient in N and P, therefore limiting crop productivity (Emongor and Mabe, 2012). Safflower development requires the proper application of fertilizers. Nitrogen fertilization significantly increased safflower yields (Golzarfar *et al*., 2016). However, fertilizer N recovery is frequently as low as 50%. Golzarfar *et al*. (2012) reported that P treatment to safflower plants influenced seed yield formation. The objective of this study was to evaluate the influence of nitrogen and phosphorus application rates on the growth and development of safflower in southern Botswana.

Materials and Methods

The study was conducted in a farmer's field around the Molepolole area. The genotype Sina was planted. The experimental design was a split-plot laid in randomized complete blocks replicated three time. The treatments were N at 0, 40, 80, and 120 kg/ha allocated to main plots; and P at 0, 25, 50, and 75 kg/ha allocated to sub-plots. Two weeks following emergence, P was applied as single superphosphate fertilizer (8.3% P as P_2O_5). Nitrogen was applied as calcium ammonium nitrate (28% N) in two splits. The first and second N splits (half of the trial rate) was applied two weeks after emergence and at the balling stage, respectively. The seed number per capitulum, seed yield and seed oil content were determined. 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) was used to separate treatment means at $P = 0.05$.

Results and Discussion

The interaction of N and P significantly ($P < 0.0001$) increased seed number per capitulum of safflower (Figure 1). In comparison to other combinations, a 40 kg N/ha + 25 kg P/ha application rate resulted in the highest seed number per capitulum. Interactions beyond 40 kg N/ha resulted in a significant ($P < 0.0001$) decrease in number of seeds per capitulum (Figure 1). Nitrogen and P application significantly ($P < 0.0001$) interacted to increase safflower seed yield (Figure 2). However, application of a combination of 40 kg N/ha + 50 kg P/ha resulted in the highest seed yield of 339.10 kg/ha. The increase in safflower seed yield was attributed to high seed number per capitulum. However, the seed yield in all treatments was low compared to what is reported in literature (Golzarfar *et al*., 2012) because of heavy rainfall that occurred in Botswana during the

experimental period which caused waterlogging. Safflower is a desert plant which is susceptible to waterlogging (Emongor, 2010). Prolonged rainfall during flowering interferes with pollination and seed set resulting in significant seed yield reduction (Mündel *et al*., 1992).

There was no significant interaction of N and P on safflower oil content. However, N and P independently significantly ($P < 0.05$) influenced the oil content. Increasing N application significantly ($P < 0.05$) increased safflower seed oil content with application of 120 kg N/ha producing the highest oil content of 46.4% (Figure 3). Application of P at 25 kg/ha significantly ($P < 0.05$) increased safflower seed oil content (46.1%) compared to control plant and plants applied with 50 and 75 kg P/ha (Figure 4). Nitrogen and P play an important role in oil formation (Salisbury and Ross, 1992; Malik *et al*., 2004). Phosphorus is a component of glycerol required in the conversion of acetate into fatty acids (Salisbury and Ross,1992).

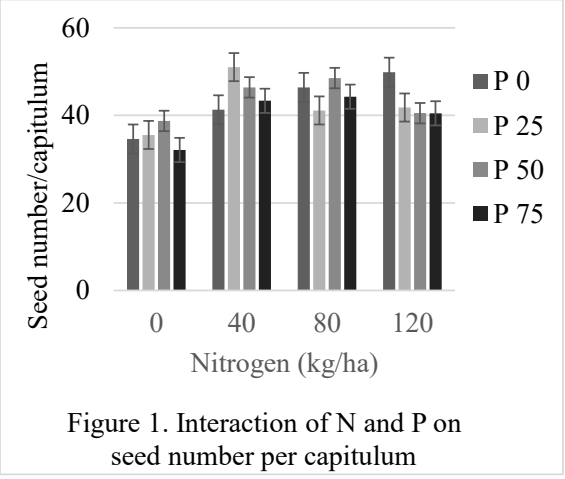

Figure 1. Interaction of N and P on seed number per capitulum

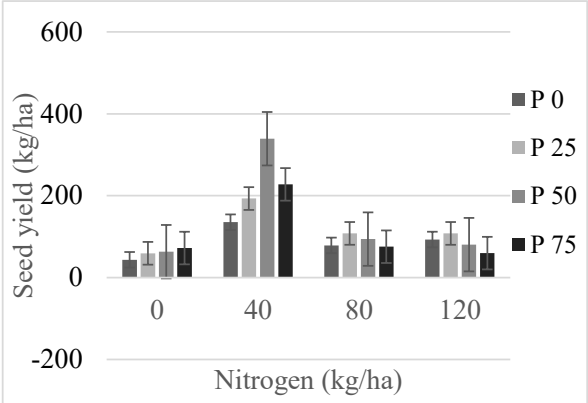

Figure 2. Interaction of N and P on seed yield

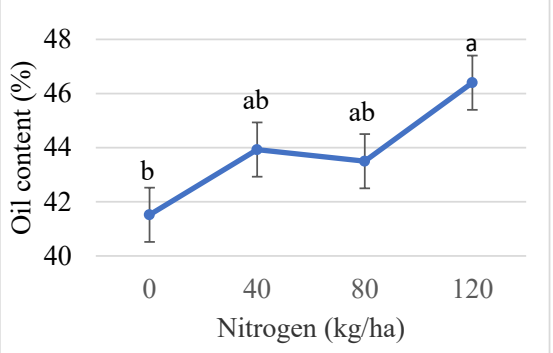

Figure 3. Effect of N on seed oil content

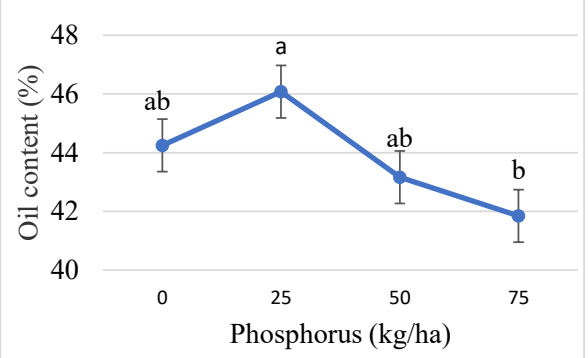

Figure 4. Effect of P on seed oil content

Conclusions and recommendations

Nitrogen and phosphorus applications increased safflower seed number per capitulum, seed yield and seed oil content. Application of 40 kg N/ha + 25 kg P/ha or 40 kg N/ha + 50 kg P/ha increased the number of seeds/capitulum and seed yield, respectively. However, independent applications

of N and P 120 and 25 kg/ha, respectively, resulted in the highest oil content. It was recommended that the trial be repeated during the dry season to get conclusive results.

Acknowledgements

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