Cactus Pears

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Cactus pears are nutritious, drought-tolerant plants that flourish in hot and arid regions. All its plant parts can be consumed by humans and animals. Fruit seed oil production is an important emerging industry in South Africa. As part of an initiative to promote cactus pears as multi-functional crops, dual-purpose cultivars should be identified, and their production increased.

Keywords: cactus pear ; fatty acids ; fertilization ; nitrogen ; oil content

1. Introduction

Spineless Burbank *Opuntia ficus-indica* is one of the most popular cactus pear species that grow in the arid and semi-arid regions of South Africa and is a noteworthy food source for humans and animals in these regions [1][2][3]. Fruit pulp processing of cactus pear leads to the discarding of the peels and seed as waste. New sources of oil and meal have been produced from these waste products [4][5]. Cactus pear fruits are valued for their distinctive flavour and aroma in addition to the nutritional properties of the oil in their seed. The Morado cultivar is one of the most popular cultivars in South Africa in relation to both human and animal consumption and food processing [6]. The existing varieties in South Africa are from the Burbank (spineless) varieties which were initially imported in 1914 for forage [3]. The annual production volume of cactus pear fruits in South Africa is 20–25 t ha^{-1}, under normal dry land conditions [2][3][6].

The cactus pear fruit is very nutritious, not only because of the high polyunsaturated fatty acid (82%) content in its seed oil, but the fruit has also been found to have antioxidant properties [7][8][9], because of the presence of betalains, ascorbic acid and carotenoids [10]. There is great variation in the number of seed, ranging from 120 to 350 per fruit [11]. The hard-coated seed, from which the oil is extracted, make up 5–10% of the fruit weight [12]. The oil makes up approximately 17% of the seed mass [13]. The oil is characterized as a low oil content seed oil, and is principally composed of unsaturated fatty acids, linoleic (61–69%) and oleic acid (12–16%) and is also composed of saturated fatty acids (18%), stearic (11–16%) and palmitic acid (3–4%), which occur at much lower amounts [14][15][16][17][18][19]. The human body is naturally unable to manufacture essential fatty acids such as the omega-3 and omega-6 fatty acids, therefore these fatty acids should be included in the diet. Oils are the main source of these very important fatty acids [20]. Cactus pear seed oil has a high level of unsaturation that makes it a potential health oil that must be further explored [14]. Its physical and chemical characteristics show similarities to other fruit/vegetable oils such as grape seed oil (linoleic acid: 68–78%; palmitic acid: 5–11%; stearic acid: 3–6%) and rape seed oil (linoleic acid: 61%; palmitic acid: 4%; stearic acid: 2%) [14][15][19]. Fatty acids such as palmitoleic acid and arachidic acid have been observed in much fewer quantities in cactus pear seed oil [21]. Other compounds found in this precious oil include β-sitosterol and γ-tocopherol [7].

Because of its high unsaturation, oxidation reactions are prone to have a negative effect on the cactus pear seed oil quality and measures should be implemented to prevent this occurrence [22]. For successful production of cactus pear fruit, management agricultural practices such as pest, disease, and weed control; pruning, thinning, irrigation, and organic/mineral nutrition are needed [23][24].

2. The Effect of Nitrogen Fertilization on the Yield, Quality and Fatty Acid Composition of *Opuntia ficus-indica* Seed Oil

Nitrogen (N) is an important nutrient for vegetative growth, development and reproduction. N is so important because it is the main component of chlorophyll, a compound that converts light energy into chemical energy in the process of photosynthesis. N is also a vital component of amino acids, the building blocks of proteins (structural and enzymatic), energy transfer compounds such as ATP (adenosine triphosphate), and nucleic acids such as DNA (deoxyribonucleic acid). Most plants get most of the N from the soil in the form of nitrate (NO_3^-) or ammonium (NH_4^+). However, the supply is limited, and plants must compete with various soil microorganisms for available N. In addition, the crops harvested each year remove a large amount of N [25]. N is the most limited nutrient in cacti, with the highest N values found in young and fertile cladodes [26]. In productive agriculture, the use of N fertilizers overcomes the N limit imposed by the environment [25].

Organic and inorganic fertilizer research has mostly centered the attention around the influence it has on fruit yield and quality [27][28], as well as off-season fruit yield [29][30][31][32][33][34]. A number of reports have shown no effects of soil applications of NPK (nitrogen, phosphorous and potassium) either on fruit yield or quality features of cactus pears at time of gathering of crops [27][35]. Fruit sugar concentration has been found to be the only exception, where higher sugar concentrations in fruit from NPK-fertilized plants have been found than from the fruit that have not undergone NPK-fertilization. It was found that cladode magnesium concentration had a significant influence on fruit sugar concentration [36]. The fertilizer effects on fruit postharvest life have not received much attention.

From this observation, Zegbe et al. [34] studied the effect of soil applied NPK on fruit quality attributes after three or four weeks of storage at room conditions for ‘Cristalina’ cactus pear, native to Mexico. The study was done over a period of three years. Fruit quality attributes evaluated after storage were flesh firmness (FF), total soluble solid concentration (TSSC) and dry matter concentration of pulp (DMCP). FF produced similar results in all treatments for all three years. The TSSC and DMCP had the same values between the different treatments. Lower TSSC and DMCP values were observed when higher quantities of N were applied. It was concluded that NPK fertilizer treatments produced incompatible results; thus, more research is required in order to address the effect of the fertilizer on the fruit quality of cactus pear.

Crops use N from the soil as nitrate (NO_3^-) or ammonium (NH_4^+), but most crops prefer a combination of the two forms. Limestone ammonium nitrate (LAN) contains 28% N, ammonium sulfate (AmSul) contains 21% N, and urea contains 46% N. The N in LAN and AmSul is readily available to the plant for uptake, although not necessarily at the ideal nitrate-N:ammonium-N ratio. Urea differs from other N sources in that it must be converted to NH_4^+ by urease. This process is called hydrolysis. The NH_4^+ produced by this process then undergoes a nitrification process to produce NO_3^-. The nitrate-N:ammonium-N ratio of LAN is 50/50, which is close to the preferred ratio for most crops. LAN is suitable for band placement and broadcasting applications due to its very low toxicity and low volatile effects. AmSul is a low-cost fertilizer most commonly used for alkaline soils. When introduced into moist soil, NH_4^+ ions are released. This produces a small amount of acid, which reduces the pH balance of the soil [37]. Urea is commonly used in solid and liquid fertilizers and has the characteristics of relatively easy handling and storage, making it the most important solid N fertilizer material in the world [38]. The current fertilizer recommendation available in South Africa is for fruit production of cactus pear. The N recommended is 60 and 90 kg N ha^{-1} for 2- and 3-year-old trees respectively. It is also recommended to apply between 13 and 16 kg ha^{-1} phosphorus (P) and 60 and 80 kg ha^{-1} potassium (K) to 2- and 3-year-old trees, respectively [39].

3. Conclusions

N fertilisation has an effect on the yield and fatty acid composition of cactus pear seed oil. Oil content significantly increased with increased N fertilization levels. The main fatty acids composition was also significantly influenced by both N source and N level, while the highest content fatty acid, linoleic acid, however, was not significantly influenced. It can therefore be concluded that N fertilization promoted an increased oil and SFA content but was detrimental to the linoleic acid content. A high moisture content did not result in a low oil content in these results. The FFDM is the only factor that decreased in content.

Although N fertilization is mostly aimed to increase the N content in cladodes, the increased seed oil content of the seed is noteworthy. This increased oil yield will benefit and add value to producers of cactus pears in arid and semi-arid conditions.

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