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Original Research Article

True potatoes seeds (TPS) as an alternative method for potato production in Namibia

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ABSTRACT

Potato plays a great role in the human diet all over the world for the achievement of food security programs due to its popularity and ability to adapt to different environmental conditions as well as its yielding capacity. Production of potatoes in Namibia however is far less than in other countries due to constraints such as the unavailability of growing materials in the form of true potato seeds (TPS) or seed tubers. This situation is not only denying the opportunity for local farmers to produce potato crops but also limiting the opportunity for Agrobusiness and crop diversification in the country. Without a formal potato seed system, farmers will continue making use of varieties of unknown origin as no improved varieties are available to the majority of the farmers. Lack of awareness about the use of improved technology and practices has also impeded the adoption of potato technologies in Namibia. This review is aimed at summarizing challenges and constraints to potato Production and value chain in Namibia, and to provide baseline information on the potato for current and aspiring producers in Namibia or similar agro-ecologies in Sub-Saharan Africa (SSA).

1. Introduction

The Irish potato *Solanum tuberosum L.)* is the world's fourth largest food crop after wheat, rice, and maize. It is regarded as an important source of food, employment, and income generation in developing countries (FAO, 2008). The tubers are high in carbohydrates, protein, and vitamins, especially vitamin C 2008). It is reported that global calories supply depends only on twelve (12) domesticated plant species, eight of which are cereals (barley, maize, millet, rice, rye, sorghum, sugar cane, and wheat) while four are in the tubers category (cassava, potato, sweet potato & yarn) (Robiansyah et al., 2014).

Potato world production stood at 381 million tons (Mt) produced annually (Zhang et al., 2017). Cultivation of Solanaceae potato is reported to have originated in the Andes of northern Bolivia and southern Peru and may date back 7 000 to 8 000 years ago et al., 2004). China is reported to be the largest potato producer worldwide in terms of either volume or area where it once served as the "lifesaving potato" and through its contribution to the reproduction and prosperity of the Chinese nation (Zhang et al., 2017). According to Allemann et al. the crop was introduced into Europe between 1570 and 1590, and from there spread to North America and later to the rest of the world. According to Zhang et al. (2017), Potato grows well in high-altitude areas with extremely cold climates. Potato crop production is widely based on the use of tubers as an asexual reproduction method or tuber pieces with eyes (nodes) from which plants emerge pers and Jansky, 2019; Jansky et al., 2016). Subsistence and smallholder farmers in dry countries like Namibia depend mainly on four staple food crops which are pearl millet, sorghum, cowpea, and maize (Mbashu and Nantanga, 2019, McDonagh and Hillyer, 2003). Potato farmers in Namibia use potato tubers (ware) which originates from neighboring South Africa for seeds.

The use of potato tubers as seeds is regarded as an easy way of potato propagation by some people however, this practice is also accompanied by many disadvantages (Khandaker et 2011). Potato tubers are meant for food and not for propagation purposes, therefore using it for propagating materials is not only wastage of food that could feed the population or enter into the market, but also posing danger to the soil as they could contain soil-

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borne pathogen carriers mel‹inders et al., 2009; Muthoni et al., 2013). Damaged seed tuber which are often of poor quality could also lead to seed degeneration and hence low yields (M uthoni et al., 2013). As a result, the Ministry of Agriculture, Water and Land Reform in Namibia has put strict measures against potato tuber seeds importation, to curb the transmission of cross boarder crop diseases as stipulated under Section 11of the Agricultural Pest Act 1973 (Act 3 of 1973).

Therefore, this paper aims to explore possibility and alternative ways to potato production in Namibia and to provide information on the crop production in other countries. In light of the above background, the objective of this review is to summarize challenges and constraints to potato Production and value chain in Namibia. To provide baseline information on potato for current and aspiring agronomists and producers in Namibia or similar agro-ecologies in Sub-Saharan Africa (SSA). The information on potato production and consumption is crucial to the agricultural sector and to the local farmers who may wish to venture into potato production.

2. Importance of potato as a food crop

Potato is the fourth most important food crop in the world after wheat, rice, and maize due to its great yield production and high nutritive value (Geohive, 2013). In addition, the potato crop is one of the economic important crops across the globe with successful large-scale production, high consumption, and affordability with easy availability in the open market (Zaheer and Akhtar, 2016). Furthermore, potatoes are very important to the human diet because it provides basic nutrients such as carbohydrates, dietary fiber, several vitamins, and minerals such as potassium, magnesium, iron (Za heer and Akht ar, 2016; Zhang et al., 2017). Potato are made up of high nutritional value, with abundant in carbohyd rate, protein, and contains various minerals, vitamins and dietary fiber (Chung et al. 2016). P articularly, it is rich in vitamin B and vitamin C which are not sufficient in cereals. Potato grows easy in most soils and thus can adapt tobe grown almost everywhere as an affordable source of food.

According to Za heer and Akhtar 16), potatoes was reported to have saved many families from hunger especially in Europe and China during the famines in the early 1770s. Haverkort and Struik reported that most of the potato crop was only grown in the developed world until 50 years ago and not much was happening in developing countries. However, developing countries nowadays produce more potatoes than developed countries (Devaux et al., 2021, Haverkort and Str uik, 2015). Therefore potato plays an important role in human health through consumption, while in China, potato consumption was associated with lowering risk of type 2 diabetes in the Shanghai women's (Zhang et al., 2017).

3. Status of Potato production and Production constraints in Namibia

Namibia consumes fresh potato with the average demand of 3800 tons per month creating a production gap of 50% potato needs (Potato News Today, 2020). USAID, 2015 report, markets ng and value chains are well organized globally. I n southern Africa, potato industry is well developed with large processing industries such as starch extraction (Alleman n et al., 2004). Potato industry in Namibia is based on household consumption and to a lesser extend processing. At the moment, potato is consumed in the form of fresh tuber in Namibia and is favoured for its delicious salad served at weddings or processed into fried potato chips (French fries) and backed wedges as in China (Zhang et al., 2017). According to New Era Reporter (2007), potato production in Namibia showed an increase in 2007 due to its higher demand and profitability in recent years. The increase in potato production in developing countries such as China and India was because of increased demand and was made possible by the introduction of modern seed technology, fertilizers and fungicides (Haverkort and Struik, 2015). Un like other developing countries, the importation of potato tubers was increased significantly due to limited local production as outlined in the Namibian Agronomic Board (NAB) reports of 2017/2018. Importation of food items cause increase in commodity prices, a situation which is not onIy likely to have disproportionately affected low-income households, who have higher relative shares of food expenditure, but also on urban households who rely more on cash purchases for consumption (Emongor and Kirsten, 2009, Levine, 2012). According to Gebru et al. (2017), low access to and high prices of seed tubers of improved potato varieties (>0.25 USD kg-* seed tubers) and scarcity of information on good fertilizer management practices for producing the potato has led to limited potato production in Ethiopia. According to Levine (2012), the Ethiopian rural low-income households dependent on subsistence agriculture which in most times negatively affected by climate change and as a result, these households could not get much share from their hard work as they are dependent on cash purchases for a large share of their consumption.

Potato production in Namibia is at low level hence most of it is being imported into the country. Potatoes from South Africa feed the neighbouring countries which includes Namibia, Angola and Botswana (Fran ke et al., 2011). Namibia has a few numbers of commercial potato producers which are found around Tsumeb, Otavi, Outjo, Groot Fontein, Otjiwarongo,

Mariental, along the Orange River, and the Hochfeld (NAB reports of 2017/2018).

ware potatoes tubers imported from South Africa finds its way into the Namibian economy and used as seeds and for human consumption (Fran ke et al., 2011). Besides, in the informal seed potato system, seed tubers produced usually as part of ware are stored under poor conditions making it unfit as seeds (Hirpa et al., 2010). Without a formal potato seed system, farmers will continue making use of varieties of unknown origin as no improved varieties available to the majority of the farmers (Hirpa et al., 2010). Lack of awareness about the use of improved technology and practices has also impeded adoption of potato technologies in Namibia. The Namibian Agronomic Board (NAB) reports of 2017/2018 financial year, further reported that potato have been the most traded horticultural fresh produce in Namibia with 39% recorded during 2018. The consumption of potatoes was at 31,498 metric tons in Namibia (NAB) reports of 2017/2018). This exceeded the country's production capacity during 2017/2018 season. Subsequently, 23,655 metric tons of potato were imported while only 7,844 metric tons were produced locally (NAB annual report 2017/2018). Despite the demand for potato tubers and seeds for production, potato propagation materials remain unavailable in Namibia. While in South Africa, potato is grown on approximately 50 thousand hectares with a yield close to 2 million tons per annum (Franke et al., 2011).

According to the Potatoes outlook South Africa report 2021, the average potato yield in 1998 was 30.4 tonnes per hectare, in 2018 the average potato yield was recorded at 46.5 tonnes per hectare and by 2028, yields close to 50 tonnes per hectare has been anticipated. Potatoes can be grown year-round provided there is sufficient water for irrigation during off season, and the average days to maturity is about 120 days. The crop perform very well with minimum amount of water (4 mm d^{-1}) supplementation even when temperatures are high and rainfall low or when grown in the winter (Haverkort and Struik, 2015). The conditions in South Africa are similar to those of Namibia hence subsistence farmers could also take part in potato production, if TPS become available to them. At the moment, potential potato farmers are challenged with the unavailability of potato seeds in the country.

Production constrains of potato includes a number of diseases as well as insect pests reported as prone to South Africa. These includes diseases such as early blight, late blight, bacterial wilt, scab and virus n et al., 2004; Khandaker et al., 2011). Insect pests such as tuber moth and leaf miner are also listed among major production constraints. Potato is the first crop where breeding for resistance to diseases was initiated due to its susceptability to the late blight attack that led to the Irish potato famine in Europe (Martin et al., 2014; Zadoks, 2008). According to Zadoks (2008), the late blight resulted from importation of a new potato breeding material from the Americas into Belgium and it began to spread in 1844, causing destruction to potato crop in Ireland and triggered the 'G reat hunger' across Europe. Following the disaster, the European governments responded quickly to the emergency and ordered both seed potatoes and potato seeds from abroad for experimentation and also to look into the matter and suggest methods of disease control (Zadoks, 2008).

4. Use of true potato seed (TPS) as a mean of propagation material

The alternative to potato tuber as propagating material is the true seed potato seed (TPS). TPS refers to the botanical seed that is harvested from a potato (Jansky et aL, 2016). Sexual propagation via TPS offers many benefits over asexual propagation via tuber pieces. The use of TPS could offer various benefits over the tuber pieces used in current potato cropping systems. As compared to seed tubers, TPS could serve as seeds for potato production because dealing with TPS is less labour and capital-intensive, and it is suitable for small-scale farmers (Almekinders et al., 2009). This method uses the botanical seed produced by sexual reproduction that is formed inside fruits (Almekinders et al., 2009; Jam ro et al., 2015). The method of using TPS started at the International Potato Center (CI P) where research into converting the potato from a vegetative clonal crop to a botanical seed crop was at forefront from 1977 to 2000 (Jansky et al., 2016). According to Muthonier a/., the use of TPS is a way to maintaining good health standards of the early generation's material generated to produce seedlings and seedling tubers. In addition, TPS has many advantages over tuber seeds especially when it comes to storing and transporting tons of tubers versus very small quantity say grams of true seeds et al., 2009; Jam ro et al., 2015). Farmers can achieve the same or better results by planting as few grams of TPS per hectare, compare to the one who usually use two tons of seed tubers to plant a hectare of potato crop to produce the same amount (Jam ro et al., 2015).

5. Possible interventions to potato production in Namibia

Poor access to quality Seeds is generally considered a yield-limiting factor. Poor quality seeds are being required for the expression of the yielding ability of the crop without constraints. The use of botanical or true potato seed (TPS) was first introduced by the International Potato Center (CIP) together with their collaborating institutions (Al!eman n et al., 2004;

AImekinders et al., 2009). Under their collaborations, an intensive research programme was implemented for over a period of 25—30 years on the use of botanical seed of potato as an alternative way of growing a potato crop (AImekinders et al., 2009). The use of TTPS was seen as a stepping stone in the development of a new crop commodity chain, requiring research on breeding, seed production, agronomy and marketing aspects. The use of TPS was especially attractive for small-scale farmers in developing countries. The difference of using TPS as compared to using seed tubers meant in many respects the development of a new crop—commodity chain, requiring research on breeding, seed production, agronomy and marketing aspects et al., 2009). In addition, advantage of having TPS is the light weigh of the product which can be carried to any place without any problem, especially by small scale farmers who do not have access to farm machinery (Allemann et al., 2004; Muthoni et a L, 2013). TPS also do not require cold storage and no virus diseases transmitted from one generation to another or soil-borne diseases from one field to another n et al., 2004; Muthoni et a!., 2013). Following the use of TPS in five different country as pilot project by CIP, China reported an extensive use of TPS that increased the enthusiasm in CIP circles for the innovative of the technology around 1984 et al., 2009; Roy et al., 2005). The CIP first directors Dr. Richard Sawyer (first director) and Dr. Orville Page (director of research) commended that the use of true potato seed would have the advantage that small-scale farmers could eat or commercialise the tubers that he or she would otherwise had to store or buy for next planting season et al., 2009). This led to the slogan 'a handful of seed replaces 2 tonnes of tubers'. Despite the CIP effort, research on TPS as an alternative in developing countries did not yield reference to a feasible large-scale use of the botanical seed for ware potato production et al., 2009; Jansky et al., 2016). The technology needs to be implemented and should be promoted in most developing countries in order to increase potato product yields. Although TPS are favoured for low transmission of diseases, they are sometimes affected by infections such as late blight, bacterial wilt and virus transmitted by aphids (Muthon! et al., 2013; Roy et al., 2005). According to Roy et al (2005), the spread of infections in TPS is attributed to contact with virus infected hands and leaves of infected plants. Therefore proper distribution channels of TPS with high yield, tolerance to diseases and less expensive way of distribution need to be put in place uthoni et al., 2013). In most countries where CIP experimentation and adoption by farmers took place, the technological advantages of using TPS were only translating in economic benefits as compared to tuber seed which are costly or not available (AImekinders et al., 2009). Since the economic performance of seed tubers is likely to continue to fluctuate, TPS is the only possible alternative available mekinders et al., 2009). Advantages associated with the use of ware potato or tuber as seeds are higher yield compare to TPS planted directly (Jansky et at., 2016). The disadvantages of propagating the crop using tubers are that the tubers have a short preservation time and the potential to accumulate systemic diseases when propagated vegetatively over field generations using TPS (Jansky et al., 2016). The possible way to bypass low yield from using direct seeding with TPS is to generate seed tubers from TPS, which are then planted as the commercial crop in the following year et a L, 2016). These seed tubers from TPS are nearly pathogen free and can guarantee a better hygienic status than locally produced ware potatoes imported from other countries in developing countries without the resources and technologies for the production of pathogen-free-certified clonal seed (Jansky et 2016).

6. Conclusion

It was found through this review that seed tubers used locally are deemed to be poor in health, unsuitable in physiological age, poor in genetic quality, impure, physically damaged and inappropriate in size. Since there is no formal seed system yet in Namibia, Emphasis should be placed on prioritizing the improving of potato seed quality by increasing awareness and skills of farmers involved in potato production. Alternatively, formal seed systems should prioritize improving the production capacity of quality seed by availing quality varieties in the form of TPS and tubers. Furthermore, quality control methods as well as improving farmer's awareness on the use of TPS as planting materials should be encouraged. Improving seed tuber quality of early generations and market access should be developed in Namibia. There is also a need to develop and improve overall the non-existing seed potato supply in Namibia. A seed certification system for farmers who can server as seed producer and distributors should be introduced, or a self-regulation and self-certification in the informal and formal cooperative seed potato systems should be create.

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