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ADAPTABILITY OF FRENCH POTATO VARIETIES IN NAMIBIA

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3RD TRIALS FINAL REPORT





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ABSTRACT

This study primarily reports on the performance of four (4) French potato varieties after the 3rd on-farm trials were conducted in Namibia about good performance during the 1st and 2nd trials, whilst also comparing their relative performance in France. A widened range of potato variety options through research can help to close the gap in access to quality and affordable seed potato varieties that are adaptable to Namibia's soil and climatic conditions. The 3rd on-farm trials were conducted to reassess the best four French potato varieties recommended during the 2nd trials, namely, Barcelona, Montreal, Rainbow, and Spunta. The attributes analysed during the current trials were pests and diseases, the number of tubers per plant, gross and net yields per hectare, percentage share of tubers \geq 50mm, dry matter content, sensory evaluation on French fries and boiled potatoes, as well as the colour of French fries.

The 3rd trials were planted at 19 different trial sites with different field sizes at various production zones, namely, North Central, Kavango, Zambezi and Central. Challenges such as frost, lack of appropriate implements, proper irrigation systems, and fertilizers were experienced. Trial sites that performed poorly due to obvious poor farming practices were excluded from the research data. Sporadic cases of diseases such as early blight and common scabs, as well as pests (potato tuber moth and leaf miners), were experienced at a few of the trial sites. However, good yields were achieved at the majority of the trial sites, which has increased the confidence in concluding that French potato varieties are adaptable to the Namibian soil and climatic conditions. All French potato varieties attained average gross yields of or above 40 tons/ha.

Barcelona scored the highest average gross yields (50 tons/ha), followed by Montreal (42 tons/ha) and both Rainbow and Spunta (41 tons/ha). Barcelona again scored the highest average net yields (43 tons/ha), followed by Spunta (40 tons/ha), Montreal (38 tons/ha), and Rainbow (36 tons/ha). Despite good average gross and net yields, some trial sites performed very well, with the highest production zone recording 69 tons/ha, 62 tons/ha, 57 tons/ha, and 52 tons/ha on average for Barcelona, Montreal, Spunta, and Rainbow respectively. When compared to their performances in France, discrepancies were trivial for all four varieties. All four varieties were proven to have an acceptable level of tubers \geq 50mm and dry matter content during the 1st, 2nd, and 3rd trials, in comparison to their performance in France. Sensory evaluation was dominated by 'strongly like' responses in both cases of aroma and texture as opposed to 'strongly dislike', 'dislike', 'neutral', and 'like'.

Literature has associated the brownness of French fries with some health risks. When the four varieties were assessed on the colours of French fries, only Rainbow had 20% of crispy brown strips, whilst none of the other 3 varieties had such colour. Barcelona had 60% slight brown, Montreal 44%, Rainbow 30%, and Spunta 16%. Thus it can be concluded that Spunta is best for French fries, followed by Montreal, ceteris paribus. Rainbow is recommended for boiling and mashed potato other than making French fries.

Based on longitudinal trial results, these four French potato varieties should be adopted in Namibia to complement the local varieties that are normally imported from South Africa.

Keywords: French potato varieties, tubers, yield, weight, dry matter content, NAB



1. INTRODUCTION AND BACKGROUND

Potato remains the most consumed horticultural commodity in Namibia, accounting for 44% of all horticultural imports and 35% of local horticultural purchases by value and a trade deficit of about 58% by value as of the 2021/2022 reporting period (NAB, 2022). In an attempt to mitigate this huge trade deficit, The Namibian Agronomic Board (NAB) and partners collaborated in testing the adaptability of French potato varieties to the Namibian soil and climatic conditions. The partners include a French seed potato-producing company called Comptoir du Plant (CDP), The University of Namibia (UNAM), and The Embassy of Namibia to France, Italy, Spain, and Portugal. The varieties tested are Barcelona, Montreal, Nicola, Rainbow, Satis, and Spunta. The first trials were conducted on small plots in the Karst and Central production zones from December 2020 to April 2021.

Based on the first trials' promising results, the NAB received 25 tons of French seed potato varieties from CDP, for testing on a bigger scale. Thirteen (13) farmers participated in the 2nd trial from Karst, North Central, Kavango, and Zambezi production zones. The seed potatoes arrived at the beginning of the winter season, hence, Central, South and Orange river production zones could not participate in the trials due to extremely low temperatures and high frost risks during the winter season. The participating farmers voluntarily catered for production input costs themselves, whereas the NAB facilitated their training. This 2nd trial yielded acceptable results, whereby Barcelona, Montreal, Rainbow, and Spunta were recommended for the 3rd trial. When compared to two local (check) varieties sourced from South Africa, namely, Mondial and Tyson, the yields of French potato varieties were not significantly different.

Because both 1st and 2nd trials had positive results, it became necessary to conduct 3rd trials to obtain longitudinal research-based conclusions and recommendations. It is against this background that the NAB and partners agreed to conduct third trials with the four French potato varieties that were previously recommended from the 2nd trial. A 26-ton lot comprising Barcelona, Montreal, Rainbow, and Spunta varieties was therefore planted from March to early April 2021 at 19 trial (farms) sites in Central, North Central, Kavango, and Zambezi production zones. A few of these sites could not succeed mainly due to frost, lack of fertilizers and appropriate implements, hence their results are excluded in this report because the challenges were caused by farmers' production practices and not variety traits.

Despite the challenges experienced by some participant farmers, good yields were obtained at the majority of trial sites, whereby all varieties performed very well, though at different intensities. It was, therefore, recommended for Namibian potato growers to commercially adopt growing Barcelona, Montreal, Rainbow, and Spunta varieties in addition to the already commercially grown varieties from South Africa which have not been easily accessible to, especially Namibian small-scale farmers.



2. PROBLEM STATEMENT

As of the 2021/2022 reporting period, potato consumption stood at approximately 35.9 thousand tons traded in the formal market, of which only about 13.3 thousand tons (37%) were locally produced, which means that nearly 22.6 thousand tons (63%) were imported. Despite being the highest consumed horticultural commodity in Namibia, potato farming remains a challenge, especially in terms of access to agricultural inputs and value addition (NAB, 2021). The availability and access to good quality seed potatoes especially by smallholder producers remains among the biggest challenges and this has affected local potato production. Potato breeding in Namibia is almost nonexistent as seed potatoes are sourced from seed-producing companies in South Africa, which is another costly exercise (NAB, 2021).

The NAB conducted seed potato trials on small plots between December 2020 and April 2021, and again on a large consignment of 25 tons from April to September 2021, of which striking results came out. Four out of six French potato varieties tested, namely, Barcelona, Montreal, Rainbow and Spunta were the most recommended for adoption in Namibia. The 3rd trials were, therefore, necessary to give assurance of the results obtained from previous trials.

3. OBJECTIVES

- To reassure the adaptability of four potato varieties to Namibian soil and climatic conditions.
- To compare the performance of four potato varieties to their performance during the 1st and 2nd trials, as well as to their performance in France.
- To reassess the internal quality, consumer preferences, and colour of French fries of the four potato varieties.
- To reassure Namibian potato growers on best-performing varieties.

4. SIGNIFICANCE OF THE STUDY

This 3rd French potato trials serve as longitudinal research that reassures the Namibian farmers on the adaptability of the four French potato varieties that were previously recommended as most suitable to Namibian soil and climatic conditions among others. These potato trials availed relevant information that will trigger domestic and foreign investment into the potato value chain. Reemphasising recommendations on these trials could also reassure policy interventions that could facilitate the increment of local potato production.

5. RESEARCH METHODOLOGY

The study is of a trial nature, where four (4) French potato varieties were retested for adaptability to the Namibian soil and climatic conditions. The quantities of seeds used in the entire project for each variety were as follows: Rainbow 416 bags, Barcelona 206 bags, Montreal 206 bags and Spunta 206

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bags. The trial designs were, therefore, dependent on the field space and affordability of inputs by the farmer. Nineteen (19) farms participated in these trials with different areas planted and the number of seeds per variety thereof. The participating farmers were from four (4) production zones namely, Central, North Central, Kavango and Zambezi. The study could not include other production zones due to frost risk as the seed potatoes arrived towards the winter season. During the harvest of the potato trials at each trial site, *yield data (weight and number of tubers)* were captured. The potatoes harvested from each production zone were further subjected to the experimentations of dry matter content analysis, sensory evaluation on French fries and boiled potatoes, as well as on the colour of French fries.

5.1 Trial Design

The seed potatoes were planted in a succession order, whereby seeds of one variety were planted until they were finished, before beginning to plant the next variety. The design, therefore, comprised four (4) French varieties only and rows for each variety were clearly marked with plant markers.

5.2 Population and Sampling Strategy

The study population was nineteen sites planted with four French potato varieties – Barcelona, Montreal, Rainbow and Spunta. From each trial site, a 10m row (2m x 5 portions) was sampled at random from each of the four varieties to represent the yields of the site for each variety. The samples from trial sites of each production zone were averaged according to varieties.

5.3 Data collection

The data collection included observation of pests and diseases, as well as harvesting (tubers counting, measuring, and weighing). Selected tubers from each production zone were subjected to analysis of dry matter (moisture content) and consumer preference for boiled potatoes and French fries, as well as the colour of the French fries.

5.3.1 Pests and Diseases

The common pests attacking potatoes in Namibia are nematodes, potato tuber moths, aphids and American leaf miners among others. Diseases that are generally complained about by Namibian potato growers include early bright, late bright and common scabs. Proper monitoring and observation were employed and pests and diseases observed in the trials were recorded.

5.3.2 Tubers Sampling Stage

Tubers sample data from a 10m row per variety were recorded and analysed in terms of the total number of tubers and their weight from each trial site. Harvested tubers were split into three groups to record the number and weight of tubers that are equal to or larger than 50mm, tubers less than 50mm but equal to or larger than 35mm, and tubers less than 35mm. Tubers larger than 35mm are regarded

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as marketable-sized tubers. The percentage shares of tubers ≥50mm were determined. Tubers equal to or larger than 50mm contribute more to high yields and market acceptability. Conversions to yield/ha were made.

5.3.3 Dry Matter Content Analysis

While the dry matter is used to determine the maturity of fruits and vegetables, for potatoes being a root crop, dry matter estimation is rather vital to ensure quality control in the supply chain and processing for human consumption. "Potatoes have a water content that varies from 75 to 85% and the rest (15 to 25%) is a dry matter that contains the nutrients for which potatoes are grown" (Trimble, 2019). According to Lemanga and Kabira (2003), potatoes with high dry matter content (above 20%) are mostly preferred for making French fries or crisps while those with low dry matter content are less preferred because the French fries or crisps will be too soft or too wet and it will need more heat to fry and evaporate the water. The dry matter content may also influence the colour of chips, which plays a crucial role in customer satisfaction.

To determine the dry matter content of the potatoes harvested of each variety per production zone, a tuber weighing at least 50g per variety was used. Potato tubers are homogenised by cutting the sample into smaller pieces and shortly blending. A fifty (50) gram sample is then weighed into a dish. The weight-recorded dish and sample are dried in a 104°C oven for 4 hours. The sample is removed from the oven and allowed to cool in a desiccator. The weight-recorded sample is placed back into the oven for one hour, cooled and weighed and this step is repeated until there is no significant weight change any more. The Analytical Laboratory Services were useful in the dry matter content analysis exercise.

5.3.4. Sensory Evaluation (Texture and Aroma)

Dent and Colins (2021) indicate aroma, texture and colour to be among the sensory evaluation attributes. Potato texture may explain the crispness, crunchiness and hardness of potato food, whereas, the aroma may be explained by the sweet, earthy, nutty, baked, pleasant and potato-like of potato food (McKenzie & Corrigan, 2016). The aroma may not only depend on the variety but also the cooking method, size of chips, storage system, and production practices. Sensory evaluation was therefore done to assess the preference of four different French potato varieties by consumers when prepared as French fries and boiled potatoes. French fries and boiled potatoes were presented to the identified participants who scored the texture and aroma as strongly dislike, dislike moderately, neither dislike nor like, like moderately and strongly like. This was done in Windhoek and participated by about 28 people, mainly NAB staff and random by-passers during the event at the Agricultural Boards building in Windhoek. Participants were informed that varieties are new in Namibia and they were informed/guided on how to fill in the evaluation sheets.



5.3.5 French Fries Colour

It was also necessary to analyse the brownness of fried chip strips from these varieties. This would give an indication of acceptance of French potato varieties by consumers and for food safety. According to the UK Food Safety Agency (FSA, 2022), starchy food is associated with producing acrylamide when heated at high temperatures, which is carcinogenic. French Fries' colours may be lightly golden, golden yellow or golden brown, with light golden being the best colour for French fries, according to the European Potato Processors Association (2022). The more golden colour of the food is, therefore, preferred to crispy brown. Twenty (20) strips (chips) of French fries from each variety were prepared by frying them in oil at 175 – 180°C for 3 minutes. The number of strips that looks light, slightly light, neutral, slightly brown and crispy brown was counted.

For this exercise, the French fries were prepared as follows:

- 20 tubers were selected from each variety.
- Each of the 20 tubers per variety was peeled, and one strip (one French Fry) was made in the middle of each potato to have the same diameter.
- A French Fryer equipment was used to fry the French fries.
- Before frying, the strips were put in hot water at 40°C to remove the starch.
- The strips were drained/dried before putting them in the frying equipment at 175 180°C for 3 minutes.
- Using the guide of pictures, the French fries were assessed as to how many tubers looked like each of the four scores. Four rating scores (Light = 0, Slightly Light = 1, Neither light nor Dark = 2, Slightly Dark = 3 and Dark = 4) were used to assess the colour of French Fries made from all varieties under this trial as presented in Figure 1 hereunder.



Figure 1: A colour guide for the evaluation of the French fries (Comptoir du Plant, France)

Figure 1 above presents the colours of French fries in different categories, namely, Light = 0, Slightly Light = 1, Neither Light nor Dark = 2, Slightly Dark = 3 and Dark = 4. The colour of French fries is very important but it may not only depend on the variety but mainly on the way it is fried, such as the

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equipment used, temperature, time of frying, sugar removal before frying, type of oil, the thickness of the strips, etc.

5.4 Data Analysis

5.4.1 Descriptive Statistics

Descriptive statistics, mainly the central tendency (averages) and percentages were used to analyse and present the results in tables and graphs. All the data collected as per the above section (Data Collection) were analysed using descriptive statistics whilst using Microsoft Excel Software. The assumed standard plant population of 40 400 plants per hectare was used in conversions to estimate the yields per hectare from each trial site, using the intra-row spacing of 33cm and inter-row spacing of 75cm. Various tables and graphs are listed throughout the report as well as their interpretations.



Figure 2: Participating farmers observing the French potato trial field during data collection at Etunda Irrigation Scheme in the North Central production zone (Up) and Sikondo Irrigation Scheme in the Kavango production zone (Bottom)



6. PRESENTATION OF RESULTS AND DISCUSSIONS

This section (6) presents and discusses the parameters of data collected to assess the performance of four French potato varieties that were subjected to 3^{rd} trials. These parameters are presented and discussed in the subsequent subheadings: pests and diseases, the average number of tubers per plant, average gross yields per hectare, average net (marketable) yields per hectare, and the average percentage of tubers equal to or larger than 50mm (\geq 50mm). Additional subheadings are dry matter content in tubers and sensory evaluation attributes i.e. aroma and texture of boiled potatoes and French fries, as well as the colour of French fries. Lastly, the performance of current and previous trials was presented, averaged, and compared to relative performance in France.

6.1. Pests and Diseases Observed from 3rd Trials

American leaf miner and potato tuber moth were the pests identified on a few trial sites, with no observed selectivity among the varieties. Early blight disease affected all the varieties at one site in each of the Kavango, Central and Zambezi production zones, but no economic losses were incurred as the signs of early blight were observable on the leaves but not on the tubers.

Common Scab disease was as well observed at one site in each of the Kavango and Zambezi production zones, mainly affecting Spunta and Montreal more than other varieties. The fields affected by the scab appear to be pure sand and very high in organic matter contents. The damage by the scab disease is estimated to have affected about 3% of marketable yields. The common scab is caused by a bacterium called *Streptomyces Species*, where its growth is favoured by high soil PH, high animal manure content and low moisture content (below field capacity) at the tuber formation stage and high soil temperature (Charkowski, 2017). The fields affected during trials appeared to be pure sand in river proximity and high in organic matter content.

Lastly, there was a trend of a few potato plants (less than 1%) dying across trial sites, mainly the Rainbow variety. It was suspected to have been caused by overwatering and soil compaction. No spots or marks were observed inside the tubers when a few tubers from samples of each variety were cut cross-sectionally. The figures below illustrate some of the pests and diseases observed during the trials.



Figure 2: Potato leaf affected by potato tuber moth



Figure 3: Potato leaf affected by Leaf Miner





Figure 4: Potato tubers affected by Scab disease



Figure 5: Potato leaf affected by Early Blight



Figure 6: Dying potato due to overwatering/soil compaction

6.2 Average Yields of 3rd Trials

This section presents the yields sampled to represent each of the four French potato varieties (Barcelona, Montreal, Spunta and Rainbow) from the 3rd trial in Namibia. Yields are expressed in four different aspects, namely the average number of tubers per plant, average gross yields per hectare, average net yields per hectare and an average weight of tubers equal to or larger than 50mm (≥50mm) for each of the four production zones (Central, Kavango, North Central and Zambezi).

6.2.1 Average Number of Tubers Per Plant Sampled from Trials

Figure 7 below presents the average number of tubers harvested per plant, irrespective of the size of each of the four varieties sampled from various production zones. The number of tubers attained per plant ranged from 7 to 14. The ideal number of tubers is 10 to 12 tubers per plant (Comptoir du Plant, 2022). In the Central production zone, only Montreal (7) attained the number of tubers below the norm, whereas, in the Kavango production zone, only Barcelona (12) and Rainbow (10) attained the number of tubers within the norm. Spunta (11) and Montreal (10) varieties were within the norm in North Central, whilst Rainbow (9) and Barcelona (9) were slightly below the norm. The Zambezi production zone was below the norm with all of the varieties as they all attained nine or fewer tubers per plant. On average, Rainbow (10), Barcelona (10) and Spunta (10) were all within the norm, whereas Montreal (8) was slightly below the norm. A variety with a high number of tubers per plant is likely to give more yields, provided the soil preparation (ridging), spacing, fertilisation, irrigation, pests and diseases control, weeding and other potato production practices are adhered to.





Figure 8 Average number of tubers per plant per variety at various production zones

6.2.2 Average Gross Yields

Figure 9 presents the average gross yields obtained per hectare for each variety sampled from various production zones. Barcelona was found to be the most yielding variety, considering that it scored an average gross yield of 50 tons/ha, whereas its highest gross yield is 71 tons/ha which was obtained at the North Central. The lowest average gross yield for Barcelona was 38 tons/ha in the Zambezi and Central production zones. However, this was due to a lack of access to fertilizers and poor irrigation systems in the Zambezi production zone, whereas, Central experienced frost on two occasions. Montreal was the second most yielding variety as it scored average gross yields of 42 tons/ha and its highest yield was 66 tons/ha that which obtained in North Central. Both Rainbow and Spunta also scored acceptable average gross yields of 41 tons/ha and the highest yields of 62 tons/ha for Spunta and 56 tons/ha for Rainbow in North Central.





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Notwithstanding the average gross yields presented in Figure 9 it is worth mentioning that the highest participant farmer in the trials obtained gross yields of 87 tons/ha for Barcelona, 81 tons/ha for Spunta, 74 tons/ha for Rainbow, and 68 tons/ha for Montreal.

6.2.3 Average Net Yields (Marketable yields)

Figure 10 depicts the average net yields (gross yields minus weights of tubers smaller than 35mm and defects) obtained per hectare for each variety sampled from various production zones. Barcelona was still the most yielding variety in terms of net yields, considering that it scored average net yields of 43 tons/ha, with the highest net yields of 69 tons/ha obtained in the North Central. As contrasted to gross yields, Montreal was outperformed by Spunta in terms of net yields. Spunta had an overall average net yield of 40 tons/ha, followed by Montreal with 38 tons/ha, and lastly, Rainbow with 36 tons/ha. However, the highest net yields for Montreal were still second with a net yield of 62 tons/ha in the North Central, followed by Spunta at 57 tons/ha, and lastly, Rainbow at 52 tons/ha. The overall net yields were pulled down by the the Central production zone which had frost on two occasions and the Zambezi production zone which was challenged by a limited supply of fertilizers and irrigation services.



Figure 10: Average net yields in tons per hectare as per samples from French potato trials

Figure 11 presents the percentage of tubers \geq 50mm out of the total tubers harvested per variety at various production zones. Both Barcelona and Montreal had the highest and equal share of 66% as averages for tubers \geq 50mm, followed by Rainbow (58%), and lastly, Spunta (53%). The Central production zone recorded a lower percentage share of tubers \geq 50mm because the plants died prematurely due to frost which attacked the trial sites on two different occasions.

Both the Kavango and North Central production zones recorded the highest percentage shares of tubers \geq 50mm, whilst the Zambezi production zone also recorded a good share of \geq 50mm for Barcelona, Rainbow, and Montreal, but a low share on Spunta. Tubers \geq 50mm contribute more to the yields, likely acceptable by the market and a lesser number of tubers are required to fill the pocket bags as contrasted to smaller tubers.





Figure 11: Average percentage of tubers equal to or bigger than 50mm per variety at various production zones

6.3 Dry Matter Content Analysis

Table 1 shows the test report of the dry matter content analysis done on the potatoes harvested from the North Central, Zambezi, Kavango, and Central production zones during the 3rd trial. The average dry matter content for each variety is presented in the last column.

Spunta and Montreal varieties scored the highest average dry matter contents of 21%, followed by Rainbow and Barcelona with average dry matter contents of 19% and 18% respectively. All varieties are within the international standard of dry matter content for potatoes, which is 15% to 25%. The potatoes harvested from Central were lowest in dry matter contents perhaps because potato plants at these sites were prematurely killed/destroyed by frost.

Variety	North Central	Zambezi	Kavango	Central	Average
Barcelona	19%	20%	18%	13%	18%
Montreal	20%	24%	23%	17%	21%
Rainbow	16%	22%	24%	15%	19%
Spunta	26%	23%	19%	17%	21%

Table 1: Test report on the dry matter of the potatoes harvested from 3rd trials

6.4 Sensory Evaluation and Analysis

This section presents the sensory evaluation done on the French fries and boiled potatoes made from potato samples harvested from each of the four participating production zones. Three attributes were



assessed – aroma and texture, to assess customer preference for boiled potatoes and French fries, as well as colour to assess the suitability of varieties to make French fries.

6.4.1 Sensory Evaluation on French Fries

Figure 12 presents the percentage responses to the aroma of French fries made from different four French potato varieties. All varieties were predominantly liked, with Barcelona (57%) and Spunta (52%) being found to have the most strongly liked aroma in their French fries. The percentage of respondents that don't like the aroma is below 8% for all varieties, whilst Spunta did not have any dislike.



Figure 12: Percentage responses of people who tested French fries' aroma

Figure 13 presents the percentage responses to the texture of French fries made from different French potato varieties. Just like in the case of Aroma, all varieties were also predominantly liked, with Barcelona (58%) and Spunta (52%) being found to be the most strongly liked texture in their French fries. Except for Montreal which had 13% of dislike moderately and 4% strongly dislike, all varieties had a dislike response of below 9%.



Figure 13: Percentage responses of people who tested French fries' texture



6.4.2 Sensory Evaluation on Boiled Potatoes

Figure 14 presents the percentage responses to the aroma of boiled potatoes made from different four French potato varieties. Although a bit lower than the case with French fries, all varieties were predominantly liked as well, with Barcelona (52%) and Spunta (45%) being the most strongly liked aroma with regards to the boiled potatoes. The percentage of respondents that didn't like the aroma was zero for Barcelona, whereas for all other varieties, this was below 15%.



Figure 14: Percentage responses of people who tested boiled potatoes' aroma

Figure 15 presents the percentage responses to the texture of boiled potatoes made from four different French potato varieties. Just like in the case of aroma, all varieties were also predominantly liked, though it is a bit lower compared to French fries. Barcelona was still the highest (52%), followed by Spunta (48%) having the most strongly liked texture. The percentage of responses that didn't like the texture was zero for Barcelona, whereas all other varieties this was below 25%.



Figure 15: Percentage responses of people who tested boiled potatoes' texture





Figure 16: Photos taken during the sensory evaluation exercise at the agricultural boards building in Windhoek, August 2022

6.4.3 French Fries Colour Assessment

Figure 17 illustrates the percentage of different colours of French fries strips made out of four different French potato varieties as per the assessment during the sensory evaluation. Except for rainbow which had 20% of crispy brown strips, none of the other three varieties had that colour. However, Barcelona had 60% of slight brown than other varieties, Montreal 44%, Rainbow 30%, and Spunta 16%. It can, therefore, be interpreted that Spunta is the best variety for French fries, followed by Montreal, *ceteris paribus*. Rainbow should rather be recommended for boiling rather than making French fries.

The Colours of French Fries When Fried at 175 - 180Ċ for 3 minutes.						
70% 60% 50% 40% 30% 20% 10%						
0.10	Barcelona	Montreal	Rainbow	Spunta		
Light	0%	22%	5%	21%		
Slightly Light	15%	33%	15%	16%		
Neither Light nor Brown	25%	0%	30%	47%		
Slightly Brown	60%	44%	30%	16%		
■Crispy Brown	0%	0%	20%	0%		

Figure 17: Visual assessment of the colour of French fries for French potato varieties

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Figure 18 hereunder illustrates the French fries assessed for the colours as explained above.



Figure 18: Pictures of French fries made from French potato varieties for colour assessment as explained above

6.5. Comparisons of Performances of Current and Previous Trials in Namibia Vs in France

Table 2 depicts the longitudinal performances of four (Barcelona, Montreal, Rainbow, and Spunta) French potato varieties during different trials and in comparison to their performances in France. On average, with regards to the gross yields of the three trials in Namibia, Barcelona is leading with 56 tons/ha, Spunta is second with 53 tons/ha, followed by Rainbow with 51 tons/ha, and lastly, Montreal with 49 tons/ha.

In terms of average net yields, both Barcelona and Spunta are equally highest with 46 tons/ha, Rainbow is second with net yields of 45 tons/ha and lastly is Montreal with 40 tons/ha. Montreal obtained the average yields equal to the average net yields obtained in Namibia, which is 40 tons/ha, whereas, Barcelona, Spunta, and Rainbow all performed higher than Namibia's average.

When considering the averages of the three different trials in Namibia, Barcelona (67%) is leading in terms of tubers \geq 50mm, followed by Spunta (61%), Rainbow (60%), and lastly, Montreal (57%). In terms of the dry matter content of tubers sampled from trials in Namibia, all varieties were within the international standard of 15% to 25% dry matter content. However, Montreal and Spunta are equally highest with averages of 20% dry matter content, followed by Rainbow (19%) and lastly, Barcelona (18%).



When compared to their performances in France, Barcelona is still leading in terms of gross yields per hectare in both countries, with 56 tons/ha in Namibia and 70 tons/ha in France, which is 14 tons higher than in Namibia. Rainbow at 70 tons/ha is equal to Barcelona in the gross yield in France, while it is third in Namibia at 51 tons/ha; Spunta at 53 tons/ha is second in Namibia. Montreal is correspondingly the last in both Namibia and France in terms of net yields.

Table 2: Average results in gross yields, net yields, percentage share of ≥50mm tubers, and dry matter content per variety during the three different trials in Namibia and compared to relative results in France

LONGITUDINAL TRIALS	FRENCH POTATO VARIETY	AVERAGE GROSS YIELDS (TONS/HA)	NET YIELDS (TONS/HA)	% TUBERS ≥ 50MM	AVERAGE % DRY MATTER CONTENT
	Barcelona	51	46	91%	16%
1 ST Trial	Montreal	45	36	77%	16%
i iiai	Rainbow	62	60	96%	18%
	Spunta	66	59	90%	16%
	Barcelona	67	50	43%	20%
2ND Trial	Montreal	61	45	28%	22%
Z IIIdi	Rainbow	51	38	27%	21%
	Spunta	51	38	39%	23%
	Barcelona	50	43	66%	18%
2RD Trial	Montreal	42	38	66%	21%
5 IIIdi	Rainbow	41	36	58%	19%
	Spunta	41	40	53%	21%
	Barcelona	56	46	67%	18%
Average	Montreal	49	40	57%	20%
(Namibia)	Rainbow	51	45	60%	19%
	Spunta	53	46	61%	20%
	Barcelona	70	55	70%	19%
EDANCE	Montreal	55	45	60%	21%
FRANCE	Rainbow	70	60	85%	18%
	Spunta	65	55	70%	19%

As contrasted to Barcelona and Spunta (both 46 tons/ha each) equally being best in Namibia, Rainbow leads in France (60 tons/ha) in terms of net yields, while it is second in Namibia. Montreal has the lowest net yields in both two countries. Although Namibia's gross yields and net yields are slightly lower when compared to relative yields in France, it is still acknowledgeable because most of the growers were first or second-time potato growers in Namibia. Except Rainbow which had 85% of tubers ≥50mm in France versus 60% in Namibia, there are no material differences among the varieties' percentage shares of tubers ≥50mm, as well as in dry matter contents when compared to their performances in France.



7. CONCLUSIONS AND RECOMMENDATIONS

This section contains concluding remarks from the 3rd trial of French potato varieties, in relation to previous trials in Namibia and France. Thereafter, recommendations based on the performances of the trials are outlined.

7.1 Conclusions

The good performances of four French potato varieties during the 1st and 2nd trials conducted previously prompted the 3rd trial to provide longitudinal evidence. The overall aim was to reassure the adaptability of four exotic potato varieties to the Namibian soil and climatic conditions as recommended in the 2nd trial. The 3rd trials on four French potato varieties were established at 19 farms in the Central, North Central, Kavango, and Zambezi production zones and these are Barcelona, Montreal, Rainbow, and Spunta. Challenges such as frost, the price of fertilizers and a lack of fertilisers, appropriate land preparation and planting equipment, and lack of local irrigation system services were encountered at various farms during the study.

Despite the aforementioned challenges and the majority of participating farmers growing potatoes for the first time, commendable results were obtained from the majority of these farms. All four French potato varieties were grown successfully until harvest and data collection was successful at eighteen (18) trial sites. However, a few of these trial sites could not contribute to the analysis presented in this report due to some challenges not associated with variety traits but rather farming practice issues. An analysis of these trials was based on specific attributes, namely, *the number of tubers per plant, gross yields per hectare, net yields per hectare, percentage share of tubers* \geq 50mm, dry matter content, and sensory evaluation.

The number of tubers attained per plant at various trial sites ranged from 7 to 14. On average, Rainbow (10), Barcelona (10), and Spunta (10) are all within the norm, whereas Montreal (8) is slightly below the norm. Good average gross yields were obtained as 50 tons/ha for Barcelona, 42 tons/ha for Montreal and 41 tons/na each for Rainbow and Spunta. It is also worth reporting that the highest trial site attained gross yields of 87 tons/ha, 81 tons/ha, 74 tons/ha, and 68 tons/ha for Barcelona, Spunta, Rainbow, and Montreal respectively. On the other hand, acceptable average net yields were attained as 43 tons/ha, 40 tons/ha, 38 tons/ha, and 36 tons/ha for Barcelona, Spunta, Montreal, and Rainbow respectively. Both Barcelona and Montreal had 66% averages for tubers ≥50mm, followed by Rainbow and Spunta with 58% and 53% respectively. All the varieties were within the international standard of dry matter content level for potato industries, which is 15% to 25%.



Although the average yields are higher in France than in Namibia, some individual trial sites attained yields higher than those in France. The percentage shares of tubers ≥50mm and dry matter contents were insignificant when compared to France. Moreover, all varieties were predominantly liked when tested for their aroma and texture. Based on the colours of French fries, Spunta and Montreal appear to be the best to make French fries when compared to Barcelona, whilst Rainbow appears to be good for boiling than for French fries.

7.2 Recommendations

- Given the current and previous performance of four French potato varieties tested for adaptability in Namibia, it is worth adopting these varieties for commercialisation to complement the local varieties that are normally imported from South Africa.
- Depending on the attributes of consideration and the prices of the seed potatoes and consumer preferences, Namibian farmers should choose to grow any of these four French potato varieties, namely, Barcelona, Montreal, Rainbow, and Spunta.
- Farmers choosing to grow potatoes should, however, primarily equip themselves with the necessary skills and resources required to attain optimal and quality yields as attained at most of the trial sites during the current and previous trials. A standard budget guide is provided as an annexure.
- The importation of seeds from France to Namibia may, however, be inefficient and competitive due to distance and the ever-increasing fuel price, hence it is advisable for farmers to rather procure in groups at each production zone for them to split the transport and admin costs (clearing agents, etc).
- It is also recommended that pertinent stakeholders consider establishing tissue culture and seed multiplication functions here in Namibia, should it be found to be feasible.
- As it has been emphasised in previous trial reports, stakeholders who wish to import seed potatoes should obtain import permits from the Plant Health Division of The Ministry of Agriculture, Water and Land Reform (MAWLR), which the seed supplier can use to obtain the Phytosanitary Certificate from the Government of the exporting country, France in this case.
- The import permit from The Namibian Agronomic Board will also be a necessity during the importation of seed potatoes.
- The Seed and Seed Varieties Act No. 23 of 2018, once it has become enforceable, means that varieties will need to be registered and shall comply with any prescribed requirements. This Act requires that seeds should be packed in a container that is sealed and branded, marked,



or labelled in the prescribed manner with the prescribed information being provided, and the seed variety should be imported only through the prescribed port of entry.

As also previously highlighted in the 1st and 2nd trial reports, Section 34 of the Seed and Seed Varieties Act No 23 of 2018 requires seed suppliers to disclose the expected performance of varieties to farmers under given conditions, and if such registered seed fails to provide the expected performance under such given conditions, the farmer may claim compensation from the producers as if that seed had a hidden defect and the producer was an expert in the provision of seed.

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9. ANNEXURES

Annexure 1: Potato Budget Guide for One Hectare (Estimates only)

NAMIBIAN AGRONOMIC BOARD					
POTATO CROP BUD	GET GL	JIDE	1ha		1
	Income		Estimate Price	Total Revenue (N\$/	
Salaa	Units	Units (kg/ha)	(N\$/kg)	ha)	
	Variable Costs	45,000 s	7.50	337,500.00	
Cost Description	Unit	Quantity	Cost/Unit	Total Cost/ ha	Sub-Total & % share of Total Cost of Production
seeds (Spacing 25 to 33cm between plants, 75 to 90cm	Plant Materia				NAD 40,000.00
between rows).	25kg Bag Land Preparation	100 on	400	40,000.00	19% NAD 2,250.00
Discing/ Harrowing (Hired tractor service)	Ha Ha	1	750	750.00	1%
Ridging (Hired tractor service)	Ha	1	750	750.00	
Superphosphate (Apply in farrows before planting)	50kg Bag	6	595.06	3,570.36	NAD 32,718.20
NPK 2:3:2 or 2:3:4 (At planting under tubers but not	50kg Bag	s	1020	8 160 00	
KAN 28% (1 week after emergence)	25kg Bag	4	680	2,720.00	
Calcium Nitrate (100kg @ Week 2, 4 & 6 after emrgence through irrigation)	25kg Bag	12	680	8,160.00	15%
Nitroph 3.1.5 (38) Band placement at week 3 & week 5 Borox/ Solubor/ Nitribor (Never mix boron fertilizers with	50kg Bag	6	680	4,080.00	
calcium fertilizers)	2kg Bag 25kg Bag	1	300	300.00	
A	grochemicals - Prev	entative	357.99	5,727.84	NAD 5,939.61
Terbifos (for Nematodes) - at planting	18kg	1	600	600.00	
Lambda (potato tuber moth)- Week 2 after emergence	Litre	1	225	225.00	
Agrimectin/ Abamectin - Week 2 after emergence Aroxytrobin/ Aroxy (Early & late Bright)- Week 4	Litre 5litre	0.5	195.11 2970	195.11 1,485.00	
Cyromazine (American Leaf Miner) - Week 5	10kg10)	1	1207.5	1,207.50	3%
Aziphos (Potato tuber moth) -Week 7 & 10	5litre	0.5	1280	1,587.00	
Altern Progib (Growth regulator), Cartap (Potato tuber moth), Chi Week 9 & 10, -Week 8,9 & 10 , Lufenuron (Potato Tuber n	ative Agrochemicals orothalonil (Early & lat noth)- Week 12 & 14.	on out break te bright)- week 9, 1	0, 11 & 13, Spinetora	n (American leaf miner)-	
	Irrigation		-	-	NAD 14,100.00
Irrigation (Fuel)	Litre Labour	600	23.5	14,100.00	7% NAD 13.732.60
Planting	Man/day	52	57.70	3,000.40	
Fertilizers Application	Man/day Man/day	30	57.70	1,731.00 4,269.80	6%
Irrigation & Spraying	Man/day	30	57.70	1,731.00	0,0
Harvesting & Packaging	Man/day	52	57.70	3,000.40	
Packaging	kaging, Transport & Pocket 10 kg	Telephone 4.500	5	22,500,00	NAD 41,800.00 10%
· assunging	Trip (200 bags/ trip	.,	-	,	
Transport (inputs & Outputs)	of bakkie with trailer)	23	800	18,000.00	. 8%
Telephone	aweh per week)	5	260	1,300.00	0.6%
Total Variable Costs Gross Profit				150,540.41 186.959.59	
Gross Margin				55%	
	Fixed Costs Unit	Number of units	Cost/Unit	Total Cost/ha	
Salaries	Month	5	3500.00	17,500.00	8%
Depreciation (Equipment, Machinery & Buildings)	Month	5	5842.11	29,210.55	14%
Land Lease	Month	5	1666.67	8,333.33	4%
Miscellaneous (5% of Cost of Production): Handling, stationeries, courier, cleanings, advertisement, repair &					
maintenance.	Times	1	8,737.33	8,737.33	4%
Total Fixed Costs N\$/ha				63,781.22	
NAB Levy (1.4% of Total Sales)				214,321.63 4,725.00	
Net Profit Before Interest & Tax N\$/ha				118,453.37	
Less: Opportunity Cost (10% pa) @ 5 Months					
Less: Value Adde Tax (VAT 15%) 50.625.00					
Net Profit (Taxable Income) 57,112.29					
Break-Even Price (N\$/kg)	Break-Even Anal	ysis		6.23	
Break-Even Yield (kg/ha)			;	37,385	
Sensitivity Analys	is				
Yield per hectare (kg)	Break-Even Price (N\$/kg)			
45,000 55,000		6.23 5.10			
65,000 The sensitivity analysis indicates that, the lower the yield, t the yield of 45 000 kg per hectare, the break-even price wa increased to 65 000 kg per hectare, the break-even price r	he higher the break-events N\$ 6.23 per kg, but veduced to N\$ 4.31 per	4.31 ven price. E.g. At when the yield is r kg.			

Note: Actual fertilizer requirement depends on the soil type and soil analysis. Pesticides and fungicides also depend on the season and outbreaks