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# Screening Introduced Potato Varieties for Yield, Stability and storability under the Arid Conditions of Sudan

**Abdalbagi E. Elraiah[1]*, Abdalwahid, I. Kheri, Awad M. Zain[1], Mahdi, A. Ahmed[1], Mamoun O. Abdelgadir[2] and Kahil S. Yousif[3]**

*Agricultural Research Corporation, Horticulture Research Centre

*-Nattional Food Research Center

* Al Zaeim Al Azhari University

*Corresponding Author: Email elraiah32@hotmail.com

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**Abstract:**
A research program was carried out to evaluate eight potato varieties during two seasons during 2017-2019 for yield, stability and storability at three locations (Khartoum, Shendi and Dongola). Potato varieties Alaska, Colombia, Evora, Fortus, Panamera, Challenger, Sagita and Markies, were received from Netherlands by the National Varieties Release Committee (NVRC), Sudan. Experiments were arranged in a randomized complete block design and a completely randomized design for storage parameters. Sagita produced the highest marketable yield in all sites. Moreover, it had the heaviest tuber weight and showed stable performance. However, Challenger had the highest dry matter content (22.5%) and Alaska showed the lowest dry matter content (16.6%). Varieties Sagita, Fortus and Chalenger showed the least weight loss percentage during six months storage period at 4ºC, while Colombia had the highest weight loss percentage.

**Keywords**: Potato tuber, Yield, Environments, Stability, Storability**.**

## Introduction:

Potato (*Solanum Tuberosum* L.) is one of the most important vegetable crops (Zarzecka *et al.,* 2019) currently grown on an estimated 19 million hectares of farmland globally and the potato production worldwide stands at 378 million tons (Campos and Ortiz, 2020) Potato has been introduced to Sudan from the Near East and Europe in late twenties off last century in Elgaily area in Khartoum State (Geneif and Sadik, 1989; Elraiah *et al.,* 2018). The traditional area for potato production is mainly North of Khartoum along both banks of the River Nile up to Dongola. Another important area is Jabel Marra in Western Sudan where potato can be grown twice a year. Other areas of production include Kassala State in the East and Gezira State in central Sudan (Mohamed *et al*, 2011). Elraiah *et al.,* (2018) reported that, the area under potato is around 30 thousands hectares with an annual production approximately 500 thousand tons and an average yield of 15 t/ha. Potato production in Sudan has increased in response to high demand due to urbanization and awareness of its nutritional value (Mohamed *et al*, 2004; Elraiah *et al.,* 2017). Improvement of productivity was attained mainly due to the adoption of high yielding

varieties and improved production practices, in addition to the availability of the improved infrastructure (storage facilities). Moreover, the high cash rewards encouraged farmers to be involved in potato production (Mohamed *et al.,* 2011; Elraiah *et al.,* 2017). Major improvement in yield could be achieved by early, heat tolerant and diseases resistant varieties. Therefore, the objective of this study was to evaluate some introduced potato varieties in terms of their marketable tuber yield and storability under different locations in Sudan.

**Materials and Methods:**

The seed tubers were received from Netherlands by the National Varieties Release Committee (NVRC), Sudan. The material consisted of eight potato varieties namely; Colombia, Evora, Fortus, Panamera, Challenger, Sagita, Markies and Alaska as a control. The experiments were carried out at three locations namely; Khartoum, Dongola and Shendi during two winter seasons 2017/18 and 2018/19. The soils in the various locations varied from light silt clay loam at Khartoum and Dongola to clay loamy at Shendi location. The experiment was arranged in a randomized complete block design (RCBD) with four replications. The design used in analyzing storability parameters was a completely random design with three replications. Husbandry practices were similar for the three locations. Land was prepared by heavy disc harrowing to a depth of 30 cm two times during October. The soil was then leveled and ridged at 70 cmridges in 20 cm a part hills. Plot size: four ridges, 3 m long (2.8X3 m). The tuber seeds were longitudinally cut into two pieces and planted during the 4$^{th}$ week of November. Before planting triple super phosphate at rate of 120 kg/ha was applied and urea at the rate of 240 Kg/ha splitted in two doses after emergence and at earthening up. Weeds were chemically controlled by using Coldal Gold 412.5 at the rate of 4.2 l/ha. Earthening up was done 45 days after planting. Insects mainly aphids, Jassids, white flies and cut worms were controlled by regular chemical spraying with Selecron 720 EC, at the rate of 1 l/ha in the 2$^{nd}$week of January and Actara 75WG at 192 g/ha in the 1$^{st}$week of February. Fungal diseases namely early blight was controlled by using Ridomil at the rate of 2.4 kg/ha applied after earthening up.

The experiments were harvested in the 1$^{st}$ week of March using hand hoes in the two seasons. Data were collected from the two middle rows in each plot at harvest for marketable tuber yield.

The storability parameters i.e. weight loss and sprouting percentage were done after harvest for the eight varieties using a sample of 4- kilogram tubers weight, packed in Jute sacks and stored at Tayfor cold stores at 4°C for six months. Each sample was weighed initially and after storage to calculate percentage weight loss and number of sprouted tubers. The data were analyzed according to the standard statistical procedure (Gomez and Gomez, 1984) using GenStat soft ware. Stability of performance for the tested varieties was carried out following Eberhart and Russell (1966) procedure. A variety with unit regression coefficient (b=1) and deviation not significant from zero (ŝd2 =0) is said to be a stable one.

**Dry matter content:**

Dry matter content was measured in all tested tubers using the potato hydrometer (APH Group, Holland) (Smith, 1987). A random sample (3.660 kg potatoes) was placed in wire basket and was dipped in water in a thirty gallon container. Readings of dry matter

content were taken as soon as the hydrometer came to rest while floating in water. The readings were triplicates for each treatment.

**Results and discussion:**

**Marketable tuber yield t/ha**

The tested potato varieties showed highly significant differences in marketable tuber yield over all sites (Table 1). This result was supported by a number of studies (Mohamed *et al.,* 2011, Elraiah *et al.,* 2018). The overall mean of marketable tuber yield at Khartoum in 2017/18 (19.35 t/ha) was better than in second season 2018/19. The differences between marketable yields over the two seasons could be attributed to the relatively cooler temperatures during the growing season of 2017/18. The two leading potato varieties in Khartoum were Sagita and Fortus which showed higher marketable tuber yield when compared to the check variety Alaska and the overall means over the two seasons. The variation in marketable yield of potato varieties might be due to the response of genotype/ variety factor. According to Marwaha *et al.,* (2007) different varieties had significant influence on marketable yield.

Shendi site in 2018/19 revealed increase in marketable yield compared to 2017/18 (Table 1). Data demonstrated that Sagita and Markies gave the highest marketable yield as compared with the control. Similar observations were reported by Elraiah *et al.*, (2018).

At Dongola location high marketable yield was recorded in 2018/19 compared to 2017/18 which was 30.3 and 17.4 t/ha respectively (Table 1).The outstanding increase in marketable yield could be attributed to the significant decrease in temperatures across the growing season of 2018/19. Sagita gave the highest marketable tuber yield followed by Fortus, Markies and Panamera. These results were consistent with the reports of Mohamed *et al.,* (2011) and Elraiah *et al.,* (2018).

The combined analysis over the three locations in two seasons showed a significant genetic variation among varieties over all environments ($p \leq 0.01$) as well as a significant variety environment (GE) interaction ($p \leq 0.01$), indicating differential performance of some of the tested varieties over the environments (Tables 2 and 3). Varieties: Sagita, Panamera and Challenger had slope around unity (b =1) and deviation not significant from zero ($\hat{s}d_2 = 0.00$), indicating that they were favorable to all environments.

**Tuber Weight (g) and number of tuber per plant:**

These parameters were measured at Khartoum site where it expressed a highly significant variation ($p \leq 0.001$) among the tested varieties (Table 4). Sagita obtained the heaviest tuber weight 119 g in the first season while Alaska exhibited the heaviest tuber weight 128 g in the second season. On the other hand Challenger obtained the lowest tuber weight (78 and 67 g) in the first and second seasons, respectively. Elraiah *et al.*, (2015), observed that varieties with heavy tubers tend to have high yield.

There was significant variation among the tested varieties for the tubers number per plant. Variety Challenger recorded the highest number of tuber in both seasons. Other varieties exhibited the same values in both seasons. Elraiah *et al.*, 2018, found that, varieties differ in number of tuber per plant and tuber weight.

**Days to 50% emergence:**

Days to 50% emergence was recorded at Khartoum site during two seasons 2017/18 and 2018/19. Analysis of variance revealed highly significant variation among the tested varieties (Table 4). The variety Challenger and check variety Alaska were the earliest and latest emerging variety in the first season; they took 18 and 23 days, respectively. On the

other hand, Panamera was the earliest (20 days) emerging variety in the second season and Fortus was the latest (24 days) emerging variety. This will be due to differences with dormancy period. Varieties with short dormancy period emerge earlier than the ones with long dormancy (Mohamed *et al.,* 2011).

**Storability:**

It is well known that storage temperature is an important factor to minimize postharvest losses during storage of potato tubers. Respiration rates of potato tubers have been reported to have a minimum at about 4°C and increase at higher temperatures (Wustman and Struik, 2007). Zaag (1989) concluded that the success of storing potatoes depends on the quality of the harvested tubers, storability of the genotypes and the possibility to regulate temperature and humidity. Results of this study showed variation in dry matter content (Table 5).Challenge gave the highest dry matter content (22.5%) followed by Sagita (21.2 %), Markies (20.6%) and Fortus (20.1%). On the contrary, the check variety Alaska produced tubers with the lowest dry matter content (16.6%). Elraiah *et al.,* (2015), found that, the dry matter content ranged from 20.2 to 16.6. Challenger, Fortus and Sagita exhibited low levels of weight loss (2.1-3.3%), firm tubers and no sprouting .On the other hand, Colombia recorded the highest weight loss (5.4 %) and exhibited moderate sprouting. This agreed with the findings of Elraiah *et al.,* (2015) who reported that the total loss ranged from 2.6 to 4% after 7 months storage and disagreed to Sid Ahmed (2001) who mentioned that, the total loss ranged from 16-19.7%.

**Conclusion:**

The results of the two seasons (2017-2019), at the three locations, namely Khartoum, Dongola and Shendi revealed that variety Sagita was the best in marketable tuber yield (24.1t/ha) than the Check variety Alaska (22.8t/ha) and the overall mean of the trial (20.6 t/ha). Sagita showed high marketable tuber yield and high stability. Varieties Sagita, Fortus and Challenger exhibited no sprouting, least weight loss after 6 months of storage conditions. Also these varieties have high dry matter content compared to the check variety Alaska.

Table (1 )Marketable yield (t/ha) of 8 potato varieties in each of the 6 environment (location/year) and combined environments during 2017/18 and 2018/19 seasons

| Variety | Khartoum | | Shendi | | Dongola | | Combined |
|---|---|---|---|---|---|---|---|
| | 2017-18 | 2018-19 | 2017-18 | 2018-19 | 2017-18 | 2018-19 | |
| Alaska | 27.15 | 26.49 | 10.95 | 20.68 | 19.10 | 32.20 | 22.8 |
| Colombia | 25.05 | 18.45 | 9.12 | 16.85 | 14.96 | 25.06 | 18.2 |
| Evora | 24.45 | 18.75 | 9.62 | 21.23 | 9.00 | 21.13 | 17.4 |
| Fortus | 31.38 | 19.64 | 10.40 | 19.28 | 18.48 | 35.06 | 22.4 |
| Panamera | 18.17 | 22.14 | 9.90 | 20.57 | 18.25 | 33.15 | 20.4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Challenger | 29.95 | 15.65 | 9.60 | 18.58 | 14.18 | 36.19 | 20.7 |
| Sagita | 36.92 | 20.48 | 10.35 | 21.48 | 26.00 | 29.52 | 24.1 |
| Markies | 17.33 | 13.15 | 10.18 | 21.67 | 19.70 | 32.74 | 19.1 |
| Mean | 26.30 | 19.35 | 10.02 | 20.04 | 17.46 | 30.63 | 20.6 |
| SE± | 1.89 | 1.12 | 0.47 | 0.45 | 1.50 | 2.71 | 0.64 |
| LSD (5%) | 5.57 | 3.30 | 1.39 | 1.32 | 4.40 | 7.97 | 1.80 |
| CV % | 14.4 | 11.6 | 9.4 | 4.5 | 17.1 | 17.7 | 15.2 |

Table 2: Combined analysis of Marketable yield for GxSxL interaction ANOVA under homogeneous error-variances

| Source of variation | d.f. | m.s. | F pr. |
|---|---|---|---|
| Location | 2 | 1531.151 | <.001 |
| Season | 1 | 1407.606 | <.001 |
| Location x Season | 2 | 1875.916 | <.001 |
| Residual | 18 | 48.728 | |
| Variety | 7 | 131.858 | <.001 |
| Location x variety | 14 | 83.776 | <.001 |
| Season x variety | 7 | 56.145 | <.001 |
| Location x season x variety | 14 | 49.894 | <.001 |
| Residual | 126 | 9.896 | |

Table (3) Mean marketable tuber yield (t/ha) and stability of potato varieties tested at six environments

| Genotype | Marketable yield (t/ha) | Regression coefficient (b) | Probability | Deviation from regression ($\hat{s}d^2$) |
|---|---|---|---|---|
| Alaska | 22.8 | 0.96 | 1.00 | 9.4 |
| Colombia | 18.2 | 0.77 | 1.00 | 8.2 |
| Evora | 17.4 | 1.2 | 0.39 | 0.51 |
| Fortus | 22.4 | 0.8 | 1.00 | 3.9 |
| Panamera | 20.4 | 0.97 | 1.00 | 11.2 |
| Challenger | 20.7 | 1.3 | 0.48 | 1.2 |

| | | | | |
|---|---|---|---|---|
| Sagita | 24.1 | 1.0 | 0.37 | 0.57 |
| Markies | 19.1 | | | |
| overall mean | | 20.6 | | |
| pooled error | | 27.3 | | |

Table 4: Tube weight, number of tuber per plant and days to 50% emergence during 2017/18 and 2018/19 seasons

| Variety | Tuber weight g | | No. of tuber/plant | | Days to 50% emergence | |
|---|---|---|---|---|---|---|
| | 2017/18 | 2018/19 | 2017/18 | 2018/19 | 2017/18 | 2018/19 |
| Alaska | 92 | 128 | 3 | 4 | 23 | 22 |
| Colombia | 88 | 79 | 3 | 4 | 20 | 21 |
| Evora | 87 | 90 | 4 | 3 | 19 | 23 |
| Fortus | 113 | 85 | 3 | 3 | 21 | 24 |
| Panamera | 75 | 88 | 3 | 4 | 22 | 20 |
| Challenger | 78 | 67 | 5 | 5 | 18 | 22 |
| Sagita | 119 | 103 | 3 | 3 | 21 | 22 |
| Markies | 87 | 102 | 4 | 4 | 22 | 22 |
| Mean | 92 | 93 | 3 | 4 | 21 | 22 |
| Sig. level | 0.01 | 0.001 | 0.03 | 0.001 | 0.001 | 0.004 |
| LSD (5%) | 24.61 | 11.57 | 1.135 | 0.63 | 1.59 | 188 |

| | | | | | | |
|---|---|---|---|---|---|---|
| CV % | 18.2 | 18.5 | 23.2 | 12.7 | 5.2 | 5.8 |

Table 5: Weight loss percentage, dry matter content of potato varieties in season 2018/19

| Variety | Dry mater content % | Weight loss ( %) | Observation 7 months storage |
|---|---|---|---|
| Alaska | 16.6 | 2.6 | Firm, no sprouting |
| Colombia | 16.7 | 5.4 | Moderately, medium firm |
| Evora | 18.9 | 4.6 | Firm, no sprouting |
| Fortus | 20.1 | 2.2 | Moderately, firm |
| Panamera | 19.8 | 4.4 | Moderately, firm |
| Challenger | 22.5 | 2.1 | Firm, no sprouting |
| Sagita | 21.2 | 3.3 | Firm, no sprouting |
| Markies | 20.6 | 3.4 | Firm, no sprouting |
| Mean | 19.5 | 3.5 | |
| $SE^{+}$_ | 0.14 | 0.134 | |
| Sig.level | 0.001 | 0.001 | |
| C.V % | 1.2 | 6..7 | |

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