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Comparative Study of Introduced Potato Varieties under some Arid Conditions of Sudan

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Abstract
A multilocation trail was carried out for three consecutive seasons (2008/09, 2009/10 and 2010/11) to evaluate sixteen promising potato varieties namely; John-76, Safari, Everest, Labadia, Sifra, Triplo, Alaska, Oceania, Banba, Burren, Emma, Orla, Amarin, Lady Olymbia , Lady Rosetta and Diamant in terms of their marketable tuber yield, stability and storability. The Potato varieties were received from Netherlands, France and Scotland by the National Potato Technical Committee, Sudan. Varieties were tested under nine different arid environments (sites x seasons) *viz*. Khartoum (three environments), Dongola (three environments), Shendi (two environments) and Merowe (one environment). Experiments were arranged in a randomized complete block design and a completely randomized design for storage parameters. Significant differences were detected among the tested varieties for marketable tuber yield ranging from 17.7 (Control variety Diamant) to 26.4 t/ha (Burren). Eight varieties namely; Burren, Alaska, Everest, Safari, Emma, Banba, Lady Olymbia and Amarin, gave higher yields than the overall marketable yield mean (22.2 t/ha) across the nine environments. Banba, Alaska and Everest were the firmest, had no sprout after seven-month storage and exhibited the least weight loss (2.6 to 3.0%). Safari was the most stable across the nine environments.
Keywords: Potato tuber, Yield, Environments, Stability, Storability

Introduction
Potato *(Solanum tuberosum* L.) is one of the most important vegetables in the world (Wang *et al.*, 2006). It is fourth most important food crop worldwide after maize, wheat and rice, with production of more than, 323 million tones. Moreover, its nutritional value is higher than most of the food crops. It is considered as the richest source of carbohydrates (Abdul *et al.*, 2013; Ali *et al.*, 2015). In Sudan, Potato is planted as a cash and food crop and plays an important role in the agricultural economy of the country. The area under potato is around 30 thousand hectares with an annual production of 400 000 tones and an average yield of 15 t/ha (Elraiah *et al.*, 2013).

Potato production in Sudan has increased in response to high demand due to urbanization and awareness of its nutritional value (Elraiah *et al.*, 2014). Improved productivity was attained mainly due to the adoption of high yielding varieties and improved production packages, 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.,* 2004; Elraiah *et al.,* 2013). The short growing season (winter) for potato in Sudan followed by a long period of high temperatures requires varieties with special adaptation to high temperature. For many years major improvement in yield and storage could be obtained with varieties, with heat tolerance, earliness and diseases resistance. 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

This multilocation trail was carried out for three consecutive seasons (2008/09, 2009/10 and 2010/11) at Khartoum Farm three seasons(2008/09, 2009/10 and 2010/11), at Dongola Research Farm three seasons(2008/09, 2009/10 and 2010/11), at Shendi Research Farm two seasons (2009/10 and 2010/11) and at New Hamdab Research Farm one season(2010/11) .The soils in the various sites varied from light silt clay loam at Khartoum and Dongola, silt loamy at New Hamdab to clay-non cracking soil at Shendi site (Mohamed *et al.,* 2004). The material consisted of sixteen potato varieties namely; John-76, Safari, Everest, Labadia, Sifra, Triplo, Alaska, Oceania, Banba, Burren, Emma, Orla, Amarin, Lady Olymbia and Lady Rosetta with Diamant as control(released and wide spread grown variety).Varieties received from the Netherlands, France and Scotland by the National Potato Technical Committee, Sudan. The experiment was arranged in a randomized complete block design (RCBD) with four replications. The seed tubers were longitudinally cut into two pieces and planted during the 1st week of December on 70 cm ridges in 20 cm a part hills. Urea at a rate of 240 Kg/ha and triple super phosphate at rate of 120 kg/ha were applied. Weeds removed manually and chemically controlled by (Coldal Gold 412.5 at 4.2 l/ha). Earthing up was done at 45 days after planting. Plots were irrigated as needed and more frequency after earthing up. Insects mainly aphids, Jassids, white flies, cut worms were controlled by regular chemical spraying with Selecron 720 EC, sprayed once, at a rate of 1 l/ha and Actara 75WG at 192 g/ha. Data were collected from the two middle rows in each plot at harvest for:

Marketable tuber yield, number of tubers per plant, average tuber weight (g), and dry matter percent was estimated by a potato hydrometer (APH Holland). The storability parameters i.e. weight loss percent and sprouting were done after harvest of the top eight yielding varieties using a sample of 5-kilograms tubers weight, packed in Jute sacks and stored at Wafra cold stores at 4°C for seven months. Each sample was initially weighed and after storage to calculate percentage weight loss and number of tubers sprouted. Weight loss and tuber sprouting were inspected every two weeks to determine weight loss and number of tubers sprouted. The design used in analyzing storability parameters was a completely random design with three replications.

The data were analyzed according to the standard statistical procedure) (Gomez and Gomez, 1990) 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 ($\hat{s}d^2 = 0$) is said to be a stable one.

Results and Discussion

Marketable tuber yield (t/ha)

In general, highly significant variety variability was observed over all environments, and also observed in a number of studies (Sid Ahmed, 2001; Pervez *et al.,* 2002 and Mohamed *et al.,* 2011). A number of the tested varieties showed higher

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marketable yield when compared to the check (control) variety (Diamant). (Table 1**)**

Table 1: Marketable tuber yield (t/ ha) of 16 potato varieties grown at various locations during three seasons

Varieties	Khartoum				Dongola				Shendi			Merowe
	2008/09	2009/10	2010/11	Mean	2008/09	2009/10	2010/11	Mean	2009/10	2010/11	Mean	2010/11
John-97	4.6	18.8	-	11.7	37.4	22.9	-	30.2	11.3	-	11.3	-
Safari	14.6	16.5	31.0	20.7	41.7	28.4	38.5	36	9.3	15.7	12.5	22.1
Everest	9.4	12.4	40.8	20.9	50.5	24.9	49.1	41.5	6.4	17.1	11.8	17.2
Labadia	9.6	5.3	25.9	13.6	39.1	36.2	38.2	37.8	4.6	4	4.3	11
Sifra	12.2	13.2	26.3	17.2	30.8	27.1	41.8	33	6.9	13.6	10.3	16.2
Triplo	12.9	20.1	27.5	20.2	30	24.5	37.6	30.7	12.3	15.3	13.8	15.2
Alaska	10.3	17.5	31.8	19.9	41.9	36.3	51	43	11.9	11.3	11.6	16.5
Oceania	7.1	11.2	29.3	15.9	34.8	30.3	37.1	34	7.4	13.5	10.5	16.6
Banba	6.1	8.5	28.3	14.3	48.3	32.2	51.8	44	6.3	9.3	7.8	23
Burren	11.7	9.7	32.1	17.8	37	39.6	60.9	45.8	6.6	17.1	11.9	23.5
Emma	10.4	5.7	30.2	15.4	45.4	34.4	46.9	42.2	5.1	17.8	11.5	19.6
Orla	12.3	5.3	21.3	13	28.5	39.4	40.4	36	3.9	11.8	7.9	13.8
Amarin	9.7	13.1	28.1	16.9	34.7	26.2	49.4	36.8	8.4	15.7	12.1	20.4
Lady Olymbia	8.9	17.8	-	13.4	45	33.7	-	39.4	4.9	-	4.9	-
Lady Rosetta	6.6	14.9	-	10.8	39.3	31.1	-	35.2	5.4	-	5.4	-
Diamant	4.6	9.6	25.1	13.1	34.9	33.9	41.6	36.8	6.5	9.2	7.9	16.1
Mean	9.4	12.5	29.1	15.9	38.7	31.3	44.9	38.3	7.3	13.2	10.3	17.8
SE±	1.4	1.7	3	1.65	3.8	1.2	3.9	1.8	1.1	1.4	1.35	4.5
Significance	***	***	***	***	***	***	***	***	***	***	***	***
C.V%	29.6	27.6	18.1	25	17	6.4	17.6	8.5	27.9	18.5	22	15.2

*** Significant at 0.001 probability level

The overall marketable tuber yield mean of Khartoum environment 2010/11 was 29.1 t / ha which was much higher than the mean at Khartoum environments 2008/09 and 2009/10 where marketable tuber yield ranged between 9.4 and 12.5 t/ha, respectively (Table 1). The outstanding increase in marketable yield could be attributed to the significant decrease in temperatures across the growing season (2010/11). The marketable tuber yield of the control variety Diamant was even less than the overall marketable yield of locations (13.31 t/ha).

Compared to Diamant seven of the tested varieties namely; Everest, Safari, Triplo, Alaska, Burren, Sifra and Amarin were prominent across Khartoum three environments in terms of marketable yield. Their mean percent increase over the control variety Diamant ranged from 30% to 60%.

The three environments of Dongola are characterized by relatively cooler temperatures and longer winters than other environments. This has a significant impact on marketable tuber yield which has increased obtaining an average of 37.7t/ha and a percent increase of 180% over other

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locations (Table 1). This is mostly due to the relatively cool and long winter season, highly fertile soil and less pests and diseases (Elraiah *et al*., 2013). The best marketable tuber yield was observed at Dongola environment 2010/11 (44.9 t/ha) compared to 38.7 t/ha and 31.3 t/ha in Dongola environments 2008/09 and 2009/10, respectively. Similarly, this could be attributed to the relatively cooler temperatures during the growing season of 2010/11. Seven leading varieties namely; Burren, Banba, Alaska, Emma, Everst, Lady Olymbia and Labadia have exceeded the control variety Diamant, at Dongola environments; with average percent increase in marketable yield ranged from 2% to 25%.

Yield at Shendi environments 2009/10 and 2010/11 was comparatively low average marketable tuber yield (9.7t/ha) (Table 1). Shendi environment 2010/11, a comparatively cooler environment, reported 13.2 t/ha while only 7.3 t/ha marketable tuber weight was obtained at Shendi environment 2009/10. A similar observation was obtained by Mohamed *et al.,* (2004).

At both Shendi environments, ten of the tested varieties (Triplo, Safari, Amarin, Burren, Everest, Alaska, Emma, John-97, Oceania and Sifra) gave a higher marketable tuber yields than the check variety (Diamant); with average percent increase over Diamant ranged from 34% to 75%.

At the ninth environment (Merowe 2010/11) the marketable tuber yield was more or less comparable to Khartoum environments (Table 1). Six of the tested varieties namely: Burren, Banba, Safari, Amarin, Emma and Everest showed higher yield when compared to the control variety (Diamant). Average percent increase in marketable yield ranged from 7% to 46%. This result is consistent with the findings of Veerman and Wustman, (2006). In general, the combined analysis over the nine environments revealed a significant genetic variation 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. Variety Safari had b =0.85 and deviation not significant from zero($\hat{s}d^2$ =1.4), indicating that it was favorable to all environments; while Burren, Alaska, Everest, Emma and Banba had b›1 indicating that they were responsive to favorable environments. On the other hand lady Olymbia was the least stable one with b=0.39 and deviation significant from zero ($\hat{s}d^2$ =26.4) (Table 3).

Table 3: Mean marketable tuber yield (t/ha) and stability of 16 potato varieties tested at 9 environments

Variety	Marketable yield (t/ha)	Regression coefficient (b)	Deviation from regression ($\hat{s}d^2$)
John-97	21.9	0.922	16.517**
Safari	24.2	0.851	1.442
Everest	25.3	1.254	28.589**
Labadia	19.5	1.159	17.538*
Sifra	20.9	0.846	0.639
Triplo	21.7	0.641	3.348
Alaska	25.4	1.147	4.46
Oceania	20.8	0.918	-2.911
Banba	23.7	1.347	8.868
Burren	26.4	1.295	28.673**
Emma	23.9	1.216	3.549
Orla	19.6	0.971	27.862**
Amarin	22.8	0.11	10.3
Lady Olymbia	23.3	0.391	26.413**
Lady Rosetta	18.5	0.773	30.041**
Diamant	17.7	0.787	24.879**
Mean		22.2	
Pool error		5.88	

*, ** Significant at 0.05and 0.01 probability levels, respectively

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Number of tubers per plant

There was a highly significant variation ($P \leq 0.001$) among the tested varieties in the number of tubers per plant across all environments ranged between 3 - 11tubers per plant (Table 2). The tested varieties responded differently to the environmental conditions. For example at Khartoum the variety Orla showed the highest number of tubers per plant (7) and Amarin had the least number of tubers per plant (3). More variability appeared at Dongola environment where the varieties Oceania and Everest showed the highest (11) and lowest (5) number of tubers per plant. Also different varieties showed up at Merowe site (Alaska and Banba). Despite this variable performance across the environments, it was observed that high yielding varieties tend to have low number of tubers per plant (Mohamed *et al.,* 2011).

Tuber Weight (g)

This parameter was measured at Khartoum and Merowe sites where it expressed a highly significant variation ($p \leq 0.001$) among the tested varieties (Table 2). Triplo obtained the heaviest tuber weight 136 g at Khartoum site. At Merowe Triplo also showed the heaviest tuber weight (94 g) followed by Burren (93 g) and Everest (92 g). It is observed that varieties with heavy tubers tend to have high yield. Similar results were obtained by Mohamed *et al.*, (2004).

Table 2: Number of tubers per plant and average tuber weight of 16 potato varieties grown at different sites in season 2010/11

Variety	Khartoum		Dongola		Shendi	Merowe
	Tuber/plant	**weight (g)**	Tuber/plant	**weight(g)**	Tuber/plant	Tuber/ plant
Safari	5	101	6	75	5	5
Everest	5	80	5	92	3	3
Labadia	4	127	7	57	4	3
Sifra	6	89	7	72	3	4
Triplo	4	136	7	95	4	3
Alaska	6	86	8	45	5	7
Oceania	6	82	11	80	4	5
Banba	7	76	10	69	4	7
Burren	6	93	9	93	4	5
Emma	5	80	9	60	6	6
Orla	6	68	10	47	4	6
Amarin	3	84	8	71	4	5
Diamant	5	77	9	66	4	5
Mean	5.	91	8	71	4	5
SE±	0.5	6.3	0.6	7.9	0.4	0.6
Significance	***	***	****	***	***	***
CV %	18.2	12	15.5	19.4	17.5	20.8

*** Significant at 0.001 probability level

Storability

The potato is a semi - perishable commodity. The purpose of storage is to maintain tubers in their most edible and Marketable condition and to provide a uniform flow of tubers to market and processing throughout the year (Maldegem, 1999). Storage losses are mainly caused by the processes like respiration, sprouting, evaporation of water from the tubers, spread of diseases, changes in the chemical composition and physical properties of the tuber and damage by extreme temperatures (Burton *et al.*, 1992). The results in table 4

show that, five leading varieties namely; Burren, Alaska, Everest, Safari and Banba when stored for 7 months exhibited low levels of weight loss (2.6 to 4.0%), firm tubers and no sprouting. On the contrary, the check variety Diamant lost up to 5% of its weight and exhibited moderate sprouting. These results explained that, the potato varieties differ in their response to storage. This agreed with the findings of Elraiah *et al.,* (2014) who reported that the total loss ranged from 4.2 to 7.5% after 7 months storage and disagreed with Sid Ahmed (2001) who mentioned that, the total loss ranged from 16-19.7%. The results obtained showed variations in the dry matter content. Oceania had the highest dry matter content (22.2). On the other hand, Labadia was the lowest dry matter (16.4). Everest and Banba with the high yielding gave high dry matter content over check variety Diamant. Beukema and Vander Zaag 1990 mentioned that, the smaller size tubers showed high dry matter content than the larger ones. Similar results were recorded by Hassan (1999).

Conclusions

Based on the results obtained in this study it can be concluded that:

1. Varieties Burren, Alaska, Everest, Safari, Emma, Banba, Amarin, and Lady Olymbia were higher in marketable tuber yield than the average yield (22t/ha) over the nine tested environments.
2. Variety Safari was favorable to all environments; while Burren, Alaska, Everest, Emma and Banba were responsive to favorable environments. On the other hand lady Olymbia was the least stable one.
3. The leading varieties (Burren, Alaska, Everest, Safari, and Banba) exhibited no sprouting, good tuber firmness and the least weight loss, after 7 months storage conditions.

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دراسة لتقييم بعض أصناف البطاطس المستوردة فى بعض أراضى السودان الجافة

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المستخلص:

اجريت تجربة متعددة المواقع لفترة ثلاثه مواسم متتاليه 2008/2009 ، 2009/2010 و 2010/2011 لتقييم 16 صنف بطاطس (John–76, Safari, Everest, Labadia, Sifra, Triplo, Alaska, Oceania, Banba, Burren, Emma, Orla, Amarin, Lady Olymbia and Lady Rosetta) من حيث الانتاجية والتخزين . تم استيراد هذه الاصناف من هولندا وفرنسا واسكتلندا بواسطة اللجنة الفنية القومية للبطاطس وزرعت الاصناف في 9 مواقع مختلفه في الخرطوم، دنقلا، شندي ومروي. نفذت التجارب بواسطة تصميم القطع العشوائية الكاملة والتصميم كامل العشوائي. ظهرت اختلافات معنوية في انتاجيه الاصناف وتراوحت بين 17.7 (Diamant) الي 26.4 (Burren) طن/ه كتار. ثمانيه اصناف Burren, Alaska, Everest, Safari, Emma, Banba, Lady olymbia and Amarin اعطت انتاجية اعلي من متوسط المواقع المختلفه 22.2 طن/ه كتار. الاصناف Banba, Alaska and Everest تتحمل ظروف التخزين وحصلت علي اقل نسبة فقد للوزن 3%–2.6 وتمتاز بالصلابه ولم يحدث فيها تنبيت للدرنات بعد 7 شهور من بداية التخزين. اما الصنف Safari اعطي افضل انتاجية في كل المواقع.

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