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Yield Performance of Potato Seed Tubers After Storage in a Diffuse Light Store (DLS)

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Abstract

An on-farm trial was carried out at KARI (Tigoni) and in Nyandarua County in central Kenyan highlands to determine the yields of some common potato cultivars following storage in a diffuse light store (DLS) for eight months. The trial was carried out for two consecutive seasons i.e. March-July 2012 (first season) and October 2012 to February 2013 (second season). Eight potato cultivars commonly grown in Kenya and of different maturity periods were used. In Nyandarua, the experiment was carried out in three farmers' fields while the KARI Tigoni station was meant for comparison. In each site, the experiment was a split-plot with potato cultivars as main-plot factor and storage as sub-plot factor. There were three replications in each site. Planting of tubers after storage in DLS gave significantly ($P \leq 0.05$) more yields than planting freshly harvested tubers. This difference was observed both on the farmers' fields and at KARI Tigoni research station.

Keywords: diffuse light store, potato cultivars, on-farm storage

1. Introduction

The potato is an important food security crop in Kenya second only to maize in terms of production and utilization. It is grown in the highlands (1800-3000) mostly by small-scale farmers as an important food and cash crop (MoA, 2008; ANN, 2009). In the Kenyan highlands, potato is grown by about 800 000 farmers, on 158 000 hectares per season, with an annual production of about 1 million tonnes in two growing seasons (Riungu, 2011). In these highlands, farmers can grow three potato crops per year unlike maize, which takes up to 10 months to mature (Kinyae et al., 2004). Therefore potato is a steadier source of income in these areas. Despite the importance of the crop, potato sector is plagued by numerous problems such as lack of proper pest and disease management, a disorganized marketing system, lack of clear policies on packaging, lack of clean seeds and poor storage facilities (Riungu, 2011; The Organic Farmer, July 2012). Kenya produces less than 1% of the national certified seed demand. Because of this, the certified seeds are highly priced and are beyond reach of most small-scale farmers. Because of shortage of clean planting materials, farmers are forced to plant seeds from informal sources such as farm-saved (self supply), local markets or neighbours. The use of seeds from informal sources has led to low yields, poor quality produce, and spread of pests and diseases (GIZ-PSDA Kenya, 2011; Riungu, 2011). What worsens the situation is that although 90% of farmers store their own seeds, only four percent have received training on proper seed storage (The Organic Farmer, July 2012). Therefore, when the rains finally come, farmers are forced to plant whatever potato tubers are available, whether well sprouted or not. Planting of unsprouted seed tubers results in plants with one or two stems and poor stand establishment leading to low yields. Such tubers also take long to emerge in the field and the plants mature late in the season; such a crop suffers from moisture stress and other pests such as aphids. In addition, climate change has led to low and erratic rainfall. In such uncertain situations, only well spouted seed tubers have a chance of carrying a potato crop to maturity. Therefore, availability of well sprouted seed tubers at the beginning of each planting season will go a long way in increasing potato productivity and yields in the Kenyan highlands.

Potato seed tubers should be allowed to pass through their normal period of dormancy and to sprout naturally. However, in the intensively cultivated Kenyan highlands where two or three potato crops are grown in a year, the

seeds are needed before the natural dormancy-breaking is over. Although various chemicals have been used to break dormancy, most of them are either expensive or unavailable to local farmers or have been banned due to environmental pollution. The resource-poor farmers accelerate seed tuber sprouting by placing them in pits, trenches or in sisal gunny bags. However, these methods lead to high storage losses due to pests such at potato tuber moth and diseases (Shibairo et al., 2006). In addition, potato seed sprouted in pits show apical dominance, they may rot or have shoot etiolation due to dark conditions. Diffuse light store (DLS) developed by the International Potato Centre (CIP) can be used for seed storage for up to five or six months (Demo, 2002). Storage in DLS has been shown to delay the physiological ageing of the tubers and to reduce apical dominance resulting in more, short and firm sprouts per tuber (CIP, 1985). This translates into more stems and hence more yields since potato is a stem tuber. In addition, there are less storage losses from pests and diseases because the crop can be easily monitored. Against this background, an experiment was set up whose objective was to determine the yields of some potato cultivars commonly grown in Kenya after storage in DLS for eight months.

2. Materials and Methods

The experiment was carried out for two consecutive seasons i.e. March-July 2012(first season) and October 2012 to February 2013 (second season). Eight potato cultivars of different maturity periods were used (Table 1).

Table 1. Characteristics of the potato cultivars used in the study

Potato cultivar	Source of original germplasm	Year of release in Kenya	Yield (ton/ha)	Maturity period (months)
Kenya Karibu	CIP	2003	35-45	3-4 (>110 days)
Kenya Mavuno	CIP	2003	35-40	4 (>120 days)
Sherekea	CIP	2010	35-45	3-4 (>110 days)
Tigoni	CIP	1998	35-45	3-4 (>110 days)
Asante	CIP	1998	35-45	3-4 (>110 days)
Dutch Robyjn	Netherlands	1945	35-40	3-4 (>110 days)
Desiree	Netherlands	1972	35-45	3-4 (>110 days)
Roslin Bvumbwe	Scotland	1974	35-45	3-4 (>110 days)

Ten kilograms of seed tubers of each cultivar were placed in a net bag and stored in a DLS at KARI Tigoni and also with six farmers in Nyandarua county for eight months at ambient temperatures and natural ventilation. The DLS at KARI Tigoni consists of a wooden structure with iron sheet roofing. The wooden planks on the sides are spaced and some iron sheets replaced with transparent sheets to allow in more light. The inner side of the DLS is lined with netting to keep off insect pests and vectors. The farmers' DLS are similar to the one at KARI Tigoni except there is no insect-proof netting. After storage, the potato cultivars were planted out at KARI Tigoni (2100 masl) and at six farmers' fields (>2600 masl). In each site, the experiment was a split plot laid out in a randomized complete block design with cultivars as main plots and storage as sub-plot and with three replications. The subplot had two levels: tubers stored under DLS for eight months and freshly harvested tubers. Each subplot consisted of one 10 meter long row with a plant population of 33 plants. Plants were spaced at 75 x 30cm and during planting, DAP (18%N: 46%P_2O_5) was applied at the recommended rate of 500 kg/ha. Weeding, earthing-up and spraying against pests and late blight were carried out as per recommendations for potato production in Kenya.

Data was collected at KARI Tigoni and at three farms (Kagema, Pyhort and Mr. Wairegi's). The other three farmers did not have credible data and so were not included in the analysis. For data collection, ten plants in each subplot were randomly sampled. Tubers from each sampled hill were separately harvested. Data collected included number and weight of tubers per hill as were as the weights of various categories of tubers. These categories were ware (>60mm in diameter), seed (28-60 mm) and chatts (<28 mm). These were then averaged across the ten hills. Data was the analyzed using Genstat statistical package, 14th edition (Payne et al., 2011) and means separated using Tukey's Test at 5% (Steel & Torrie, 1980).

Weather data was collected from the nearest meteorological stations which were less than 300 meters from the experimental sites.

3. Results and Discussion

Generally the second season experienced higher temperature than the first season at KARI-Tigoni (Table 2). Generally, KARI-Tigoni experienced higher temperatures than the other sites (Table 2, 3, 4). All the sites had cool temperature and ample rainfall that are favourable for potato production.

Table 2. Weather data during the experimental period at KARI-Tigoni

	2012										2013	
	First season							Second season				
Month	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Total rainfall (mm)	49.1	690.1	3751.3	521	26	100.3	113.1	413.3	248.3	291.5	91.2	5.1
Number of rainy days	3	20	24	10	4	2	4	13	15	10	6	2
Mean air temp (°C)	19.3	16.5	17	14.1	13.9	16.0	22.6	23.5	22	21.7	24	45.3

Table 3. Weather data during the experimental period at Pyhort and Kagema

	2012										2013	
	First Season							Second season				
Month	March	April	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Jan.	Feb.
Total rainfall (mm)	3.5	267	206	106	173.6	142.3	80	120.7	34.6	77.2	55.3	0
Number of rainy days	1	18	0	13	20	14	3	10	4	5	3	0
Mean air temp. (°C)	15.9	16.5	15.1	14.4	15.8	13.9	14.1	15.1	15.3	16.9	15.1	18

Table 4. Weather data during the experimental period at Mr. Wairegis

	2012										2013	
	First Season							Second season				
Month	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Total rainfall (mm)	65.3	830	2013	1123	120	150	95	351	325	312	65	10
Number of rainy days	5	19	21	12	3	2	3	6	5	5	3	1
Mean air temp. (°C)	17.2	14.2	13.2	10.2	11.2	14.2	15.3	16.2	14.3	15.6	14.6	13.5

There were significant ($P \leq 0.05$) differences among potato cultivars, between the storage methods and in cultivar x storage interaction in terms of total tuber yields in both seasons at KARI Tigoni (Table 5). This could have been due to the wide genetic variation that exists among potato cultivars with regards to tuber dormancy (Suttle, 2007).

Table 5. Total tuber yields (ton/ha) over the two seasons at KARI Tigoni

		Second season		First season	
Source of variation	d.f.	m.s.	F pr.	m.s.	F pr.
Block	2	15.32		104.79	
Potato cultivar	7	173.55	0.041*	98.11	0.003**
Error a	14	59.21		18.00	
Storage	1	4502.75	<.001**	5845.46	<.001**
Cultivar x Storage	7	96.88	0.036*	49.21	0.014*
Error b	16	33.31		13.26	
Total	47				

*=significant at P≤0.05; **=significant at P≤0.01; ns= non significant.

In addition, the mean yields in the second season (44.86 tons/ha) were higher than the first season (28.76 tons/ha). This could have been due to the higher temperature experienced in the second compared with the first season (Table 2).

Generally, the DLS – stored seed tubers out-yielded the freshly harvested ones (Figures 1 and 2). In the first season Sherekea gave the highest yields followed by Kenya Karibu while in the second season, Sherekea gave the highest yield followed by Asante (Figure 2).

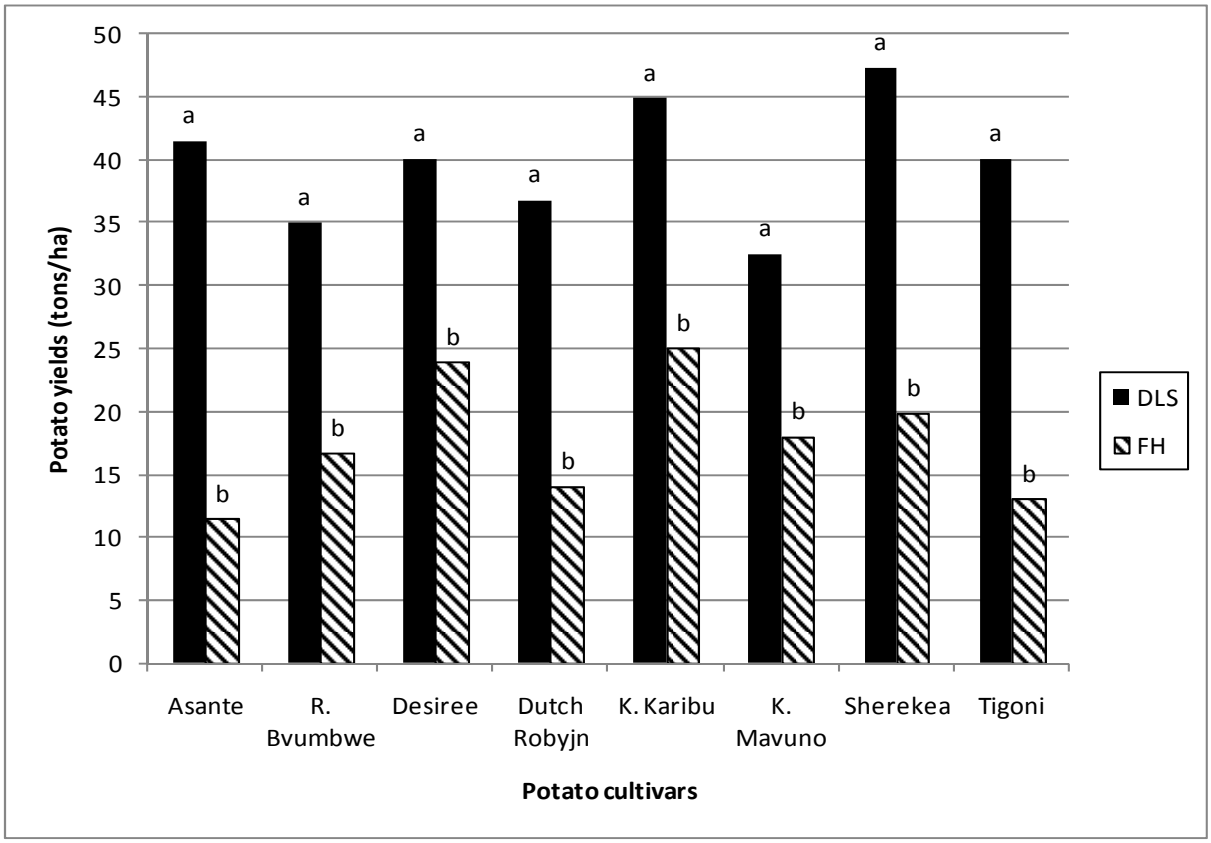

Figure 1. Tuber yields of the various potato cultivars in the first season at KARI Tigoni

DLS= Diffuse light store; FH= Freshly harvested.

For each potato cultivar, columns headed by the same letter are not significantly (P≤ 0.05) different from each other.

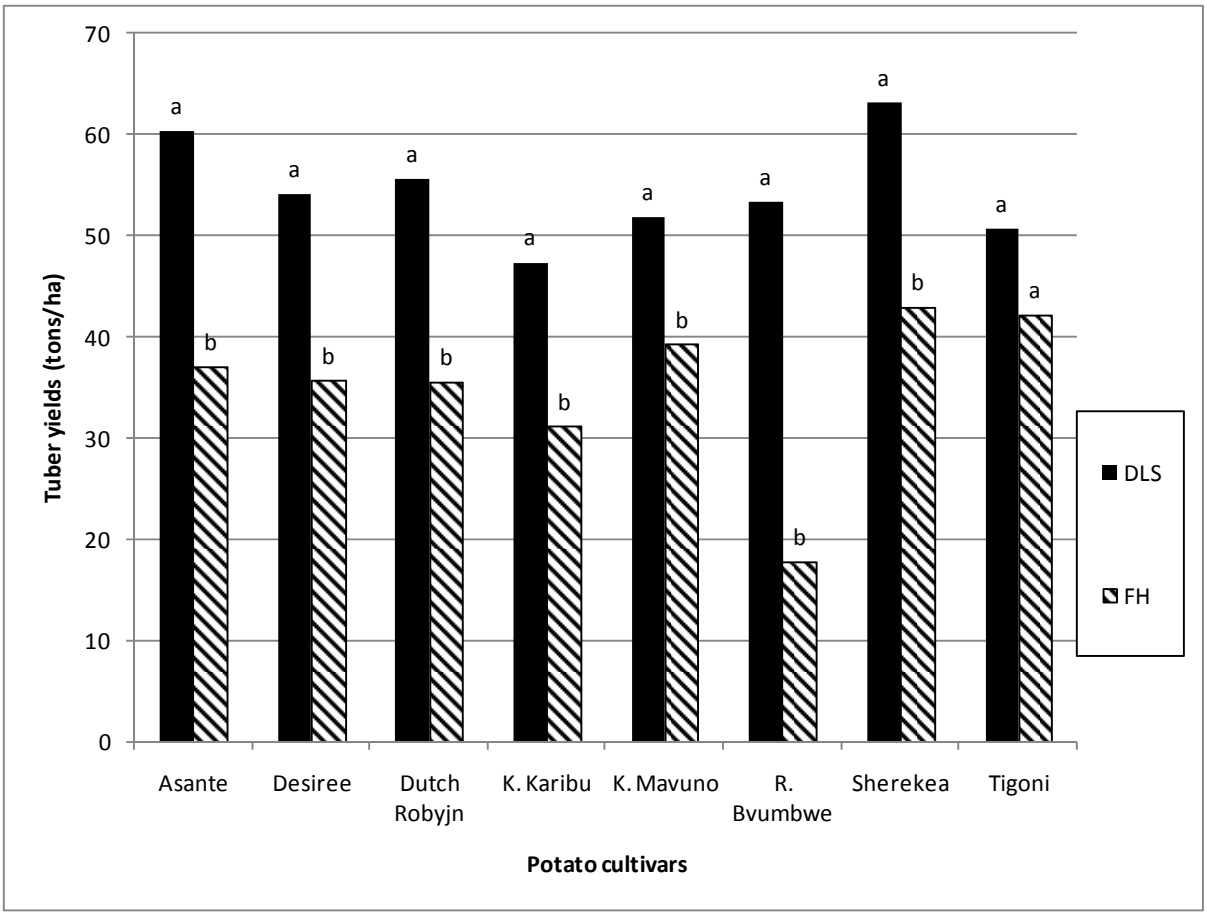

Figure 2. Tuber yields of the various potato cultivars in the second season at KARI Tigoni

DLS= Diffuse light store; FH= Freshly harvested.

For each potato cultivar, columns headed by the same letter are not significantly (P≤ 0.05) different from each other.

There were significant differences in yields of different tuber size categories among the potato cultivars and between the storage methods in both seasons at KARI Tigoni (Table 6).

Table 6. Yields (ton/ha) of different tuber sizes in both seasons at KARI Tigoni

		First season			Second season		
		Ware	Seed	Chatts	Ware	Seed	Chatts
Source of variation	d.f.	F pr.	F pr.	F pr.	F pr.	F pr.	F pr.
Block	2						
Potato cultivar	7	0.002**	0.148ns	0.620ns	0.002**	0.023*	0.003**
Error a	14						
Storage	1	<.001**	<.001**	<.001**	0.005**	<.001**	<.001**
Cultivar x storage	7	0.005**	0.110ns	0.317ns	0.023*	0.018*	0.247ns
Error b	16						
Total	47						

*=significant at P≤0.05; **=significant at P≤0.01; ns= non significant.

In the first season, storage methods gave significantly (P≤0.01) different yields in all the three potato tuber size categories. The potato cultivar and the interaction between cultivar and storage gave significantly (P≤0.01) different yields in the ware size category only (Table 6).

In the second season, seeds were the most followed by ware while chatts were the least across all potato genotypes (Table 7). Seed tubers stored under DLS gave significantly (P≤0.05) higher yields than freshly harvested ones in terms of ware and seed sizes; no significant differences were observed in the chatts.

Table 7. Yields (tons/ha) of different potato tuber size categories in the second season at KARI Tigoni

	Ware		Seed		Chatts	
	DLS	FH	DLS	FH	DLS	FH
Asante	22.3b	12.7a	33.7b	20.0a	4.4a	4.4a
Desiree	6.5a	5.2a	40.7b	25.2a	7.0a	5.2a
Dutch Robyjn	15.5a	10.4a	33.4b	20.8a	6.7a	4.3a
Kenya Karibu	10.1a	13.6a	32.9b	14.8a	4.4a	2.7a
Kenya Mavuno	16.7a	18.5a	30.7b	17.8a	4.5a	2.9a
Roslin Bvumbwe	18.3b	7.4a	30.5b	6.8a	4.6a	3.6a
Sherekea	31.1b	19.0a	27.4b	19.6a	4.7a	4.4a
Tigoni	12.7a	14.7a	32.1b	22.8a	5.8a	4.7a
Mean	16.6	12.7	32.7	18.5	5.2	4.0
Mean	Ware = 14.7		Seed = 25.6		Chatts = 4.7	

Within each tuber size category and within each potato cultivar, numbers followed by the same letter are not significantly (P≤ 0.05) different from each other.

Across the two seasons, the farmers had significantly different yields (Figure 3). The cultivars were also significant and the interaction between storage method, cultivar and farmer was significant (Figure 3). Generally, Wairegi had lower yields than the other two farmers; his field was flooded most of the times during crop growth. All the three farmers got more than the national average of less than 10 ton/ha. This is probably due to the fact that they had previously been taught on good potato management practices.

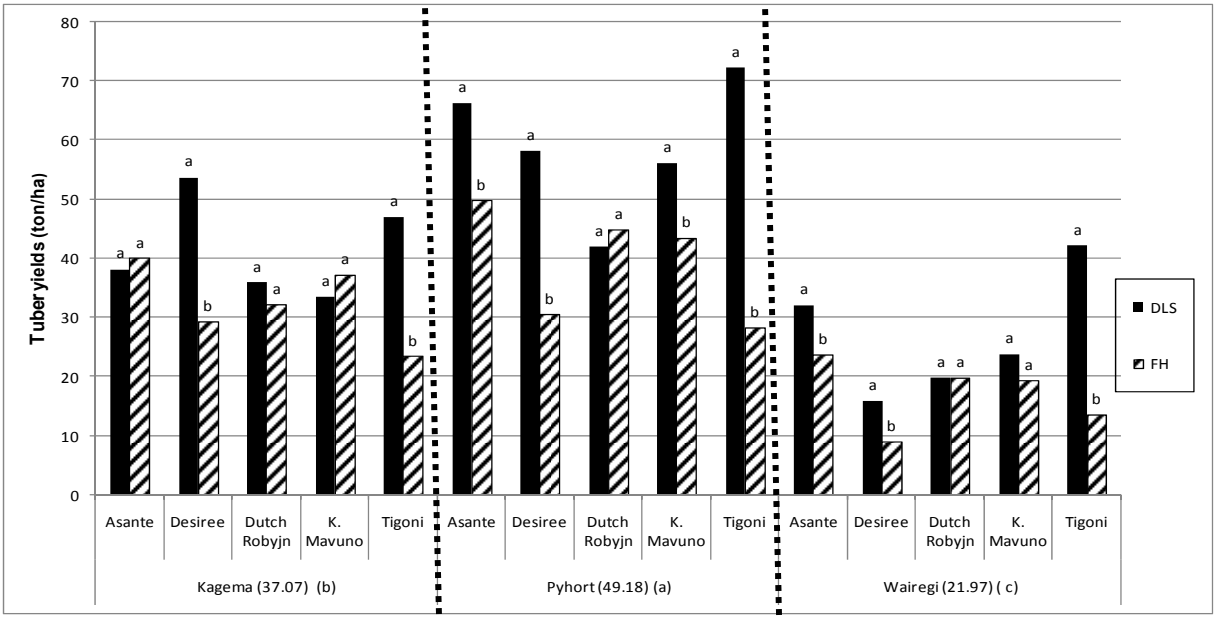

Figure 3. Average tuber yields of the various potato cultivars among the three farmers across the two seasons DLS= Diffuse light store; FH= Freshly harvested.

Within each farmers and within each potato cultivar, numbers followed by the same letter are not significantly ($P \leq 0.05$) different from each other. Five potato cultivars planted by both the farmers and at KARI Tigoni (i.e. Asante, Tigoni, K. mavuno, Desiree and Dutch Robyjn) were used to compare the farmers (site1) and KARI Tigoni (site 2). There was no significant difference between the total tuber yields attained by the three farmers averaged across the two seasons (site 1) and the yields attained at KARI Tigoni averaged across the two seasons (site 2) (Table 8). There was a highly significant difference ($P \leq 0.01$) in total tuber yields between the storage, its interaction with site, cultivar and the interaction of all the three (Table 8).

Table 8. Analysis of variance. Comparison of total yields between farmers and Kari Tigoni in both seasons

Source of variation	df	ms	Fpr.
Block	2	4.747	
Site	1	6.534	0.225ns
Error a	2	2.176	
Cultivar	4	52.119	0.028*
Site x cultivar	4	47.548	0.038*
Error b	16	14.418	
Storage	1	3878.496	<.001**
Site x Storage	1	153.600	<.001**
Cultivar x Storage	4	129.190	<.001**
Site x Cultivar x Storage	4	153.873	<.001**
Error c	20	7.961	
Total	59		

The lack of difference between farmers' yields and the yields attained at KARI Tigoni (Table 8) could possibly be due to the fact that these farmers had been taught on good ware potato production practices and they are applying these practices on their farms. All the seven farmers come from Nyandarua; farmers and extension agents in this area have previously received a lot of training on potato production by researchers from KARI Tigoni. From this experiment, it appears that storing potatoes in DLS for 8 months led to an increase in yields compared to planting freshly harvested tubers in all the cultivars tested.

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