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Agronomic Performance of Onion (*Allium cepa* L.) Varieties in Buno Bedele and Ilu Ababor Zones, Southwestern, Ethiopia

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Abstract

Onion is widely produced in Ethiopia for domestic consumption and also generate income for the producers. However, lack of well adapted varieties across the potential agro-ecologies is one of the constraints for low yield. Hence, adaptation trial of Onion varieties were conducted in Buno Bedele and Ilubabor Zone to evaluate the performance and adaptability of introduced and improved varieties in different onion varieties. Six onion varieties including local check were evaluated for their vegetative growth performance and bulb yield under rain fed conditions in Randomized Complete Block Design with three replications. Data on different important characters were collected and analyzed using SAS Software of 9.4 version. Thus, combined analysis of data revealed that, varieties showed highly significant at ($P < 0.01$) for days to maturity, bulb length, bulb diameters, Marketable bulb yield, unmarketable bulb yield and total bulb yield. Accordingly, the highest marketable bulb yield was obtained from variety Nafis (9.89 t ha^{-1}) followed by Local (6.12 t ha^{-1}), while the lowest marketable bulb yield was obtained from variety Nafid (2.60 t ha^{-1}). The result of the correlation analysis also revealed that bulb length and bulb diameter were significantly and positively correlated with Marketable bulb yield. Thus, Nafis variety which followed by local variety showed better performance with its mean yield and yield component. Thus, Nafis variety is recommended to be demonstrated on farmer's field for further scaling up.

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Bulb yield, Nafis, Onion, *Allium cepa* L.

Introduction

Onion (*Allium cepa* L.) is one of the bulb crops belonging to the family Alliaceae. It is an important bulb crop in the world. Regarding area coverage, worldwide 5,039,908 hectares of land and 96,773, 818 tons and in Africa 953,123 hectares of land and 12,453,010 tons of dry onion bulbs were produced annually (1). It is an important cash crop for Ethiopian farmers hence the crop is produced in different parts of the country for local consumption (2). Currently, onion is a popular crop relatively its recent introduction to the country because of its yield potential per unit areas, the presence of high domestic and export markets and easily propagated by both seed and bulb method (3).

Ethiopia has massive potential to produce the crop throughout the year both for domestic use and export market. Its production also contributes to commercialization of the rural economy and creates many job opportunity (4). It is well adapted to highland and low land soils of the country. In Ethiopia a total area 36,373.48 hectares of land was under onion production with total annual bulb production of 2.07 million t ha^{-1}.The average productivity of onion in Ethiopia is 8.23 t ha^{-1} which is lower than world average (20.32 t ha^{-1}) (5).

In Oromia the area covered by onion was 14,566.55 hectars and production in was 1.01 million tone which lower than yield of national level (5). The agro-ecologies of Buno Bedele and Ilubabor zones are suitable for cultivation of any types of horticultural crops including onion. In Buno Bedele and Ilubabor zone over 8407 households are producing onion (5). Despite suitability of soil and climate of the areas, there were no works done in introducing and evaluating adaptability of improved varieties of onion on the study area.

Currently, improved varieties have been released for high land and mid altitude agro ecology by research system. Thus it was good opportunity to introduce those varieties and evaluate their feasibility under specific ecological condition to increase productivity of onion production. Thus, objective of this study was to identify adaptable, high yielding and diseases tolerant onion varieties for study area and similar agro ecology.

Materials and Methods

Description of Study Area

The experiment was conducted at Dabo Hana and Bure Districts districts during 2022-2023 main cropping seasons. Dabo Hana district located in Buno Bedele Zone, Oromia Region, Southwest Ethiopia. The district bounded by Chawaka District in North, East Wollega Zone of Jimma Arjo district in the East, Bedele district in South, Mako, Dega districts and West Wollega Zone in West. It is located between 08°30'28.7" to 08°41'34.6"N and 036°26'19.2" to 036°30'41.1" E with altitude ranging from 1791 to 1990 masl (6). The minimum and maximum annual air temperatures are 12.9 and 25.8°C, respectively, The predominant soil type in Southwest and Western Ethiopia in general and the study area in particular, is Nitisols according to the soil classification syste (6). Nitisols are highly weathered soils in the warm and humid areas of the west and southwest Ethiopia (6).

Bure is one of the district in Oromia Region of Ethiopia and part of the Ilubabor Zone. The District is bordered on the south by Nono,on the southwest by Gambela Region, on the west by Kelem Welega Zone, on the northeast by Matu and on the southeast by Alee. The mean annual rainfall and mean annual temperature of Bure districts are 1340mm and 220C respectively (6) Agriculture is the main economic activity and source of livelihood in the study area. The major cereal crops grown in the area include maize and sorghum. From horticulture and spice crop hot pepper is the major crop in the district (6).

Experimental Material, Treatments and Design

The experiment consists of six Onion varieties namely Robaf, Nafis, Nasic Nafid and Adama red from Melkasa Agricultural research center while farmers' variety (local) bought from union for comparison. The design of the experiment was Randomized Complete Block Design in three replications. Each variety was planted in the main field in a gross plot size of 2.4m*3.2m (7.68m^2) with recommended spacing double rows, rows and plants were 40cm, 20cm and 10cm respectively (8). The three middle rows were used for data collection leaving the two rows as borders. All agronomic practices (transplanting time, cultivation, and weeding and fertilization application) were applied uniformly for all plots according to the recommendation of the crop.

Raising and Transplanting Seedlings

Land preparation for the nursery bed was done using human labor. The seeds of the Varieties were drilled by hand onto four nursery beds of 1 m width and 5 m length. After sowing, the beds were covered with dry grass mulch until emergence for the purpose of conserving moisture and enabling uniform germination of seedlings and water was applied using watering cans regularly. All management practices (fertilizing, watering, weeding, pest control, etc) were applied as require. Furthermore, prior to lifting, plots were watered to facilitate easy lifting of the seedlings and prevent too much root damage. Seedling gap filling was done within a week after transplanting.

Data Collection and Analysis

All phonological, growth and yield parameters of Onion data were collected based on the standard procedures described by Adem *et al.,* (9) from the central three rows with net plot area of 3.78m^2 (2.1m x 1.8m). Data were collected using the standard procedures as described below.

Data Collected on Plot Basis

Days to 90% Maturity: Was number of days elapsed from the date of transplanting up to the date when 90% of the plants in the plot area attained at least one physiologically matured pods were counted. Plant height (cm): Was measured from the soil surface to the apex of the plant using ruler at the time of harvest. The highest point reached by the plant was recorded as the height of the plant. Bulb length (cm): Was The lengths of ten

randomly selected bulbs per plot were measured from the bottom to the top using caliper and the mean value was computed for further analysis (10). Bulb diameter (cm): The mean size of the bulb at harvest was computed by measuring the diameters at the middle. Marketable bulb yield (t ha^{-1}): Were determined after discarding the unmarketable bulbs (damaged, small bulbs, splitter, thick necked, doubles, rotten, off-color and discolor bulbs). Weight of healthy bulbs and having locally acceptable marketable bulb size were taken at harvest from each harvestable plot, excluding borders (8). Unmarketable bulb yield (t ha^{-1}): Harvested bulbs which were under as well as oversized (160g), misshaped, decayed, discolored and diseased and (3). Total bulb yield (t ha^{-1}): Was obtained by adding marketable and unmarketable bulb yields and expressed as ton per ha (10). Average Bulb Weight (g): Was ten randomly selected plants from the net plot were taken and calculated as the mean fresh bulb weight measured by sensitive balance after harvesting and used for further analysis (10). Ten randomly selected bulbs in each plot using caliper (8).

Data Analysis

The collected data on different growth and yield parameters were subjected to the analysis of variance (ANOVA) using SAS Version 9.4 Brunner (11) and the interpretation was made following the procedure described by Gomez and Gomez (12). Least Significance Difference (LSD) test at 5% probability level was used for treatment mean comparison when ANOVA shows significant differences. Correlation analysis was carried out by calculating simple linear correlation coefficients between growth and yield parameters.

Results and Discussion

Combined Mean square for varieties were highly significant ($P<0.01$) for Days to maturit, bulb length, bulb diameter, Plant height, Marketable yield, Unmarketable yield, Total bulb yield and Average bulb weight (g): showed highly significant ($p<0.01$) (Table 2). This indicated that the presence of significant variations among varieties and the varieties had inconsistent performance over years.

Days to 50 % Maturity

Significant ($P<0.01$) variations were observed among the onion varieties in the number of days to attain physiological maturity (Table 2). The longest days to maturity (122.78 days) was recorded from Robaf variety while the shortest days to maturity (107.50 days) was recorded from Bombaye red. This might be due to the fact that maturity period is dependent on the Varieties and climatic conditions. This is in agreement with the report of Tadesse *et al.,* (13) who noted that the maturity is a varietal characteristic which can be influenced by planting date, climatic condition and adopted cultivation practices. Similarly Gebretsadkan *et al.,* (14) and Alemu *et al.,* (15) reported that significant difference among onion varieties for maturity date.

Plant height(cm)

Plant height was not significantly influenced ($P>0.05$) by varietal difference. However, somewhat highest plant height was recorded from Nafis (46 cm) and cocal red (45.7cm).Whereas lower values were obtained at the varieties of Nafid (41 cm) and Bombay red (42 cm). The result is in contrast with the findings of Fikre *et al.,* (16) in which higher plant height (57.40 cm) was recorded from Nafis and (66.26 cm) at Nasik red. This greater plant height might be due to favorable soil and climatic conditions during the season

Bulb Diameter (cm) and Bulb length

The result indicated that there was significant influence ($p<0.01$) by varietal effect on bulb diameter. The wider bulb diameter was measured from variety Local, Nafis and robaf varieties respectively (2.77cm, 2.71cm and 2.69cm) while the narrow bulb diameter was obtained from variety Nafid (2.09cm). Similar finding was reported by Demisie and Tolessa (17) as the genotypic difference in the varieties of onions affect bulb length and diameter.Onion genotypes with high bulb diameter are known to have large bulbs and small neck diameter attributes, which are believed to make them not to store well. Bulb diameter contributes to bulb size and shape index. The result should that Onion varieties had showed highly significant ($P < 0.01$) on bulb length (Table 2). The longest bulb length 2.90cm, 2.77cm and 2.71cm were recorded from varietie of local, Robaf and Nafis respectively and the shortest bulb length (1.92cm) was recorded from Nafid. The variation may be attributed to that the difference in genetic potential among onion varieties.

Marketable yield (t ha^{-1}) and Unmarketable yield

The combined analysis of mean values showed significant variations in Marketable yields among Onion varieties (Table 2). The highest marketable bulb yield

was obtained from variety Nafis (9.89 t ha-1) followed by Local (6.12 t ha^{-1}), while the lowest marketable bulb yield was obtained from variety Nafid (2.60 t ha^{-1}). The difference due to Bulb yield might be genetic variation among onion varieties. This is in line with the finding of Tadesse *et al.,* (13) who reported that there was significance difference ($p< 0.05$) among varieties for marketable bulb yield. It is also in agreement with the finding of Zeleke *et al.,* (3) who mentioned that the combined. Similarly, Gebretsadkan *et al.,* (14) reported that improved onion varieties were showed significant difference for marketable bulb yield t ha^{-1}.More over, in agreement with the present result Mebrahtu (18) reported the variation observed on marketable bulb yield between varieties. Variety Nafis gave maximum unmarketable bulb yield (1.17 t ha-1) and variety Nafid gave minimum unmarketable bulb yield (0.46 t ha-1). The reason for variability among onion varieties in relation to marketable bulb yield might be because of genetic potential differences among them. Furthermore, onion variety with highest marketable bulb yield is an indication of best performance and yielding potential and also these characteristics could be because of genotypic variability among varieties and then could be the main criteria for the variety selection. Unmarketable yield was highly significantly ($P<0.01$) influenced by the onion varieties. Variety Nafis had produced significantly higher unmarketable yield (1.17t ha^{-1}) while Nafid (0.46t ha^{-1}) and Bombay red (0.64t ha^{-1}) had produced significantly lower unmarketable yield.

Average bulb weight (g)

The average bulb weight is a bulb yield component of onion, and it was significantly impacted by onion varieties at $p<0.01$ probability level (Table 2).Thus, the highest average bulb weight was recorded from Nafis variety (91.98g).While the lowest was recorded from Nafid and Nasik varieties (83.3g and 83.85g).In agreement with the finding of Tadesse *et al.,* (13) who reported that there was significance difference ($p\leq 0.05$) among varieties for average bulb weight.

Additionally, the present result is in line with findings of Demisie and Tolessa (17) who obtained the highest average bulb weight from variety Nafis than other varieties. It is also in line with the finding of Zeleke *et al.,* (3) who mentioned that analysis of variance showed that significant difference between improved onion varieties in relation to average bulb weight in gm. Genetic difference/variation in each variety contributed to the yield difference among them. Bulb weight is an important trait that is directly related to the quality and yield of onion.

Total bulb yield (t ha^{-1})

Total bulb yield is summation of marketable and unmarketable bulb yield. The combined total bulb yield results were significantly ($p<0.01$) affected by onion varieties (Table 2). The higher total bulb yield was recorded from variety Nafis (11.06) and the lower total bulb yield was obtained from variety Nafid (3.07 t ha^{-1}) (Table 4). Significant difference between improved onion varieties for marketable bulb yield was reported by Gebremedhn *et al.,* (14). In disagreement with the finding of Zeleke *et al.,* (3) who expressed that analysis of variance showed that improved onion varieties were non-significantly different in total bulb yield in t ha-1.

Similarly, in disagreement with the report of Addis (19) who revealed that improved onion varieties were showed non-significant difference for total bulb yield. The more increase in marketable yield appeared due to increased bulb weight and bulb diameter.

Disease Incidence

Purple blotch, was major disease observed on Onion during the experimental period. Accordingly, variety all other varieties showed moderately resistant (30 ms) (Table 4). However, variety Nafis showed resistance (10r) to disease as compared to other varieties (Table 4).

This variation in response to disease incidence is probably due to genetic variation in the susceptibility among the varieties.

Correlation among Growth Parameters of Onion varieties

The Correlation analysis between bulb yield and yield components of onion varieties were showed strong and positive association among the parameters (Table 5).

Positively significant association was observed between bulb yield and yield components of onion varieties. Significantly and positive correlation coefficient were observed between bulb length with marketable yield ($r=0.36^*$) and Bulb diameters ($r=0.65^{**}$). Moreover, Marketable yield Significantly and positive correlation with diameters ($r=0.39^*$), bulb lenth ($r=0.36^*$), total bulb yield ($r=0.98^{***}$), unmarketable bulb yield ($=0.63^*$), grain and Average bulb weight ($r=0.35^*$).

Table.1 Description of Onion varieties used in the experiment

No	Varity	Seed source	Released year	Altitude (masl)
1	Robaf	Melkassa Agricultural Research Center	2017	1000-2200
2	Nafis	Melkassa Agricultural Research Center	2010	1000-2200
3	Nasic	Melkassa Agricultural Research Center	2004	1000-2201
4	Nafid	Melkassa Agricultural Research Center	2004	1000-2202
5	Bombaye red	Melkassa Agricultural Research Center	-	-
6	Local-check	Farmers Varieties'	-	-

Source: MAO [7]

Table.2 Combined Mean square values on phenological and yield component response variables of Onion verities 2022-2023 cropping season

Source of variation	DF	DM	BL	BD	MY	UMY	TBY	ABW
Rep	2	14.06ns	1.95ns	0.61ns	0.97ns	0.11ns	1.47ns	15.08ns
Var	5	575.50***	1.86***	1.59***	99.16***	1.17**	121.68***	209.99***
Yr	1	3.34ns	0.01ns	0.01ns	0.79ns	4.63**	1.59ns	88.38ns
Loc	2	39.15ns	0.21ns	1.25*	8.64ns	0.88**	11.15ns	0.06ns
Var*Year	5	19.14ns	0.66ns	0.36ns	2.38ns	0.04	2.87ns	5.93ns
Var*Loc	10	26.34 ns	0.04ns	0.02ns	0.58ns	0.05ns	0.63ns	2.77ns
Var*Year*Loc	12	73.95*	0.09ns	0.02	0.86ns	0.19	1.08ns	2.86ns
Error	70	16.71	0.36	0.21	9.39	0.1	10.88	4.36
CV		3.61	23.91	18.66	19.69	31.84	16.02	2.38
P value		0.0001	0.1188	0.0152	0.054	0.0001	0.0341	0.0001

Note: DF=Degree of freedom, DM= Days to maturity, BL =Bulb Length, BD = Bulb diameter, MBY=Marketable bulb yield, UMBY =Unmarketable bulb yield TBY=Total bulb yield, CV=Coficient of variation, ***=very highly significant, **=highly significant, **=highly significant and ns=non-significant

Table.3 Combined mean bulb yield related parameters of Onion varieties over two years at Dabo Hana, Bure and Bedele districts

Varieties	DM (day)	PH(cm)	BL(cm)	BD (cm)	MY (t/ha)	UMY (t/ha)	ABW (g)
Robaf	122.78^{a}	43	2.77^{a}	2.69^{a}	3.83^{c}	0.59^{b}	87.63^{c}
Nafis	117.17^{b}	46	2.71^{a}	2.77^{a}	9.89^{a}	1.17^{a}	91.98^{a}
Nasic	111.20^{c}	43.56	2.33^{b}	2.17^{b}	3.29^{c}	0.49^{c}	83.85^{d}
Nafid	109.22^{c}	42.67	1.92^{c}	2.09^{b}	2.60^{d}	0.46^{c}	84.3^{d}
Banboyered	107.50^{d}	41	2.44^{b}	2.19^{b}	3.59^{c}	0.64^{c}	88.01^{c}
Local	109.67^{c}	45.7	2.90^{a}	2.71^{a}	6.12^{b}	0.76^{b}	89.8^{b}
LSD (0.05)	3.17	6.56	0.35	0.28	1.03	0.13	1.69
CV (%)	4.24	5.21	21.18	17.43	31.01	29.31	2.91
P-Value	**	NS	**	**	**	**	**

DM=Days to Maturity,PH=plant Height, MY=Marketable Yield, UMY= Marketable Yield, BL=Bulb length BD=Bulb diameter ABW=Average Bulb Weight, LSD (0.05)= Least significant differences, CV (%)= coefficient of variation and **=Highly significant

Table.4 Combined mean bulb yield (t/ha) of Onion varieties tested at Dabo Hana, Bure and districts for two years

	D/Hana			Bure			Bedele	Over Aaa	Disease (PB)
Varieties	1st Year	2nd Year	Combined	1st Year	2nd Year	Combined	2nd Year		
Robaf	3.85[b]	4.49[b]	4.55[c]	4.49[c]	4.67[b]	4.25[c]	4.51[c]	4.23[c]	30Mr
Nafis	10.30[a]	8.32[a]	12.01[a]	10.83[a]	8.80[a]	10.89[a]	12.16[a]	11.06[a]	10Mr
Nasic	4.04[b]	3.03[b]	3.94[c]	3.34[c]	3.09[c]	3.55[c]	4.66[c]	3.79[c]	30Ms
Nafid	3.42[b]	1.85[c]	2.98[c]	2.84[d]	2.70[c]	3.05[c]	4.15[d]	3.07[d]	30Ms
Bombaye red	5.03[b]	2.60[c]	4.32[c]	4.18[c]	3.04[c]	4.02[c]	5.50[c]	4.23[c]	30Ms
Local	7.46[a]	6.62[a]	7.78[b]	6.17[b]	5.71[b]	6.55[b]	7.49[b]	6.88[b]	30Ms
LSD (0.05)	4.08	1.71	2.65	1.41	1.41	1.65	1.18	1.09	
CV (%)	39.45	20.97	37.8	12.78	16.58	26.01	10.12	29.44	
P-Value	*	**	**	**	**	**	**	**	

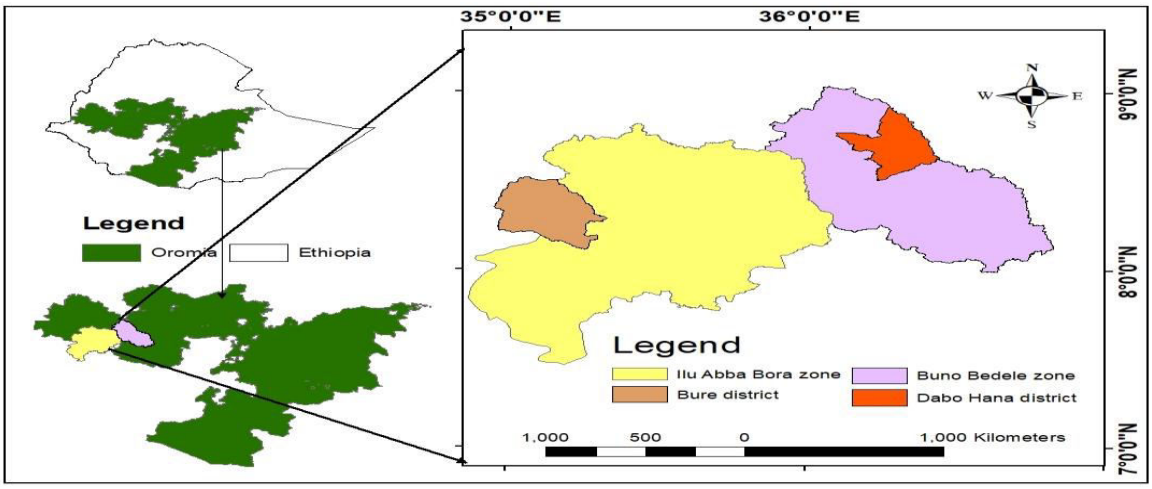
Note: LSD (0.05)= Least significant differences (0.05) and CV (%)= coefficient of variation, r=resistance, Ms=moderately susceptible and Mr=Moderately resistant and PB= Purple blotch,**=highly significant and *=significant

Table.5 Correlation days to maturity, bulb length, bulb diameter, Marketable bulb yield, unmarketable bulb yield, total bulb yield and Average bulb weight in onion varieties

	DM	BL	BD	MY	UMY	TBY	ABW
DM	1						
BL	0.19ns	1					
BD	0.30ns	0.65**	1				
MY	0.29ns	0.36*	0.39*	1			
UMY	0.13ns	0.23ns	0.21ns	0.63*	1		
TBY	0.28ns	0.36*	0.39*	0.98***	0.70**	1	
ABW	0.14ns	0.26ns	0.44*	0.58**	0.35*	0.58*	1

Note: DM=Days to maturity, BL= bulb Length, BD=bulb Diameter, MY=Marketable bulb yield UMBY= unmarketable Bulb yield, TBY= total bulb yield and ABW=Average bulb weight in onion varieties, ***=very highly significant, **=highly significant, **=highly significant and ns=non-significant

Figure.1 Map of the study areas



The present results showed that the all collected yield and yield contributing parameters: days to maturity, bulb length, bulb diameters, Marketable bulb yield, unmarketable bulb yield and total bulb yield were significantly varied among the onion varieties. Accordingly, The highest marketable yield and total bulb yield was obtained from variety Nafis (9.89 and 11.06 t ha^{-1}) and the lowest from variety Nafid (2.6 and 307 t ha-1 respectively). The result of the correlation analysis also showed that bulb yield was posotively and significantly correlated with bulb length (r = 0.36*) and bulb diameter (r= 0.39*).

Conclusion

Onion has many prominence in Buno bedele and Ilubabor zones for the consumption and commercial purposes. Althouth farmers have been producing onion crop for consumption and market purposes its productivity and production is very low due to lack of improved onion varieties. For this case farmers obliged to use local onion variety which is low yielder. Accordingly, field experiment was conducted during 2022 to 2023 cropping season at onion potential areas of Buno Bedele and Ilubabor Zone using six recently released onion varieties (Robaf, Nafis, Nasik,Nafid, Bombay-Red and Local) under Rain fall conditions. The area has high potential for production of onion in rainy season. Thus, evaluating the adaptability of different onion varieties for yield and yield components is very vital in Buno Bedele and Ilubabor Zones. The study results showed significant variation between improved onion varieties for some agronomic, and bulb yield. The highest marketable yield and total bulb yield was obtained from variety Nafis (9.89 and 11.06 t ha^{-1}) and the lowest from variety Nafid (2.6 and 307 t ha-1 respectively). The result of the correlation analysis also showed that bulb yield was posotively and significantly correlated with bulb lengh (r = 0.36*) and bulb diameter (r= 0.39*). From this it conclude that Nafis variety was popularized and demonstrated to farmers for onion production in study areas and similar agro ecological areas.

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