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Evaluation of cauliflower (*Brassica oleracea* var. *botrytis* L.) cultivar for yield

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Background: Cauliflower, one of the important commercial vegetable crops, grown in the plains and mid hills of Nepal, ranks first in terms of area and production among vegetables in Nepal. The majority of the farmers grow cauliflower in mid-season (September-December) because of favorable environmental conditions, low cost of production and higher yield than those in early and late seasons. During the mid-season, farmers use hybrid cultivars predominantly because of their relatively high yield. However, in terms of taste along with qualitative characteristics and production cost, open pollinated (OP) cultivars are far superior to hybrids. In addition, OP cultivars also serve as the organic farming avenues as well and there is a need to promote these OP cultivars.

Methods: An experiment was conducted in the horticulture farm of the Campus of Live Sciences located at Tulsipur, Dang, Nepal at an altitude of 725 m for two consecutive years (2021 and 2022 AD) to evaluate the growth and yield performance of different open pollinated cauliflower cultivars. Five open pollinated cauliflower cultivars viz. Kathmandu Local, Khumal Jyapu, Agheni, Terai-1 and Terai-2 were treated as treatments and were replicated four times in Randomized Complete Block Design.

Results: The experiment revealed that the cauliflower cultivar Khumal Jyapu and Agheni had consistently higher plant height, stem diameter, leaf number, leaf length, leaf breadth, fresh leaf weight, biological yield, economic yield, and harvest index.

Conclusion: Considering their economically important growth and yield attributes Khumal Jyapu and Agheni were found to be the suitable mid-season cultivars under Dang condition. Hence, Khumal Jyapu and Agheni could be promoted for cultivation in the agro climatic zones related to that of Tulsipur, Dang.

Keywords: *open pollinated, cauliflower varieties, mid-season cultivars, performance*

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L.), belonging to the Brassicaceae family, is also known as the king of Cole crops (Giri, 2020). It is one of the important commercial vegetable crops in Nepal (Khanal et al., 2022). The economical and edible part of cauliflower is immature curd and is a rich source of several vitamins, minerals and fibers (Poudel et al., 2017). Cauliflower also has medicinal value as it helps to prevent chronic cancer and cardiovascular diseases (Keck & Finley, 2004). Cauliflower is consumed as raw, cooked vegetables, curry and serves as the best ingredient in noodles, burgers and sandwich preparation (Kushwah et al., 2023). Worldwide, cauliflower is cultivated in a total area of 1226455 ha of land with a total production of 6,822,153,522 t and productivity of 18.1 t/ha (FAO, 2023). Cauliflower ranked first in terms of area and production among vegetables in Nepal with a total area of 39,214 ha and a total production of 611,015 tons with an average productivity of 15.58 t/ha (MOALD, 2022). It is grown especially in Terai and mid hills of Nepal (Pradhan et al., 2023; Giri et al., 2020). The productivity of cauliflower in Nepal is lower

than the global productivity. In Nepal, only four open pollinated varieties i.e. Sarlahi Dipali, Dolpa Snowball, Kathmandu Local and Khumal Jyapu have been released by the National Seed Board to date (SQCC, 2021). Among them, Kathmandu Local and Khumal Jypau are mid-season types whereas Sarlahi Dipali is early and Dolpa Snowball is of late type (SQCC, 2021). With the development of these cultivars along with the improved agronomic practices the productivity of cauliflower has not increased to the desired level (Pradhan et al., 2023).

There is a need for genetic improvement for the development of cauliflower cultivars with acceptable and better traits. Majority of the Nepalese farmers grow cauliflower in mid-season because of favorable environmental conditions, low cost of production and higher yield as compared to early and late season (Giri et al., 2020). In order to boost the production level, farmers are using hybrid cultivars requiring more fertilizers and pesticides which affect the postharvest longevity of the curd as they decrease the cellular and sub cellular parts of the curd (Basnet et al., 2023) and at the same time increased the cost of production as compared to open pollinated cultivars (Bhattarai et al., 2014 & Poudel et al., 2017). More often, the farmers have an illusion that the imported hybrids are far better than the OP improved or local varieties and thus the hybrid seeds' import has shoot up drastically since the past few years. This is not always true especially from the point of view of quality and/or even yield. There are several instances where even our local cultivars have yielded at par or out yielded the imported hybrids (Basnet et al., 2017). Farmers are always in search of varieties with superior traits i.e. productivity, postharvest quality and resistance to biotic and abiotic factors which is challenging (Khanal et al., 2022). Open pollinated cauliflower possesses excellent color, compactness of curd, good taste and postharvest longevity characteristics and fetches higher prices in national and international markets (Basnet et al., 2023). The yield performance of cauliflower differs in different growing regions (Bhattarai et al., 2014) and is governed by the varietal characteristics along with the environmental conditions (Cisse, 2001). So, this study was carried out to identify the suitable open pollinated variety for mid-season planting in Dang, western mid-hill of Nepal.

Materials and methods

Location and agro climate of the experimental site

A field experiment was conducted at the horticulture farm of Campus of Live Sciences, Tulsipur, Dang, at an altitude of 725 m for two continuous cauliflower growing seasons of 2021 and 2022.

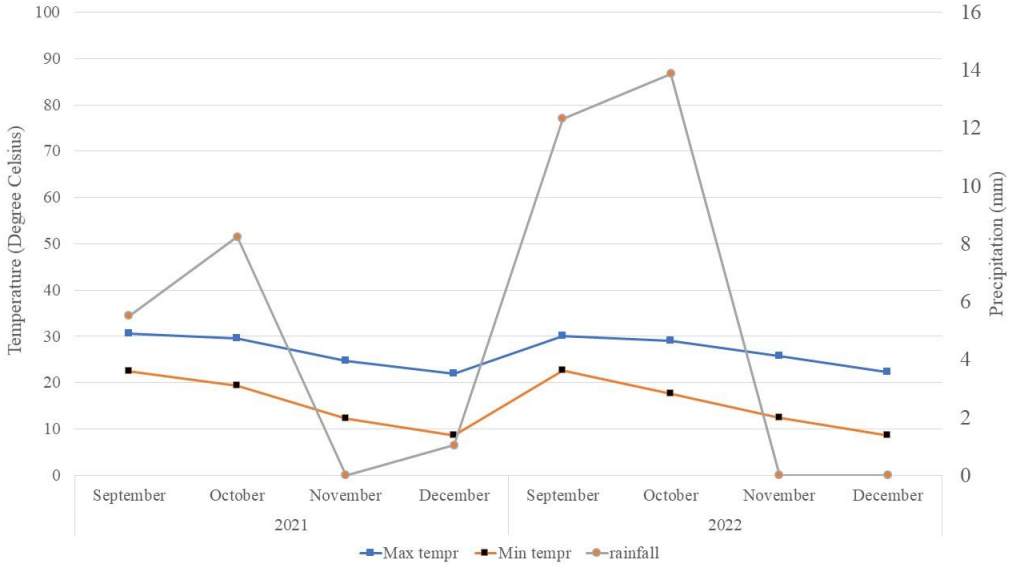

Figure 1. Agro climatic parameters (rainfall, maximum temperature, minimum temperature, and relative humidity) during the crop season

The experimental site lies in the Terai geographical region of the latitude and the longitude of 28°15'45" N, 82°32'35" E, respectively. Weekly average data on different weather parameters such as maximum and minimum temperatures, total rainfall, and relative humidity during the cauliflower growing period were collected from Tulsipur Sub metropolitan City office, Tulsipur, Dang. The average temperature and relative humidity of the cropping period were 22.22°C and 78.09% respectively in 2021 whereas in 2022 the average temperature and relative humidity were 21.09°C and 77.897%, respectively.

Design of the study

Five OP cauliflower cultivars viz. Kathmandu Local, Khumal Jyapu, Agheni, Terai-1 and Terai-2 (seeds sourced from National Horticulture Research Center, (NHRC), Khumaltar, Lalitpur) were replicated four times in randomized complete block design in the horticulture farm of Campus of Live Sciences in Dang, Nepal. There was a total of 20 plots. Individual net experimental plot area comprised of 3 m × 2.5 m (7.5 m^2) with 25 plants. Cauliflowers were planted at a spacing of 60 × 50 cm. There were a total of 500 plants including the border plants in the plots. The space between blocks and plots was 1 m and 0.5 m respectively.

Nursery raising, land preparation, transplanting and fertilization

Nursery tray and peat moss were used for nursery raising of the cauliflower. Plowing the experimental field thoroughly up to 25-30 cm depth was done and a full dose of farm yard manure i.e. 30 tons per hectare was applied one month before transplanting of the seedlings. Four - week - old seedlings were transplanted in the experimental field. The recommended dose of fertilizer for cauliflower i.e. 30 t Farm Yard Manure (FYM) and 200:120:80 Nitrogen (N), Phosphorous (P) and Potassium (K) kg/ha (Giri, 2020) was applied. Full dose of P and K and half dose of N were applied during transplanting whereas; half of the nitrogen was applied after 30 days of transplanting. Similar intercultural operations (weeding, irrigation, pesticide application) were carried out in all experimental plots.

Parameters observed

Plant height was measured from the ground level to the growing point in five tagged plants of each plot. The stem diameter (basal portion of the stem) from the five tagged plants of each plot was measured with the help of Vernier's Caliper. Effective leaf numbers were counted in five tagged plants from each plot. The length of the leaf in the plant was measured from the base of the leaf tip and the width of the leaf was also measured in five selected plants. Diagonal length and width at the top surface of the plant representing the plant coverage were measured from the selected five plants. The observation for plant height, stem diameter, leaf number, rosette diameter, length and width of the leaf was recorded at 25, 40, and 55 days after transplantation (DAT) and harvesting day, later the mean was calculated.

The days to curd initiation and curd maturity of five tagged plants were recorded from the date of transplanting and means were calculated. At the time of harvesting, the fresh weight of leaves and stems per plant were recorded with the help of spring balance. Similarly, the height and diameter of the curds from five selected experimental plants were recorded at the time of harvesting with the help of a meter scale. The total weight of curd, roots, stem and leaves immediately after harvest was recorded from five experimental plants as biological yield whereas, the economic yield was calculated as total curd yield along with 3-4 inner jacket leaves. The net plot yield was then converted to $tonha^{-1}$. Harvest index was calculated as (Dhakal et al., 2009).

$$\text{Harvest Index (\%)} = = \frac{Economic\ yield\ (curd\ yield)}{Total\ biological\ yield} \times 100$$

Statistical analysis

Data were systematically arranged on the basis of various observed parameters. Analysis of variance (ANOVA) was done using IBM SPSS statistics V.27. Means were compared using Duncan's Multiple Range Test (DMRT) at 0.05 and 0.01 level of significance.

Results

Plant height and stem diameter of cauliflower

The combined analysis of variance showed a significant variation of plant height and stem diameter among cauliflower cultivars across 25, 40, and 55 days after transplanting (DAT) and at the harvest stage of the crop. The mean separation showed, Agheni variety had a consistence higher plant height at 25, 40 and 55 DAT while Khumal Jyapu variety had the highest plant height at harvest stage of the crop. Similarly, Khumal Jyapu had the highest stem diameter at 25, 40, 55 DAT and at harvest stage of the crop. The mean plant height of various cauliflower varieties at 25, 40, and 55 DAT and harvest stage was found to be 14.1 cm, 22.8 cm, 35.6 cm, and 42.6 cm, respectively. Moreover, the grand mean of stem diameter at 25, 40 and 55 DAT and harvest stage was 0.5 cm, 0.7 cm, 1.1 cm, and 1.6 cm, respectively. The

maximum variation on both plant height and stem diameter was observed at the early growth state at 40 DAT. Later, the net variation on plant height and stem diameter was found to be reduced.

Table 1. Mean plant height and stem diameter of OP cauliflower varieties at periodic growth stages in Tulsipur, Dang during September to December months of 2021 and 2022.

Treatments	Plant height (cm)				Stem diameter (cm)			
	25 DAT	40 DAT	55 DAT	At harvest	25 DAT	40 DAT	55 DAT	At harvest
Terai-1	13.70^{ab}	18.57^{a}	26.93^{a}	28.36^{a}	0.5137^{bc}	0.6175^{a}	0.933^{a}	1.101^{a}
Agheni	15.26^{bc}	24.87^{b}	40.50^{b}	47.59^{bc}	0.5815^{c}	0.8038^{bc}	1.410^{b}	1.726^{bc}
Terai-2	11.81^{a}	21.86^{ab}	40.19^{b}	44.56^{b}	0.4225^{ab}	0.6600^{ab}	1.227^{b}	1.603^{b}
Khumal Jyapu	16.17^{c}	24.61^{b}	42.80^{b}	48.56^{c}	0.6041^{c}	0.9538^{c}	1.324^{b}	1.864^{c}
Kathmandu Local	13.67^{ab}	24.32^{b}	27.37^{a}	43.87^{b}	0.3362^{a}	0.6900^{ab}	0.739^{a}	1.679^{bc}
Grand mean	14.1	22.8	35.6	42.6	0.5	0.7	1.1	1.6
SEM	0.52	0.99	1.05	0.95	0.03	0.04	0.05	0.06
F-test	**	**	**	**	**	**	**	**
$LSD_{0.05}$	1.5	2.88	3.06	2.75	0.08	0.13	0.15	0.17
CV %	10.4	12.3	8.4	6.3	15.1	16.4	12.8	10.3

*Means with same letter in column are not significantly different at p = 0.05 by DMRT. *Significant at 5% (p < 0.05), **Significant at 1% (p < 0.01) and ns: not significantly different at 5% (p > 0.05). SEM = Standard error of mean, LSD = Least significant difference, CV = Coefficient of variance*

Leaf characteristics (number, length and breadth) of cauliflower

The cauliflower varieties showed a significant variation in leaf related parameters as well. Combined analysis of variance revealed a significant variation in leaf number, leaf length (cm) and leaf breath (cm) across 25, 40, and 55 DAT and at the harvest stage of the crop. Terai -1 variety showed incessantly the highest leaf number across 20, 40, and 55 DAT while Kathmandu local had the highest leaf number at the harvest stage of the crop. Similarly, the highest leaf length was observed in Kathmandu local at 25 DAT whereas Agheni had at 40 DAT. Moreover, Khumal Jyapu had the highest leaf length at 55 DAT and harvest stage of the crop. The highest leaf breadth was observed in Khumal Jyapu during its overall growth period. The maximum variation among cauliflower varieties for leaf number, leaf length, and leaf breadth was observed at the harvest stage, 25 DAT, and 40 DAT, respectively.

Table 2. Mean leaf number, length and breadth of different OP cauliflower at periodic stages of growth in Tulsipur, Dang during September to December months of 2021 and 2022.

Treatments	Leaf number				Leaf length (cm)				Leaf breadth (cm)			
	25 DAT	40 DAT	55 DAT	harvest	25 DAT	40 DAT	55 DAT	harvest	25 DAT	40 DAT	55 DAT	harvest
Terai-1	6.241^{c}	9.050^{d}	13.17^{d}	11.34^{a}	11.11^{ab}	16.11^{a}	22.30^{a}	25.36^{a}	5.787^{ab}	8.13^{a}	14.38^{b}	14.28^{a}
Agheni	5.685^{c}	7.402^{bc}	9.87^{bc}	10.79^{a}	12.99^{ab}	22.05^{c}	36.68^{bc}	40.54^{c}	6.587^{bc}	11.11^{b}	18.94^{c}	19.83^{c}
Terai-2	4.371^{ab}	6.210^{ab}	9.52^{b}	12.19^{ab}	8.94^{a}	17.18^{ab}	32.99^{b}	36.84^{b}	4.835^{a}	10.01^{ab}	15.81^{b}	16.64^{b}
Khumal Jyapu	4.861^{b}	7.671^{c}	10.98^{c}	14.39^{b}	14.21^{ab}	21.27^{bc}	37.44^{c}	42.47^{c}	7.068^{c}	11.53^{b}	19.41^{c}	20.67^{c}
Kathmandu Local	4.119^{a}	5.866^{a}	7.60^{a}	11.55^{ab}	15.11^{b}	20.99^{bc}	22.86^{a}	36.21^{b}	5.044^{a}	10.29^{ab}	11.14^{a}	15.50^{ab}
Grand mean	5.1	7.2	10.2	12.1	12.5	19.5	30.5	36.3	5.9	10.2	15.9	17.4
SEM	0.17	0.31	0.35	0.71	1.38	1.03	0.97	0.85	0.27	0.72	0.5	0.47
F-test	**	**	**	*	*	**	**	**	**	*	**	**
$LSD_{0.05}$	0.5	0.9	1.01	2.06	4.01	2.99	2.8	2.48	0.8	2.08	1.44	1.36
CV %	9.7	12.1	9.6	16.7	31.4	14.9	9	6.7	13.2	19.8	8.8	7.7

*Means with same letter in column are not significantly different at p = 0.05 by DMRT. *Significant at 5% (p < 0.05), **Significant at 1% (p < 0.01) and ns: not significantly different at 5% (p > 0.05). SEM = Standard error of mean, LSD = Least significant difference, CV = Coefficient of variance*

Rosette diameter of cauliflower

The combined analysis of variance revealed a significant variation in rosette diameter of OP cauliflower varieties across 25, 55 DAT and at the harvest stage of the crop and found non-significant at 40 DAT. Khumal Jyapu variety showed incessantly highest rosette diameter across 25, 40, and 55 DAT while, Terai-2 had at the harvest stage of crop. The

mean rosette diameter at 25, 40, 55, and harvest stage was 15.1 cm, 24.6 cm, 42.6 cm, 46.8 cm, respectively with maximum variation observed at 25 DAT up to 55 DAT, before surge at harvest stage.

Table 3. Mean rosette diameter of different OP cauliflower at periodic stages of growth in Tulsipur, Dang during September to December months of 2021 and 2022.

Treatments	Rosette diameter (cm)			
	25 DAT	40 DAT	55 DAT	At harvest
Terai-1	16.23^{b}	22.75^{a}	45.36^{b}	36.22^{a}
Agheni	15.45^{b}	24.00^{a}	44.15^{b}	47.42^{abc}
Terai-2	10.82^{a}	24.67^{a}	43.61^{b}	59.16^{c}
Khumal Jyapu	16.35^{b}	28.20^{a}	52.86^{b}	52.71^{bc}
Kathmandu Local	16.75^{b}	23.41^{a}	27.24^{a}	38.63^{ab}
Grand mean	15.1	24.6	42.6	46.8
SEM	1.48	1.97	2.61	3.91
F-test	*	NS	**	**
$LSD_{0.05}$	4.29	5.72	7.57	11.36
CV %	27.7	22.7	17.3	23.6

*Means with same letter in column are not significantly different at p = 0.05 by DMRT. *Significant at 5% (p < 0.05), **Significant at 1% (p < 0.01) and ns: not significantly different at 5% (p > 0.05). SEM = Standard error of mean, LSD = Least significant difference, CV = Coefficient of variance.*

Yield parameter of cauliflower

The combined analysis of variance revealed that there was a significant variation on fresh stem weight (g), fresh leaf weight (g), curd height (cm), curd diameter (cm), days to curd initiation, days to curd maturity, biological yield (kg/ha), economic yield (kg/ha), and harvest index. Agheni had the highest fresh stem weight, curd height and curd diameter. Kathmandu local had the longest days to curd initiation and curd maturity. Khumal Jyapu had the highest fresh leaf weight, biological yield, economic yield, and harvest index. Since, Khumal Jyapu had the highest harvest index, economic yield and biological yield as well. Khumal Jyapu variety can be promoted for cultivation in the agro climate of Tulsipur, Dang.

Table 4. Mean fresh stem weight, leaf weight, and curd height and curd diameter of different open pollinated cauliflower genotypes in Tulsipur, Dang during September to December months of 2021 and 2022.

Treatments	Fresh stem weight (g)	Fresh leaf weight (g)	Curd height (cm)	Curd diameter (cm)	Days to curd initiation	Days to curd maturity	Biological yield (t/ha)	Economic yield (t/ha)	Harvest index
Terai-1	47.24^{a}	148.7^{a}	7.61^{a}	12.63^{a}	36.62^{a}	54.50^{a}	21.98^{a}	9.06^{a}	41.41^{ab}
Agheni	81.78^{c}	506.5^{c}	12.46^{b}	17.96^{b}	47.50^{b}	72.88^{b}	35.34^{c}	16.13^{b}	46.00^{ab}
Terai-2	68.13^{bc}	341.3^{b}	10.58^{ab}	16.44^{b}	52.75^{c}	75.00^{bc}	27.67^{b}	11.35^{a}	41.14^{ab}
Khumal Jyapu	67.87^{b}	628.7^{d}	10.64^{ab}	15.93^{b}	38.25^{a}	76.25^{c}	46.33^{d}	21.89^{c}	47.33^{b}
Kathmandu Local	71.85^{bc}	227.0^{a}	10.02^{ab}	11.41^{a}	65.50^{d}	93.00^{d}	21.24^{a}	8.32^{a}	39.21^{a}
Grand mean	67.4	370.4	10.3	14.9	48.1	74.3	30.5	13.4	43
SEM	3.34	26.82	0.74	0.54	0.93	0.71	0.9	0.76	2.4
F-test	**	**	**	**	**	**	**	**	*
$LSD_{0.05}$	9.7	77.84	2.15	1.56	2.71	2.06	2.62	2.21	6.97
CV %	14	20.5	20.5	10.2	5.5	2.7	8.4	16.1	15.8

*Means with same letter in column are not significantly different at p = 0.05 by DMRT. *Significant at 5% (p < 0.05), **Significant at 1% (p < 0.01) and ns: not significantly different at 5% (p > 0.05). SEM = Standard error of mean, LSD = Least significant difference, CV = Coefficient of variance*

Discussion

Cauliflower is a thermo-sensitive plant and it requires specific climatic conditions for different types of cultivars. Mid-season cultivars require 13-19^{0}C for their optimum yield (Pradhan et al., 2023; Giri et al., 2020), which coincides with the temperature observed during the research. The combined analysis revealed that there was a significant variation in vegetative characteristics (plant height, stem diameter, leaf number, leaf length, leaf breadth, rosette diameter and fresh stem and leaf weight) and yield characteristics (days to curd initiation and maturity, curd height, curd diameter, biological yield, economic yield and harvest index) of cauliflower among different cultivars. This variation might be

due to genetic characteristics and environmental factors (Giri, 2020). Moreover, Santhosha et al. (2014); Jindal & Thakur (2004); Chittora & Singh (2015) & Pradhan et al. (2023) found similar variations in vegetative and yield parameters on different cauliflower cultivars due to the genotypes governed by different genes, which were influenced by environmental factors and management practices. Similarly, the vegetative and yield characteristics of cauliflower within the cultivars were due to genetic characteristics and were influenced by environmental factors and management practices (Ram et al., 2009; Yadav et al., 2013; Poudel et al., 2017 & Pandey, 2003). Moreover, the yield variation among the cultivars is influenced by the genetic characteristics and environmental factors and similar findings were reported by (Sharma et al., 2018; Giri et al., 2020 & Shrestha, 2022). The highest yield performance by Khumal Jyapu and Agheni was due to its consistence higher plant height, stem diameter, leaf length, leaf breadth and net biomass accumulation. Similarly, Budhathoki et al. (2004); Shrestha et al. (2019) & Pradhan et al. (2023) have also reported that Khumal Jyapu showed the highest plant height, stem and rosette diameter, leaf number, length and breadth, along with the yield related parameters followed by Agheni and lowest was found in Terai-1 and Terai 2 cultivars of cauliflower. Higher biomass accumulation by the plant is always beneficial for yield performance since, the vegetative part has a major contribution on photosynthesis and carbohydrate synthesis (Basnet et al., 2023, 2017).

Conclusion

The experiment revealed that the Cauliflower variety Khumal Jyapu and Agheni had consistently higher plant height, stem diameter, leaf number, leaf length, leaf breadth, fresh leaf weight, biological yield, economic yield, and harvest index. Hence, Khumal Jyapu and Agheni could be promoted for cultivation in the agro climatic zones related to that of Tulsipur, Dang.

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Author contributions

Manoj Basnet: Project research execution, data collection, analysis writing original draft and editing. Arvind Srivastava: writing- review and editing and validation. Kalyani Mishra: writing- review and editing and validation. Kishor Chandra Dahal: Validation, software, methodology, investigation, conceptualization.

Conflict of interest

The authors declare no conflict of interest.

Ethics approval

Not applicable.

AI tool usage declaration

No AI tools have been used in manuscript preparation.

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