# YIELD MATURITY PARAMETERS OF HYBRID GRAPEVINE (*VITIS SP.*) CULTIVAR 'ZILGA'

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**Abstract**
The number of grape (*Vitis* sp.) cultivars is increasing every year, the focus point of recent grapevine studies are heading to producing high quality fruits for producing quality wine. A field trial with cultivar 'Zilga' was established in 2007 at the Estonian University of Life Sciences and in 2010 in a greenhouse. 'Zilga' is one of the well adopted cultivars in Estonia, which has been used mostly for producing wine and grown in open field conditions. The aim of the present experiment was to find out the yield maturity parameters of cultivar 'Zilga' for red wine in Estonian conditions. Data was collected from the year 2011 to 2013. The bunch weight and °Brix were determined from fresh materials, but all the other biochemical parameters were determined from frozen (-20 °C) grapes. The recommended content (20 °Brix) of soluble solids was not obtained in open field conditions, but reached to 24.1 °Brix in greenhouse conditions in 2013. Titratable acids content was higher than recommended values, ranging from 1.4 to 1.6 mg 100 $g^{-1}$ in open field and showing the lowest content (1.2 mg 100 $g^{-1}$) in greenhouse conditions. Maturity index values ranged from 117 to 224, and the optimum was reached in two years from three. The highest total phenolics content, 293 mg 100 $g^{-1}$ was obtained in 2011, while anthocyanin content was significantly increased in 2013.
**Key words:** berry ripening, soluble solids, titratable acids, total phenolics, anthocyanins, maturity index.

## Introduction

The increasing interest of viticulture in cool climate countries leads to the demand for winter hardy cultivars. Good results have been achieved in grape (*Vitis* sp.) breeding by P. Sukatnieks and G. Vēsmiņš in Latvia (Kaufmane et al., 2013). In cool climatic conditions, cultivars of hybrids of *V. labrusca*, *V. riparia* and *V. amurensis* are the ones with good winter hardiness and disease resistance. The day and night temperature fluctuation and direct sunlight interception are the main factors that affect the accumulation of biochemical compounds and grape quality as well (Gustafsson and Mårtensson, 2005; Nicolosi et al., 2012).

A common problem in cool climate conditions for wine producers is insufficient grape maturation – titratable acids (TA) being high but soluble solids content (SSC) too low (Gustafsson and Mårtensson, 2005). H. Schalkwyk and E. Archer (2000) recommend SSC for red wine grapes from 20 to 23 °Brix and TA from 0.6 to 0.7 g 100 $g^{-1}$ FW. Thereby the measurement of SSC alone is not enough to ensure the maturity of grapes (Ferrer-Gallego et al., 2012; Iyer et al., 2012). Additionally, a combination of SSC and pH values is generally used to determine the optimum ripeness of red wine grapes, maturity index (MI = °Brix × $pH^2$) optimally ranging from 200 to 270 (Coombe et al., 1980; Hunter et al., 1991; Schalkwyk and Archer, 2000; Iyer et al., 2012). Too high values are also not preferred – optimal ripening conditions and sufficient maturity could be obtained in greenhouse, but it is not common practise to grow wine grape cultivars in indoor conditions.

In addition to sugars and acids, the content of phenolic compounds (including anthocyanins) is important. Total phenolics content (TPC) varies depending on multiple factors such as temperature, cultural practices and grape developmental stage (Haselgrove et al., 2000; Peña-Neira et al., 2004; Ferrer-Gallego et al., 2012; Palliotti et al., 2012). For red grapes, anthocyanins content (ANC) varies among cultivar and grape maturity, production area, seasonal conditions and yield (Haselgrove et al., 2000; Ryan and Revilla, 2003; Fournand et al., 2006; Hülya Orak, 2007; Falcão et al., 2008; Topalovic, Mikulic-Petkovsek, 2010; Ferrer-Gallego et al., 2012; Pedneault et al., 2013). Fruit biochemical composition depends on the grapevine cultivation area and specific conditions of the growing year (Martin and Dunn, 2000). In Nordic climate, differences between the years can significantly affect ripening; therefore, the expected concentrations may not be achieved (Pedneault et al., 2013), as cool and wet weather conditions may influence ripening (Nicholas et al., 2011).

Latvian origin 'Zilga' is one of the well adopted cultivars, which has been on the list of recommended cultivars suitable for growing in Estonia from the year 2004 and used mostly for producing wine. Open field trials with this cultivar was conducted in 2007 at the Estonian University of Life Sciences, and it has been under investigation since. Through the years the research objectives have been changing in relation to the development of viticulture. At the beginning of vine research, the main aim was selecting suitable species and their cultivars for growing in Nordic climatic conditions. For today, as the number of suitable grape cultivars is increasing constantly, the focus point of recent studies is heading for producing high quality fruits for producing quality wine. The

aim of the present experiment was to find out the yield maturity parameters of cultivar 'Zilga' for red wine in Estonian conditions.

**Materials and Methods**

*Experimental site*

The vineyard was established at the Rõhu experimental station of the Estonian University of Life Sciences (58° 23′ 17″ N, 26° 41′ 50″ E) in June 2007 and at the Saare-Tõrvaaugu (58° 37′ 42″ N, 25° 8′ 17″ E) greenhouse in May 2010. The data was collected and samples were taken from 2011 to 2013 in open field and in 2013 in greenhouse conditions. Plantation soil was sandy loam with pH (KCl) 5.8, with 4.4% humus content and 50 cm thick humus layer. The content of P, K, Ca and Mg was sufficient in the soil of both experimental areas and hence, no fertilizers were used. The grapevines were propagated *in vitro* and grown as own-rooted. Vines were spaced 2 × 2 m apart and planted in single rows with 0.04 mm thick and 1 m wide black polyethylene mulch with turf between the mulched beds. In the greenhouse, the mulch is all over the floor area. The experiment was conducted using randomized block design in 4 replications and 8 vines in each. Vines were neither irrigated nor covered for winter. For greenhouse cultivation, plastic tunnels 45 m in length, 8 m in width and 4 m in height were used. Vines were planted in 2010, in 1.65 × 3.5 m spaces and trained in high double trunk trellis. The greenhouse area was covered with 0.18 mm thick UV-stable low-density polyethylene at the end of April. White polypropylene fabric and spruce (*Picea*) branches were used as a winter cover; no additional heating system was used in plastic tunnels. Rows were oriented from north to south. Vines were neither irrigated nor covered for winter. The training system was low in open field and a high double trunk in the greenhouse. Leaves adjacent to berry clusters were removed at the beginning of veraison from the east side of the canopy to allow the morning sun exposure due to the occurrence of dew.

*Cultivar*

Grape cultivar 'Zilga' is a hybrid (*V. amurensis* × *V. labrusca* × *V. vinifera*) bred in Latvia by Pauls Sukatnieks (Vēsmiņš, 2012). Berries are medium sized and able to obtain 16…19 °Brix. They ripen in the middle of September in Latvian agroclimatic conditions with clusters from 100 to 400 g weight. 'Zilga' is one of the cultivars most often used for producing wines in Latvia (Dishlers, 2003). In Estonian conditions, 'Zilga' has been characterised as a cultivar with roundish and uniform sized berries covered with greyish wax layer (Kivistik, 2012). Cane maturation occurs early, and in autumn the foliage is nicely red-coloured. The cultivar is winter hardy (-30…-35 °C). 'Zilga' is also on the list of recommended cultivars for growing in commercial or home gardens in Estonia from 2004 onwards.

*Weather conditions*

On 15 April 2011, temperatures were above 5 °C and rose to 20 °C by the end of the month. The period of active plant growth temperatures (>10 °C) in 2011 was from 7 May to 8 October. The summer of 2011 was warm – mean temperature in July was 3.3 °C higher than the long term mean (Table1). First night frosts occurred on 20 October. In 2011, the sum of active temperatures was 2498 °C, and the length of active plant growth period was 155 days. In 2011, there was almost no rain in April and 27 mm more rain than the long term mean in September (Table1).

In 2012, temperatures were above 10 °C from the beginning of May until 6 October. The active plant growth period was 150 days. Late spring frosts stopped in the mid-May and temperature remained >0 °C until the 20 October. Mean temperatures in June and July were cooler than in 2011; respectively 3.9 °C and 2.3 °C lower (Table1). The sum of active temperatures from 1 April until 31 October 2012 was 1967 °C. In 2012, the precipitation level was significantly higher in April, May and June but almost at the same level in August and September in comparison with many years.

In 2013, the active plant growth period started from the 7 May and ended on 23 September. Frost-free period was 145 days long, which is 22 days more than long-term mean. The last spring frost occurred on 3 May, but the first autumn frost on 26 September 2013. The sum of active temperatures (>10 °C) from 1 April to 31 October was 2263 °C. This is 332 °C more than many years mean (1936 °C) but less compared to the year 2011. The precipitation sum from 1 April to 31 October was 352 mm which is 152 mm less than in 2012, 43 mm more than 2011 and 86 mm less than the mean (438) of 1971 – 2000.

*Biochemical analysis*

Grapes were picked every year in September in open field conditions from 2011 to 2013 and in the greenhouse in 2013. The weight of ten randomly selected bunches of vine was determined in each replication. SSC was measured from fresh berries by refractometer (Atago Pocket Refractometer Pal-1). For °Brix measurement, 30 grapes in 3 replications from the different parts of a cluster were picked and analysed.

All the other biochemical parameters were determined from frozen (-20 °C) grapes. TA content was determined by the titration method (Mettler Toledo EasyPlus Pro Titrator) with aqueous 0.1 M NaOH solution, using pH 8.2 endpoint titration type.

Table1

**Weather conditions in 2011 – 2013: monthly mean air temperature and total monthly precipitation compared to many years mean (1971 – 2000)**

| Month | Air temperature (°C) | | | | | Precipitation (mm) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2011[a] | 2012[a] | 2013[a] | 2013[c] | Mean [b] | 2011[a] | 2012[a] | 2013[a,b] | Mean [b] |
| April | 5.7 | 4.6 | 4.0 | - | 4.7 | 1 | 45 | 36 | 33 |
| May | 11.0 | 11.4 | 15.5 | - | 11.1 | 58 | 78 | 65 | 53 |
| June | 17.2 | 13.3 | 17.8 | 21.6 | 15.1 | 35 | 98 | 29 | 69 |
| July | 20.0 | 17.7 | 17.5 | 21.1 | 16.9 | 48 | 80 | 67 | 76 |
| August | 15.9 | 14.8 | 16.6 | 18.9 | 15.6 | 55 | 80 | 73 | 80 |
| September | 12.3 | 11.9 | 10.8 | 12.8 | 10.4 | 80 | 61 | 38 | 67 |

[a] Data was collected from automatic weather station of open field experimental station
[b] Data according to the Estonian Hydrological and Meteorological Institute (www.emhi.ee) database
[c] Temperatures were measured with specially installed thermometers in the greenhouse

The TA was expressed as g of tartaric acid per 100 g of fresh weight (FW). pH was measured from grape juice with a pH electrode of Mettler Toledo EasyPlus Pro Titrator. MI was calculated according to the formula determined by B.G. Coombe et al. (1980): MI = °Brix × $pH^2$. ANC was estimated by a pH differential method from grape skin (Cheng and Breen, 1991). Absorbance was measured with a UVmini-1240 Shimadzu spectrophotometer at 510 and at 700 nm in buffers at pH 1.0 (HCl 0.1N) and pH 4.5 (citrate buffer). The results were expressed as mg of malvidin-3-glucoside equivalent per 100 g of FW. TPC was determined from grape skin with the Folin-Ciocalteau phenol reagent method, using a spectrophotometer (UVmini-1240 Shimadzu) at 765 nm. The TPC was expressed as mg of gallic acid equivalents per 100 g of FW.

*Statistical analysis*

The results of grape chemical composition were tested by one-way analysis of variance. To evaluate the effect of year, the least significant difference ($LSD_{0.05}$) was calculated. Different letters on figures and tables mark significant differences at $p \leq 0.05$.

**Results and Discussion**

*Soluble solids content*

The SSC ranged from 13.5 to 24.1 °Brix (Figure 1). In open field conditions, the SSC did not reach the optimum, but the recommended °Brix values (20 °Brix) were obtained reaching to 24.1 °Brix in greenhouse conditions in 2013. SSC was the lowest (13.5 °Brix) in 2012, when summer temperatures in June, July and August were respectively 3.9, 2.3 and 1.1 °C lower than in 2011.

According to literature, 'Zilga' is able to obtain 16…19.5 °Brix depending on the growing site (Dishlers, 2003; Vēsmiņš, 2012). Similar results were also achieved in our experiment in 2011 and 2013. The weather conditions in 2011 and 2013 were considered to be warmer according to the sum of active temperatures (>10 °C) (respectively 2498 °C and 2263 °C) than in 2012 (1967 °C) and long-term mean (1936 °C). Therefore, it can be suggested that sugar accumulation was advanced, grape berries had sufficient time and temperatures for ripening. In 2012, there was also higher precipitation level through the vegetation period, which could affect the biochemical composition and also sugar accumulation. K.A. Nicholas et al., (2011) indicate cool and wet weather as inhibiting factors for grape ripening. The recommended SSC in 'Zilga' grapes, up to 24.1 °Brix, was obtained in comparison to the variant in a greenhouse, which indicates a high potential of the cultivar.

*Titratable acids*

TA content ranged from 1.4 to 1.6 mg 100 $g^{-1}$ in open field and showed the lowest content, 1.2 mg 100$g^{-1}$, in greenhouse conditions (Figure 2). These concentrations are extremely high compared to H. Schalkwyk and E. Archer (2000) who suggest optimally for red table wine grapes TA content from 0.6 to 0.7 mg 100 $g^{-1}$. In Latvian climatic conditions, 'Zilga' TA has been close to 1.0 mg 100 $g^{-1}$ (Dishlers, 2003). In our experiment, only the greenhouse-grown berries TA content (respectively, 1.2 mg 100 $g^{-1}$) remained close to the previously indicated value. Organic acids accumulate in the berry during berry formation, yet due to the increasing fruit size, their concentration is reduced (Kennedy, 2002; Topalovic and Mikulic-Petkovsek, 2010). The content of TA can roughly be climate dependent. As a result, the acids tend to show higher concentrations in cooler regions (Kennedy, 2002). This suggests that the temperatures in Estonia are too low in the first period of berry development, which influences the berry composition significantly.

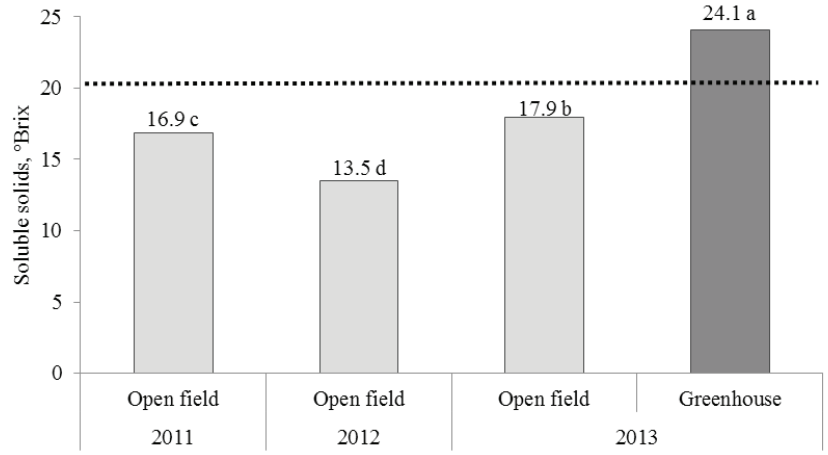



Figure 1. Soluble solid content of open-field (2011 – 2013) and greenhouse-grown 'Zilga' (2013). Horizontal line on the figure indicates the recommended 20 °Brix for wine berries (Schalkwyk and Archer, 2000).

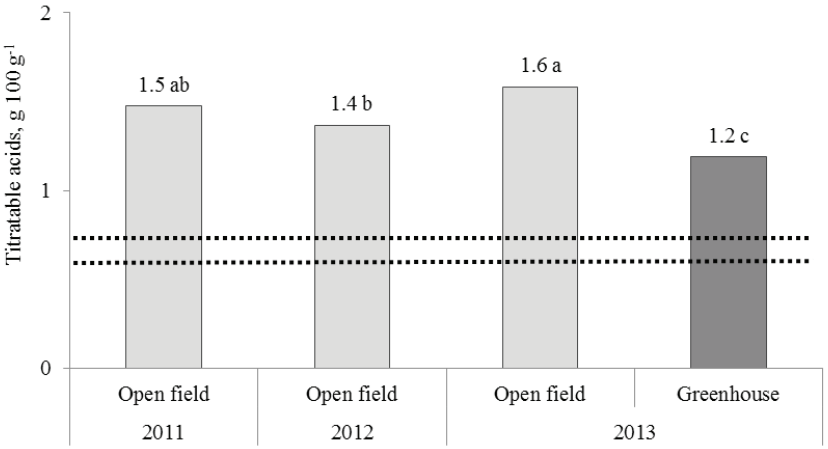



Figure 2. Titratable acids content of open-field (2011 – 2013) and greenhouse-grown 'Zilga' (2013). Horizontal lines on the figure indicate the recommended interval of TA for red table wine (Schalkwyk and Archer, 2000).

*Maturity index*

MI values ranged from 117 to 312, and did not reach the optimum only in 2012 (Figure 3). In a greenhouse, the MI increased above the optimum. MI is a combination of SSC and pH values that is generally used to determine the optimum ripeness of red wine grapes (Coombe et al., 1980). Our results indicate that there is a problem with obtaining MI because of SSC being low (Figure 1) and pH values high. Agroclimatic conditions and differences between the years lead to the fact that the weather has essential importance when growing high quality grapes (Martin and Dunn, 2000; Pedneault et al., 2013). This refers especially to cool climate conditions like in Estonia.

*Total phenolic content*

TPC varied from 214 to 540 mg 100 $g^{-1}$ (Figure 4). In open field trials, the highest contents (293 mg 100 $g^{-1}$) were obtained in 2011, while the TPC showed equally lower concentrations in 2012 and 2013. Extremely high TPC (540 mg 100 $g^{-1}$) in greenhouse-grown berries could be related to day and night temperature fluctuations. TPC depend on several factors such as temperature (Haselgrove et al., 2000; Ferrer-Gallego et al., 2012); cultural practices (Peña-Neira et al., 2004; Palliotti et al., 2012) and grape developmental stage (Haselgrove et al., 2000). Phenolic compounds accumulate rapidly during the few weeks after veraison and may be variable according to the vine growing conditions (Topalovic and Mikulic-Petkovsek, 2010).

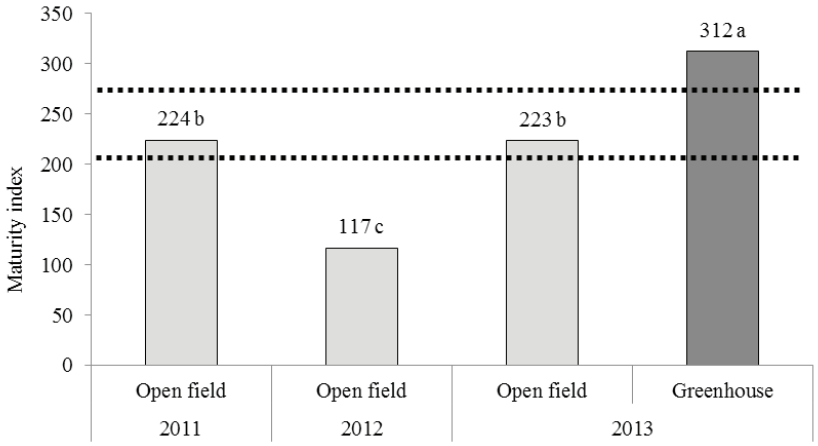



Figure 3. Maturity index of open-field (2011 – 2013) and greenhouse-grown 'Zilga' (2013). Horizontal lines on the figure indicate the recommended interval for wine grapes (Coombe et al., 1980).

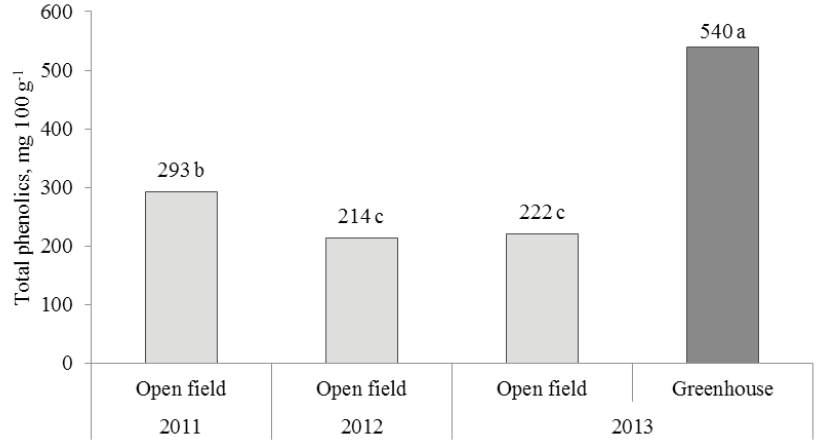



Figure 4. Total phenolic content of open-field (2011 – 2013) and greenhouse-grown 'Zilga' (2013).

High variability on temperature scale decreases water status and is more stressful to vines when compared to open field conditions. More phenolic compounds (including anthocyanins) accumulate under dryer and warmer conditions (Rio Segade et al., 2008). The temperature fluctuations and precipitation rate play the major role in grape ripening; even more when the minimum and maximum rates vary differently under the greenhouse conditions.

*Anthocyanin content*

ANC varied greatly ranging from 50 to 112 mg 100 $g^{-1}$ (Figure 5). In open field conditions, ANC was significantly increased in 2013 (64 mg 100 $g^{-1}$), probably due to dryer and sunnier weather conditions in August and September compared to other experimental years (Table 1). Similar levels of ANC were determined in 2011 and 2012, 54 and 50 mg 100 $g^{-1}$ respectively. The ANC varies greatly depending on cultivar and grape maturity (Ryan and Revilla, 2003; Fournand et al., 2006; Topalovic and Mikulic-Petkovsek, 2010). Secondly, the production area and seasonal conditions play the major role in red pigment accumulation (Ferrer-Gallego et al., 2012). Light interception and temperatures influence anthocyanin metabolism significantly, but too high temperatures (above +35 °C) inhibit their accumulation (Haselgrove et al., 2000). Though in the greenhouse the temperatures rose in some days extremely above +40 °C maximum, but the day and night temperature variations could have been affecting the ANC.

**Conclusions**

The present experiments with grape cultivar 'Zilga' can be concluded as follow:

1. Yield maturity parameters were significantly influenced by the weather conditions occurring in the specific growth year.

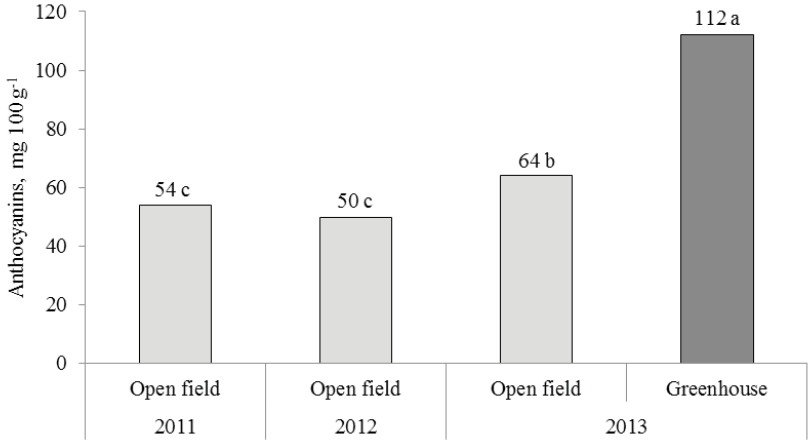



Figure 5. Anthocyanin content of open-field (2011 – 2013) and greenhouse-grown 'Zilga' (2013).

2. The recommended SSC was not obtained in an open field, but was reached in greenhouse conditions. TA remained too high compared to recommended values despite the conditions. MI (°Brix × $pH^2$) optimum was reached in two years from three, and the values were above the recommended level in greenhouse-grown grapes. Phenolic maturity was different according to the year – the highest TPC was obtained in 2011, but ANC in 2013.
3. The results of the present experiment suggest that Latvian origin hybrid grape cultivar 'Zilga' is with a good potential of quality red table wine production, but maturity parameters differ among the years. Therefore, further experiments with suitable growing technologies (like pruning, removing the leaves etc.) are in need to find out possibilities for achieving optimal maturity parameters in open field conditions.

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