

# Czech bitter varieties of hops

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**Agnus (registered in 2001).** Agnus was gained by selection from hybrid descendants with the Sládek, Bor, Saaz, Northern Brewer and Fuggle hop varieties as well as additional breeding materials in their origin. It has a strong hoppy or even spicy aroma and an herbal scent in the background. High intensity.

**Rubín (registered in 2007).** Rubín was gained by selection from the descendants of Bor and a male plant that is a multiple cross of hybrid materials (Saaz and Northern Brewer). Its aroma is spicy, floral and herbal. After having reached its technical maturity, the aroma can show traces of sulfur. Medium intensity.

**Vital (registered in 2008).** Vital was developed from the Agnus maternal variety and a paternal plant gained from semi-finished breeding materials. It has a hoppy or even spicy aroma with a fruity and herbal scent in the background. High intensity.

**Gaia (registered in 2017).** Gaia was gained from Agnus and a male plant originating from the Yeoman hop variety from England and breeding materials of Czech and foreign hop varieties. It has a hoppy or even spicy aroma with a fruity and floral scent in the background. Medium to high intensity.

**Boomerang (registered in 2017).** Boomerang was developed by selection from hybrid descendants originating from a multiple hybridization of Agnus, Magnum and Premiant as well as semi-finished breeding materials with Saaz, Sládek, Northern Brewer and Fuggle in their origin. Its aroma has a higher share of a spicy scent and a hoppy, woody, herbal and fruity scent in the background. High intensity.



## 1. Evaluation of hop yield

In the years 2011 to 2022, the Czech hop varieties Agnus, Rubín, Vital, Gaia and Boomerang were evaluated in terms of their hop yield. The highest hop yield was recorded in Gaia (2.99 kg/plant) and Vital (2.92 kg/plant). Boomerang had the lowest yield (2.11 kg/plant.). The lowest variability of yield was determined in Vital (19.74%) and the highest in Boomerang (33.29%) and Agnus (32.98%). Vital demonstrated the lowest decreasing trend of hop yield over a period of 12 years. Rubín showed the highest decreasing trend.

Within an 11-year time series, based on linear regression, all hop varieties show a decrease in hop yield (Table 2). The decrease in hop yield over a period of 11 years demonstrates a high level of reliability in Rubín ( $r^2 = 0.58$ ). In contrast, a very low level of reliability was determined in Vital ( $r^2 = 0.03$ ). The remaining hop varieties have a low reliability level as well. The results show that only Rubín experiences a decrease in hop yield due to aging, the impact being 58%. The decrease in the hop yield of the remaining hop varieties is due to other influences (agrotechnology, temperature, precipitation etc.) rather than aging.

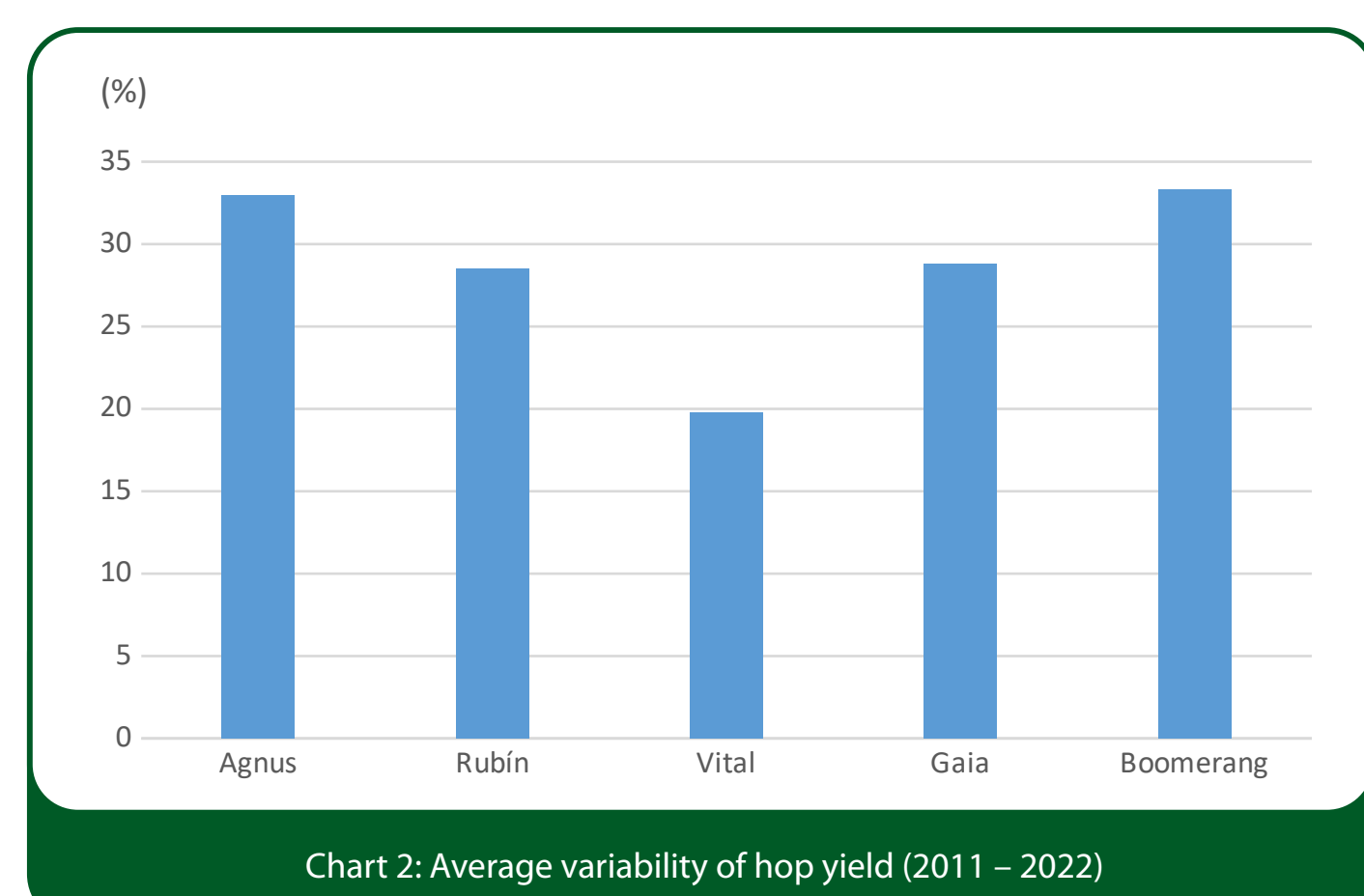
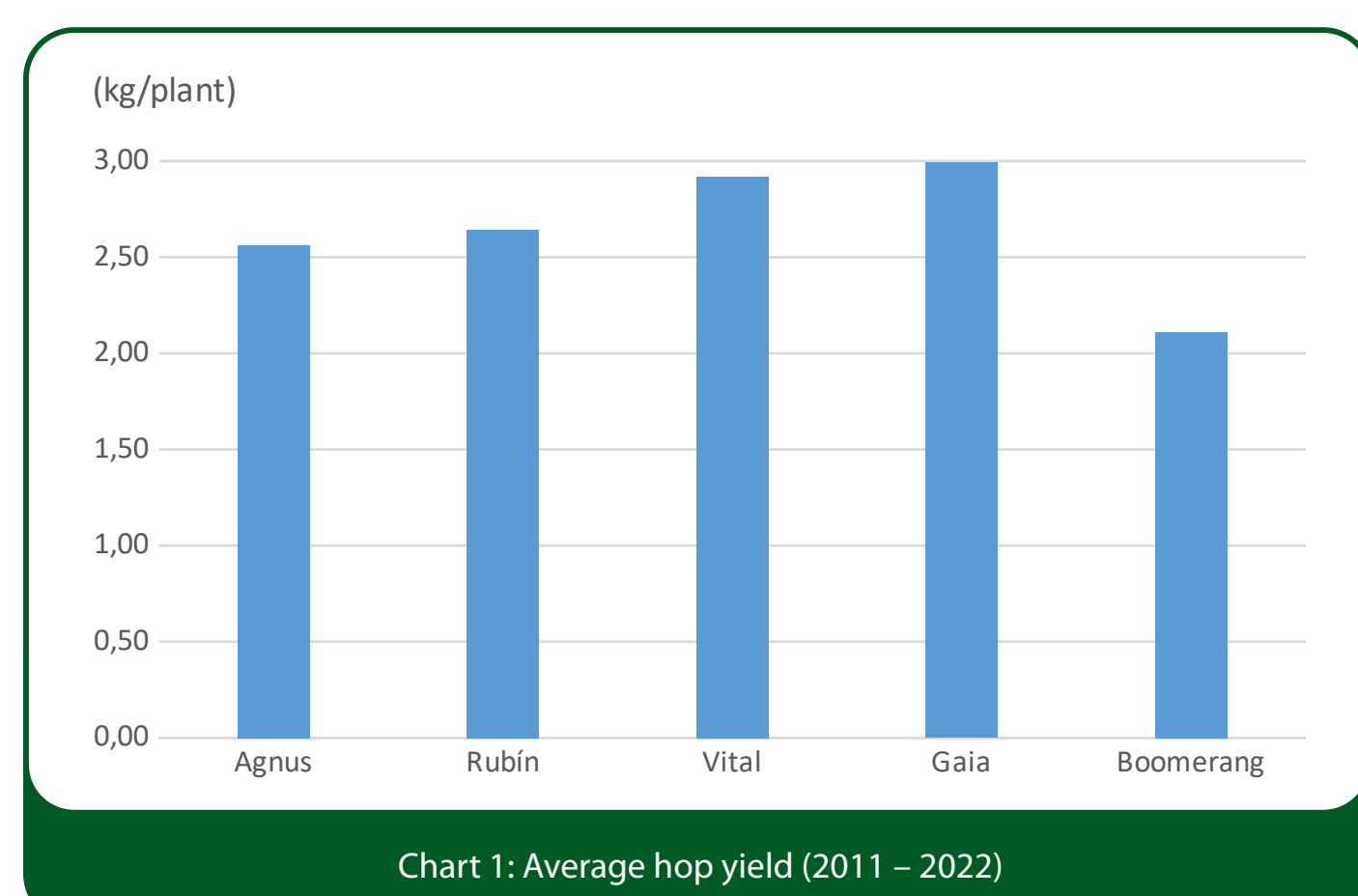
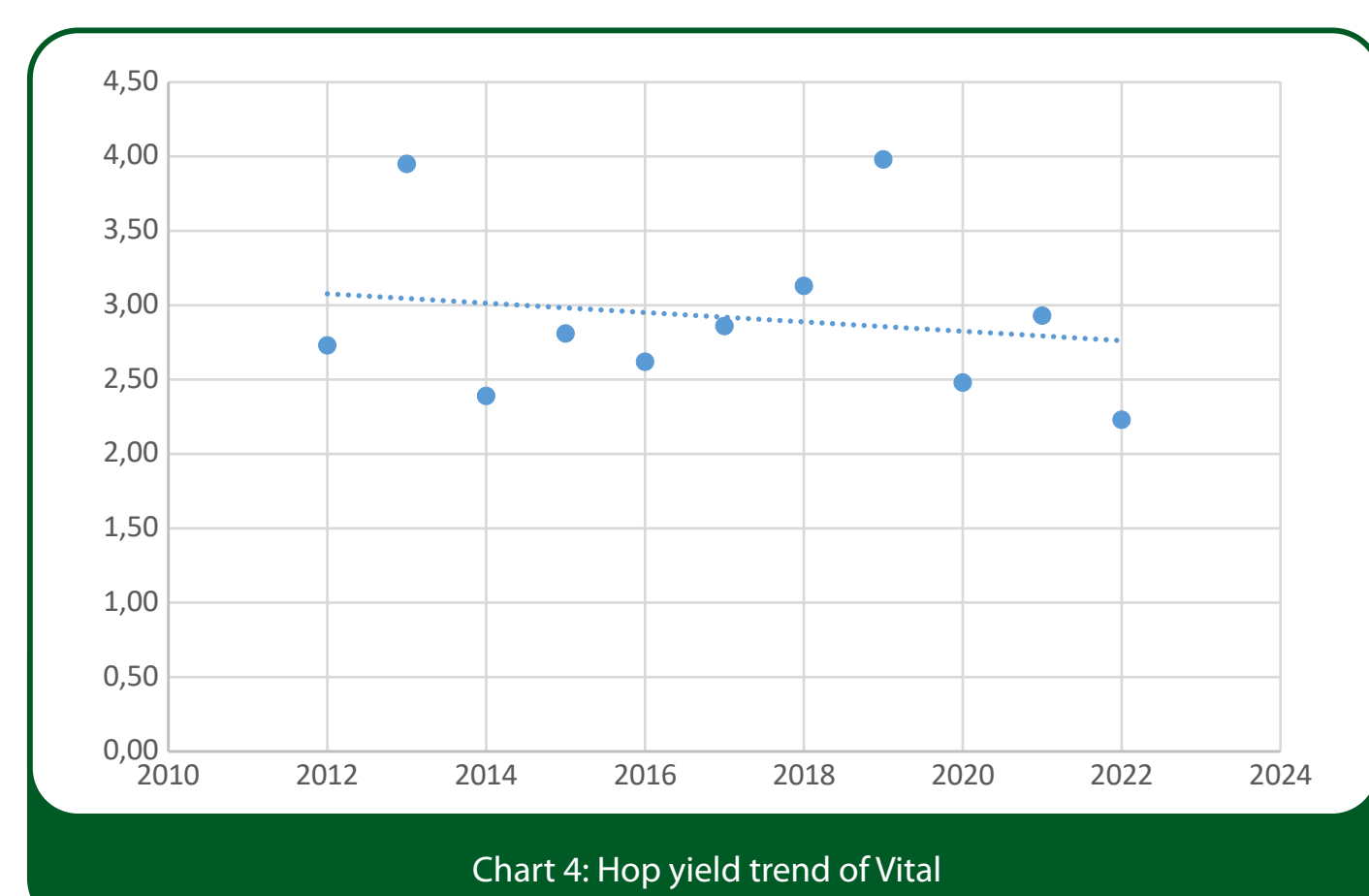
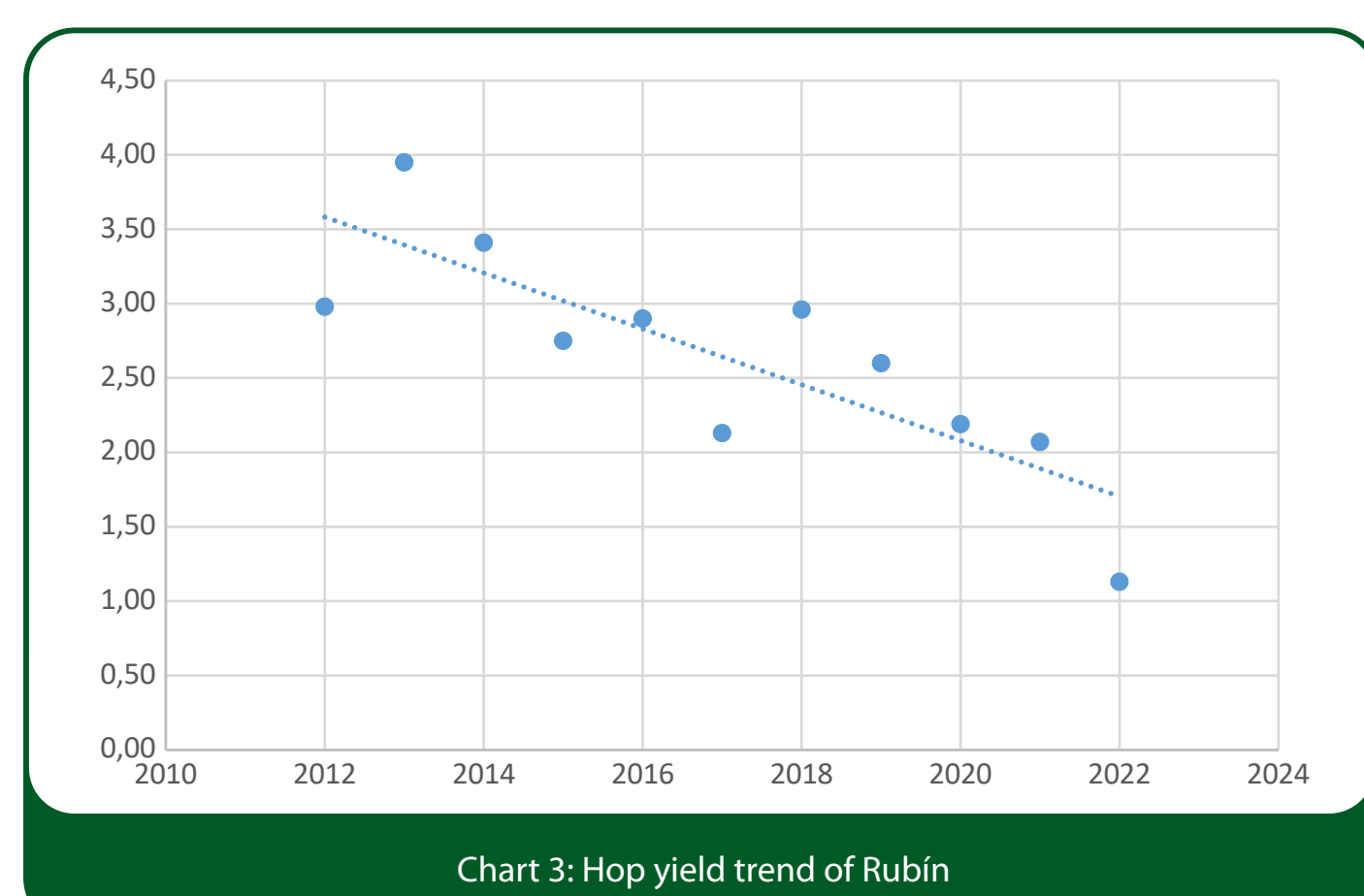


Table 1: Significance of difference determined by using a paired t-test with significance level  $\alpha$ .

	Gaia		Vital		Rubín		Agnus
Vital	-						
Rubín	0.1		-				
Agnus	0.1	0.05		-			
Boomerang	0.01	0.01	0.01		-		

Table 2: Linear regression equation (y) and reliability value ( $r^2$ ) of hop yield

Hop variety	y	y	$r^2$
Agnus	$-0.1169x + 238.37$	$-0.1169x + 238.37$	0.21
Rubín	$-0.1879x + 381.66$	$-0.1879x + 381.66$	0.58
Vital	$-0.0315x + 66.363$	$-0.0315x + 66.363$	0.03
Gaia	$-0.1189x + 242.83$	$-0.1189x + 242.83$	0.21
Boomerang	$-0.1026x + 209.13$	$-0.1026x + 209.13$	0.23



## 2. Evaluation of the content of alpha acids

Czech bitter varieties were evaluated between 2010 and 2022. Hop varieties have an average content of alpha acids between 10.24 % w/w (Agnus) and 13.73 % w/w (Gaia). As to variability, all bittering hops have a good stability of alpha content because variability is below 15%. All varieties shows a decrease in the content of alpha acids over a period of 13 years of hop cultivation. The new bitter genotypes Uran and 5304 have an average alpha acid content of 11.56 % w/w and 10.82 % w/w.

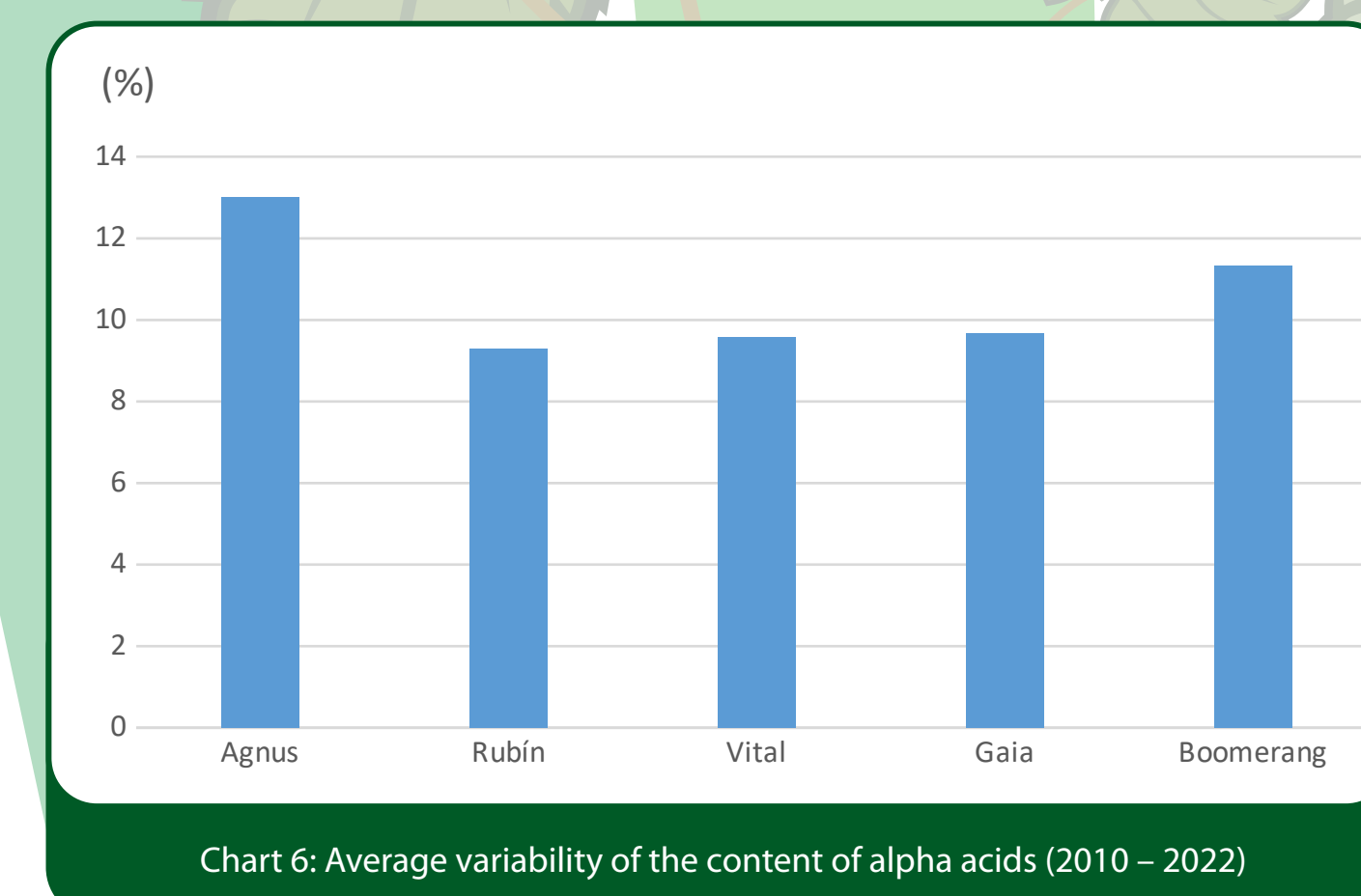
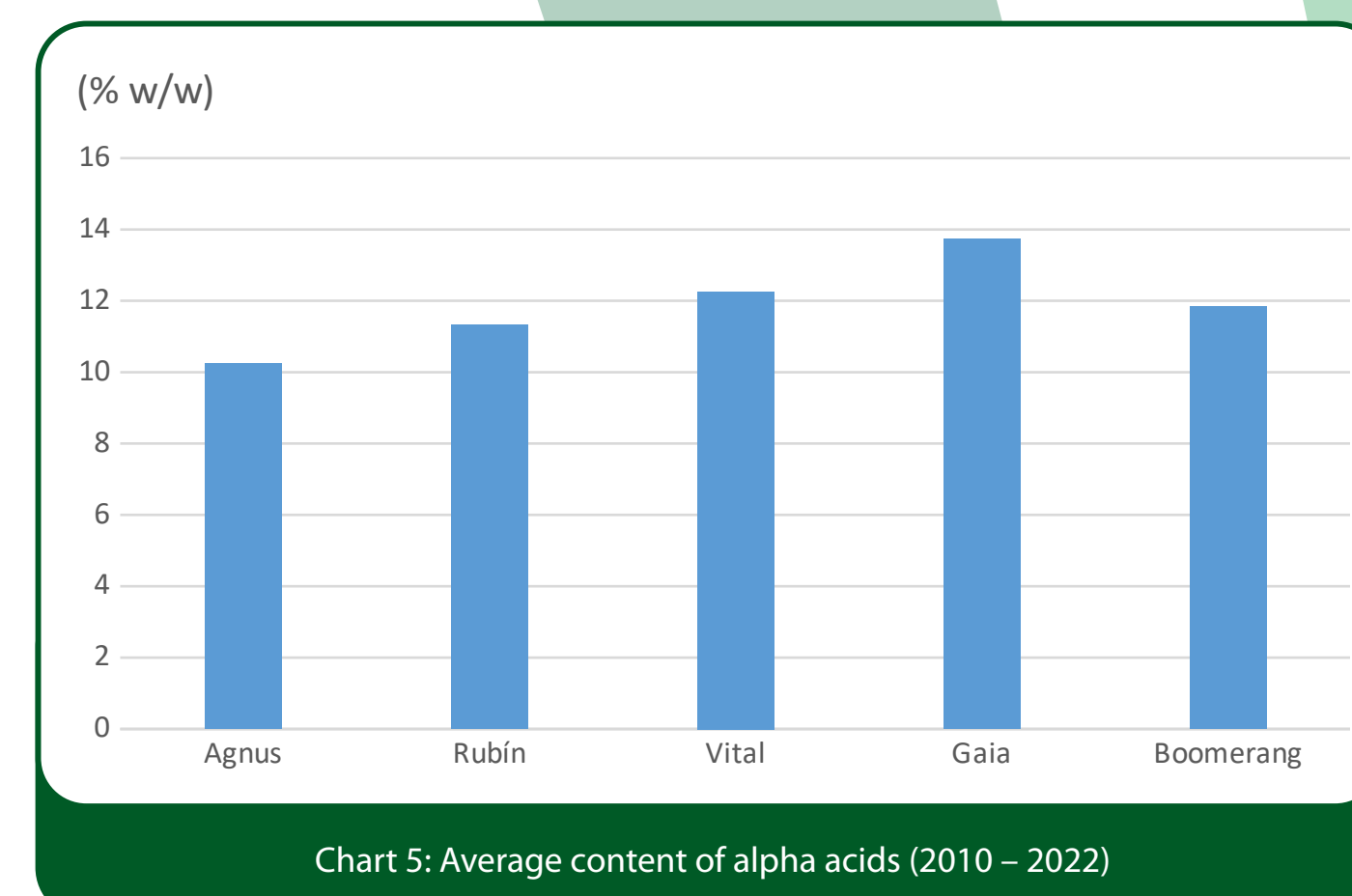
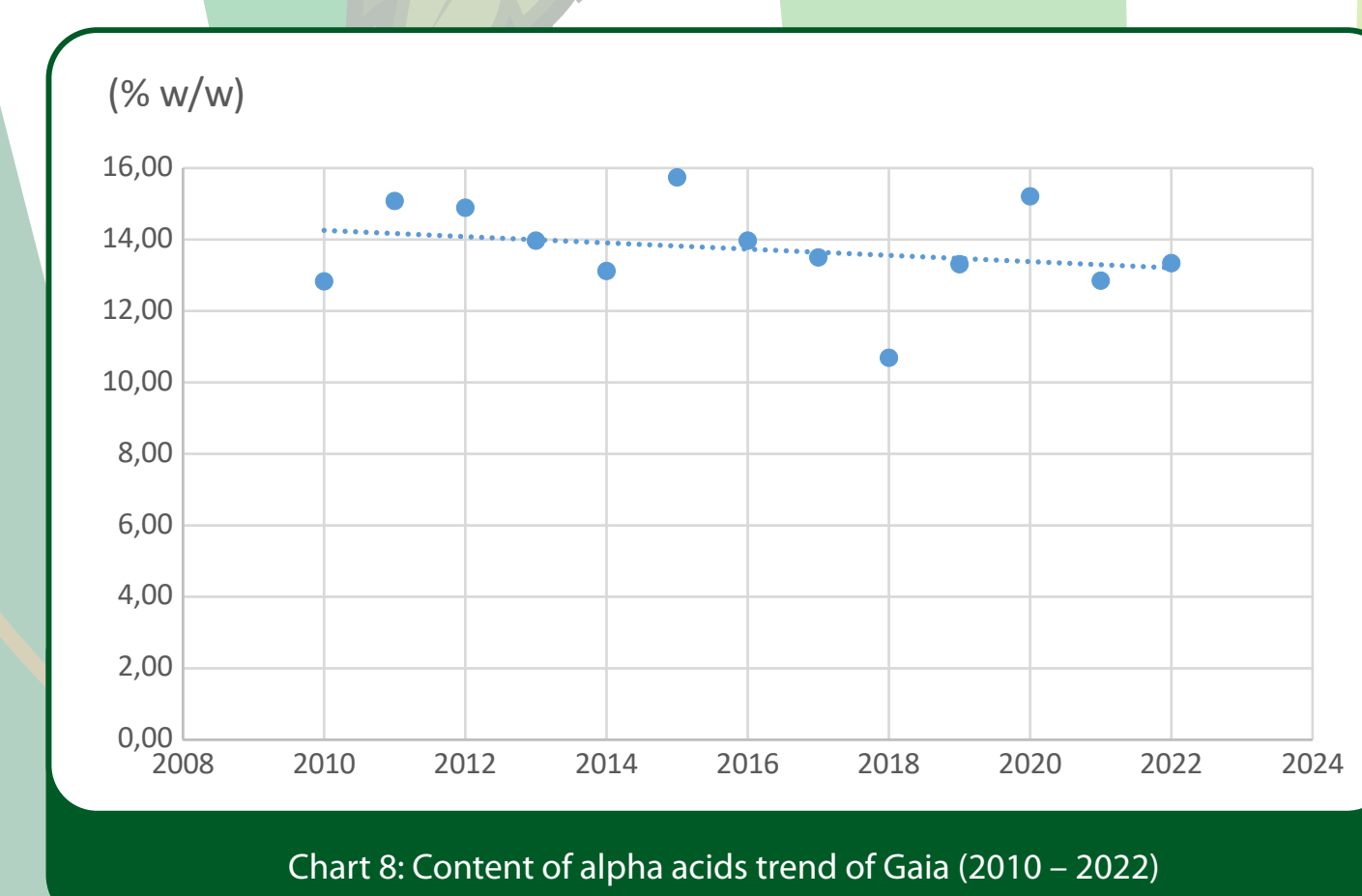
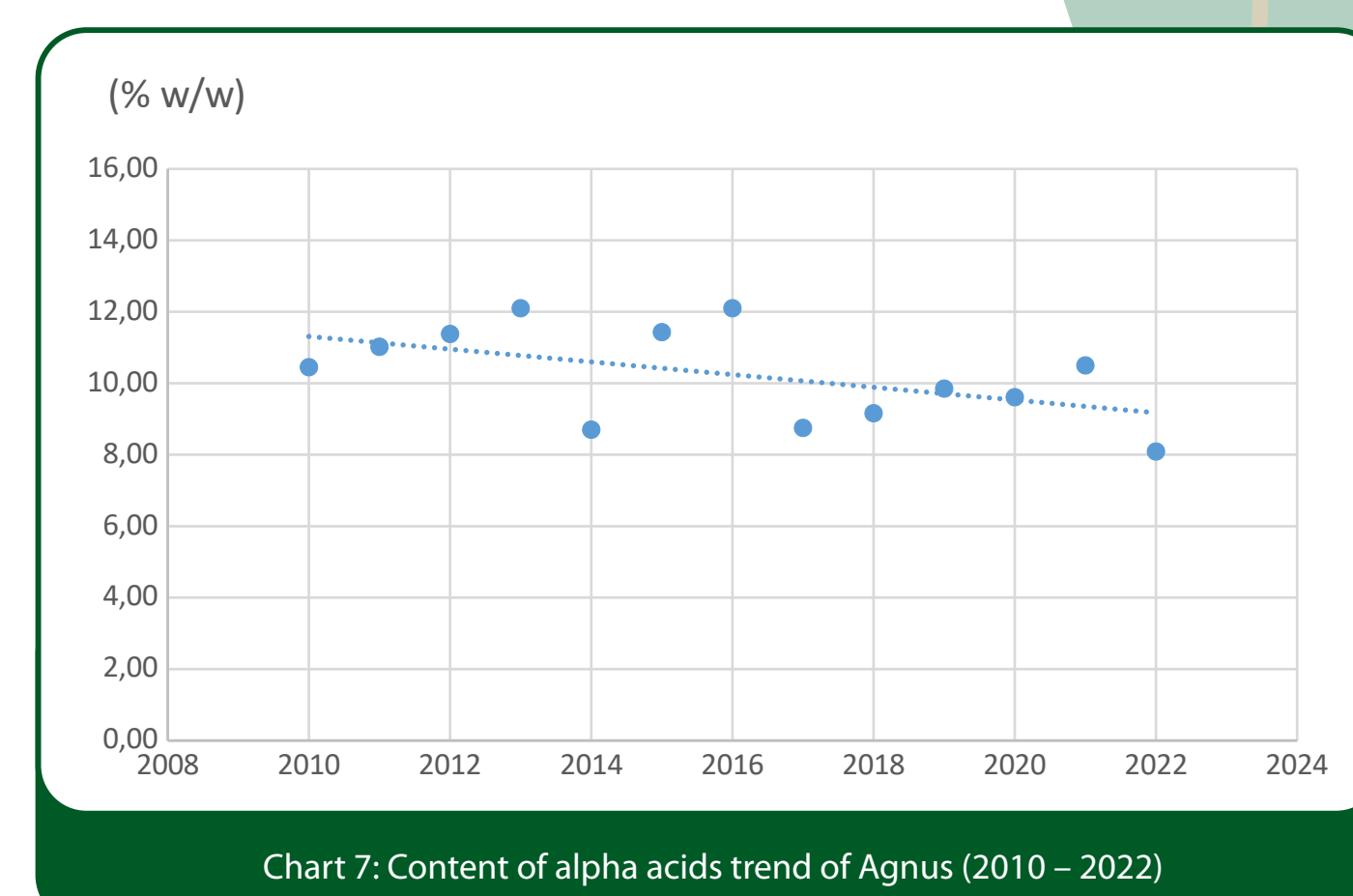


Table 3: Significance of difference in the content of alpha acids determined by using a paired t-test

	Gaia		Vital		Boomerang		Rubín
Vital	0.01						
Boomerang	0.01		-				
Rubín	0.01	0.01		-			
Agnus	0.01	0.01	0.01		-		

Table 4: Linear regression equation (y) and reliability value ( $r^2$ ) of the content of alpha acids (2010 – 2022)

Hop variety	y	$r^2$
Agnus	$-0.1777x + 268.58$	0.27
Rubín	$-0.1316x + 276.73$	0.24
Vital	$-0.1130x + 240.00$	0.14
Gaia	$-0.0873x + 189.74$	0.07
Boomerang	$-0.1061x + 225.73$	0.10



## 3. Evaluation of alpha acids production

Since 2021, a research project entitled "Application of new hop varieties and genotypes resistant to drought in hop growing and beer brewing" (QK21010136) has been implemented within a program of the National Agency for Agricultural Research (NAZV). The objective of the project has been to gain new hop varieties resistant to drought. In 2022, 5 new genotypes were included in the registration tests of the Central Institute for Supervising and Testing in Agriculture (ÚKZÚZ), two of which are bittering hop genotypes.

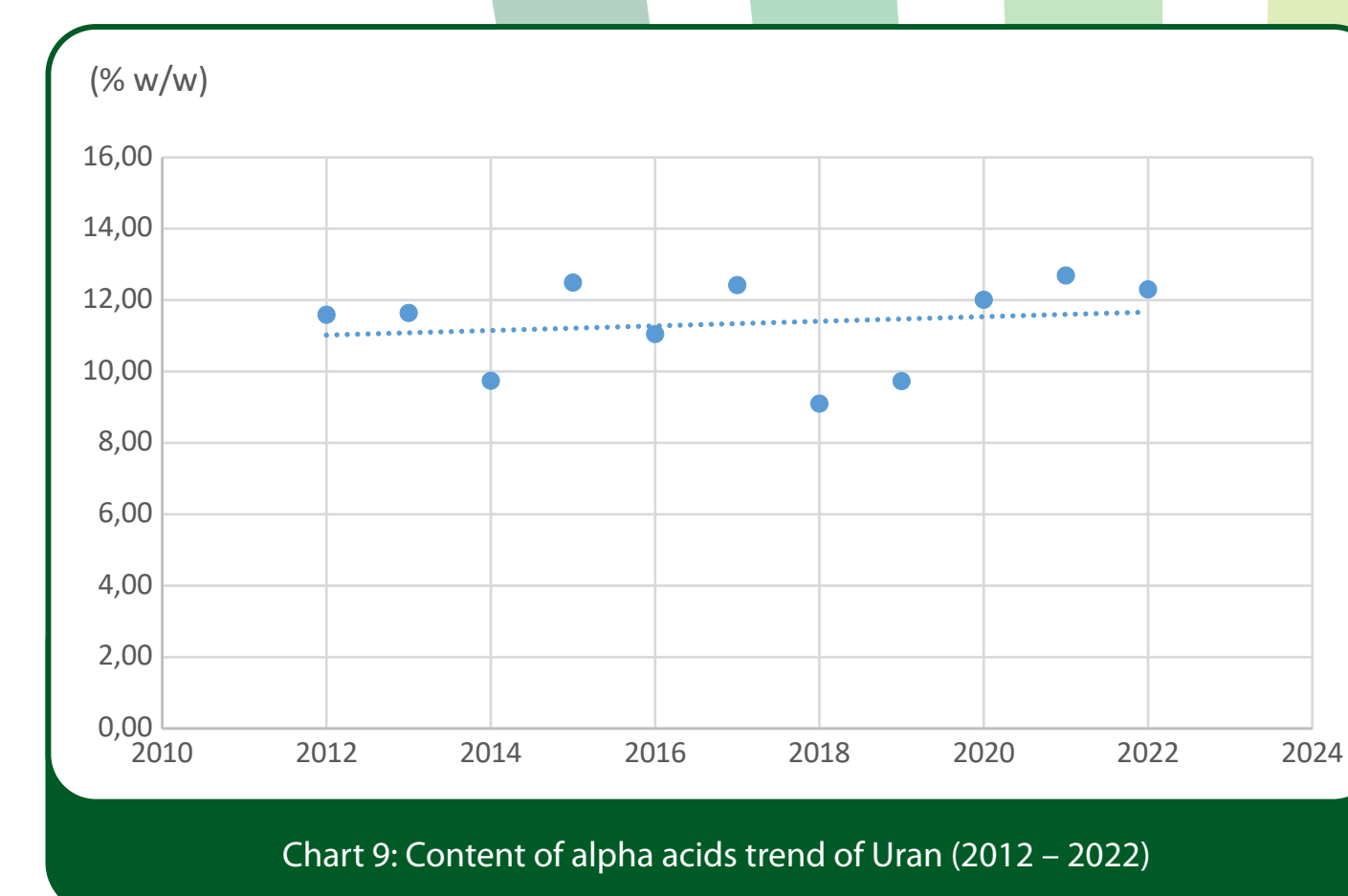
**Uran** is a multiple cross of hybrid materials of European and American bittering hops. This genotype was evaluated from 2012 to 2016 only. Its registration is likely in 2025. Its aroma has a higher share of a spicy scent and is also woody with forest fruits in the background. After having reached its technical maturity, the aroma can have an unpleasant garlicky scent. High intensity.

The **5304** genotype was gained after the hybridization of European bittering hop varieties, with the highest share of Agnus and Taurus. This genotype was evaluated from 2016 to 2022 only. Its registration is possible in 2025. It has a hoppy aroma with a spicy and herbal scent in the background. Medium intensity.

From the perspective of profitability of hop growing, production of alpha acids per hectare of a hop growing area is a very important indicator as well. Table 6 shows that only Gaia and Uran demonstrate a production of alpha acids above 300 kg/ha. In contrast, Agnus and Boomerang produce less than 200 kg of alpha acids/ha. The 5304 genotype, which is resistant to drought, also shows a high production of alpha acids (285.65 kg/ha). It needs to be noted that the average yield of Uran hops was calculated for a 10-year time series and of the 5304 genotype for a 7-year time series only.

Table 5: Production of alpha acids per 1 hectare of hops

Hop variety	Yield (t/ha)	Content of alpha acids (% w/w)	Production of alpha acids (kg/ha)
Agnus	1.92	10.24	196.61
Rubín	1.98	11.33	224.33
Vital	2.19	12.26	268.49
Gaia	2.24	13.73	307.55
Boomerang	1.58	11.83	186.91
Uran	2.56	11.56	302.85
5304	2.64	10.82	285.65



## Acknowledgement

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