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THE INFLUENCE OF DIFFERENT ROOTSTOCKS AND PLANTING SYSTEMS ON SEVERAL APRICOT CULTIVARS' GROWTH IN THE BUCHAREST AREA

Imad Jabbar Wadi AL SUWAID[1], Ana Cornelia BUTCARU[2], Cosmin Alexandru MIHAI[1], Florin STĂNICĂ[1, 2]

[1]Faculty of Horticulture, University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania
[2]Research Centre for Study of Food and Agricultural Products Quality, University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author emails: mcosminalexandru@yahoo.com, ana.butcaru@qlab.usamv.ro

Abstract

This study presents the growth and fruiting parameters of some new apricot varieties cultivated in Bucharest. The research was conducted on 28 apricot cultivars (Prunus armeniaca L.) in the Experimental Field of the Faculty of Horticulture, USAMV of Bucharest. Myrobalan 29C (M29C), Saint Julien A (SJA), and Grande Ferrade 677 (GF677) rootstocks were used, with two different planting systems, Parallel-U and Trident. The biometric parameters included trunk cross-sectional area (SST), axis cross-sectional area (SSB), canopy volume, and the total number and length of annual shoots under their influence. Generally, the cultivars grafted on M29C rootstock increase more vigor than those grafted on GF677 and Saint Julien A, regardless of the system planting. The use of the Parallel-U system compared to Trident involved the development of the SSB, with higher values in some studied cultivars. Depending on the purpose of growing the plants and the climatic conditions of the cultivation area, it is good to use rootstocks and the corresponding cultivation system to obtain the best performance of the cultivars used.

Key words: *Trident, Parallel-U, Saint Julien A, Myrobalan 29C, GF677.*

INTRODUCTION

Apricot, scientifically known as *Prunus armeniaca* L., belongs to the Rosaceae family group of diploid trees. The origin of this plant is Central Asia (Hormaza, 2002; Janick, 2005). Globally, the apricot cultivation area was nearly 560,000 hectares, which led to the harvest of about 4 million tons per year (FAO, 2022).

Pruning is one of the most critical technical functions in the cultivation technology of fruit trees. During the plant growth period, proper pruning produces strong branches with a suitable angle in the plant; this issue ensures that maximum light reaches the plant canopy and increases the strength and durability of its components. Balanced conditions are provided for the growth and development of flower and fruit buds in the tree. In addition, proper pruning in fruit trees causes the regeneration of damaged branches and controls the size of the tree canopy and the plant height (Demirtas et al., 2010).

Pruning in temperate regions is generally performed at the end of winter and the beginning of spring at the same time as the plant's dormant season (Demirtas et al., 2010). Proper pruning in the plant optimizes the relationship between shoot growth, available leaf surface, and photosynthesis, which ultimately affects the production of high-quality products (Lang, 2001).

Various planting systems, such as Vertical axis, Bi-Baum, Trident, etc., are effective in orchard management. Increasing planting density in orchards is also one of the results (Lauri & Lespinasse, 2000; Robinson et al., 2011; Hoying et al., 2012). Increasing the number of axes to two in the form of Bi-Baum, Tatura trellis, Parallel Y, etc.; also, increasing the number of axes to three in the Trident systems and even expanding the number of axes to four in Mikado led to the development of new canopy shapes in trees (Widmer & Krebs, 2001; Musacchi, 2008; Dorigoni et al., 2011; Stănică & Platon, 2011; Elkins & DeJong, 2011).

In Mediterranean regions, in apricot cultivation, Myrobalan rootstock and trees obtained from wild apricot are commonly used (Ercisli, 2009; Miodragovic et al., 2019). Rootstock affects scion phenology, vegetative growth, fruit quality, plant performance, and tolerance to biotic stress and nematodes (Layne, 1994). The regression relationship between tree height, canopy diameter, and branch height was linear. Moreover, it was said that there is a positive and non-linear relationship between trunk cross-section and tree height, canopy diameter, branch length, and canopy volume.

Due to the limited compatibility between scions and rootstocks originating from different climatic conditions, studying and evaluating the climatic compatibility of different apricot rootstocks is vital and essential (Bujdoso et al., 2019). In each cultural system, depending on the climatic conditions, the right combination of rootstocks and scions should be determined and selected in research programs (Opriță & Gavat, 2018).

In the study carried out in Romania, it was also found that the use of a Trident planting system in the apricot culture led to the facilitation and improvement of the productivity, stability, and efficiency of the new varieties introduced in Romania (Stănică & Eremia, 2014).

Our study presents the growth and fruiting parameters of some new apricot varieties cultivated in Bucharest.

MATERIALS AND METHODS

The research was conducted on 28 apricot cultivars (*Prunus armeniaca* L.) in the Experimental Field of the Faculty of Horticulture in Bucharest. Myrobalan 29C (M29C), Saint Julien A (SJA), and Grande Ferrade 677 (GF677) rootstocks were used, with two different planting systems, Parallel-U and Trident. The monitored biometric parameters included trunk cross-sectional area (SST), axis cross-sectional area (SSB), canopy volume, and the total number and length of annual shoots under their influence.

The research period was 2020-2022.

The plantation was established in 2017. Two rows containing 33 trees per row had planting distances of 4 x 2 m, with tall concrete posts and four wires used to support the canopy. In the Bi-Baum system, the third row had 45 trees with a 4.5 x 1.5 m planting distance. The shape of the canopy resulted from manual pruning carried out annually in the summer in two stages, the first being before the appearance of the fruits and the second after harvesting.

The biological material consisted of the newest apricot cultivars, tested in the specific Bucharest conditions. On the Trident system were cultivated Faralia/M29C, Fareli/SJA, Anegat/M29C, Farbali/M29C, Farbali/SJA, Farbela/M29C, Farclo/SJA, Farclo/M29C, Farlis/M29C, Fartoly/SJA, and Primaya/SJA. In the Bi-Baum (2.0 m) were cultivated Wonder Cot/M29C, Lady Cot/M29C, Delice/M29C, Lilly Cot/M29C, Milord/ M29C, Swired/M29C, Congat/M29C, Mikado/M29C, Lido/M29C, Med Flo/M29C, and Flopria/M29C. In the Bi-Baum (1.5 m) were cultivated Congat/GF677, Primando/ SJA, Primaya/SJA, Rubista/M29C, Portici/ M29C, Pisina/M29C, CMBU/M29C, Bergeron/M29C, Vitilo/M29C, Boccuccia Liscia/M29C.

The methods used to evaluate the growth and fruiting parameters of some new apricot varieties planted in the Bucharest area were:

The formula determined the **cross-sectional area of the trunk** (SST):

$SST = \pi \times r^2$,

where r = D/2, D = trunk diameter.

The trunk diameter was measured 30 cm above the grafting point using a digital caliper.

The formula determined the **cross-sectional area of the axis** (SSB):

$SSB = \pi \times r^2$,

where $r = P/2 \times \pi$, P = axis section perimeter.

The perimeter of the axis section was measured 30 cm from the starting point, and the measuring tape was used. They were calculated for the two or three axes and then averaged the values.

To determine **the volume of the canopy**, the formula was used:

$V = \pi \times 3^{-1} \times r^2 \times h$,

where:

r = the length of the canopy in the direction of the row and the width of the canopy at an angle of 90 degrees to the row (average of these two data/ 2 = r);

h= the tree's height from the first branches to the top (without the height of the trunk).

The number and length of fruiting branches were determined each year during the dormant period of each tree in the experiment.
Statistical analysis of data was performed with Microsoft Office (Excel) and SPSS programs, using a 5% probability level.

RESULTS AND DISCUSSIONS

The cross-sectional area of the trunk (SST)
In the series of cultivars with the Trident canopy shape, the highest value of SST in the first year of the study was observed in the cultivar Farbali/M29C (42.22 cm^2), and the lowest at Anegat/M29C (24.71 cm^2) and Farlis/M29C (22.80 cm^2). In the second year of the study, the highest SST value was observed in Farbali/M29C, and Faralia/M29C cultivars, and the lowest was recorded in Anegat/M29C. In the third year of the study, the highest values were recorded in the cultivars Farclo/M29C, Farbali/M29C, Farely/M29C, and Faralia/M29C (Table 1).

Table 1. Evolution of SST during the period 2020-2022 (cm^2) at the Trident system

Variant	2020	2021	2022
Anegat/M29C	24.71b	25.67b	30.72c
Faralia/M29C	32.71ab	41.66a	43.84abc
Farbali/M29C	42.22ab	42.39a	46.35ab
Farbali/SJA	33.94ab	33.95ab	39.52bc
Farbela/M29C	29.87ab	28.77ab	34.88bc
Farclo/M29C	37.29ab	38.62ab	52.69a
Farclo/SJA	28.60ab	31.61ab	38.45bc
Farely/SJA	36.42ab	38.72ab	45.91ab
Farlis/M29C	22.80b	30.33ab	33.30bc
Fartoly/SJA	29.44ab	33.25ab	36.59bc
Primaya/SJA	28.38ab	32.59ab	42.39abc
Average	31.49ab	34.33ab	40.42abc

Analyzing the influence of rootstock on SST growth, SJA induced a lower increase than M29C rootstock in Farbali and Farclo cultivars in all three years of study.
In the three years of research, the series of apricot cultivars in the Bi-Baum (2.0 m) planting system showed similar results. Thus, the highest reported increase in trunk cross-sectional area was in Lido/M29C and Med Flo/M29C cultivars compared to the other cultivars studied in each research year. Maximum values ranged between 25.90 cm^2 (2020), 29.48 cm^2 (2021) and 35.22 cm^2 (2022).

Table 2. Evolution of SST during the period 2020-2022 (cm^2) at the Bi-Baum (2.0 m) system (M29C rootstock)

Variant	2020	2021	2022
Congat	19.35ab	19.62abc	25.26abcd
Delice	21.79ab	24.46ab	26.95abcd
Flopria	12.86bc	15.00Bc	18.69cd
Lady Cot	19.28ab	20.75abc	25.41abcd
Lido	25.90a	29.49A	35.22a
Lilly Cot	18.91ab	22.42Ab	27.66abc
Medflo	24.01a	27.72A	34.39ab
Mikado	11.02bc	14.55Bc	20.35bcd
Milord	21.06ab	23.35Ab	28.09abc
Swired	8.24c	9.19C	13.32d
Wonder Cot	20.80ab	22.24Ab	23.59abcd
Average	18.14ab	20.41abc	24.88abcd

Swired/M29C showed the most diminutive increase relative to the SST parameter in each year of the study, 8.24 (2020) - 9.19 (2021) - 13.32 (2022) cm^2. Similar behavior was shown by Mikado/M29C and Flopria/M29C cultivars (Table 2).
In the series of apricot cultivars in the planting system Bi-Baum (1.5 m), Primando/SJA and Primaya/SJA showed the highest increases in SST over the three years of the study, and Bergeron/M29C and Rubista/M29C the lowest values (Table 3). The other cultivars had no significant differences between them.

Table 3. Evolution of SST during the period 2020-2022 (cm^2) at the Bi-Baum (1.5 m) system

Variant	2020	2021	2022
Bergeron/M29C	10.67b	12.90b	17.81c
Boccuccia Liscia/M29C	13.79ab	17.66Ab	19.82bc
CMBU/M29C	13.21b	17.38Ab	23.86bc
Congat/GF677	15.53ab	20.19a	22.49bc
Pisana/M29C	15.30ab	19.19Ab	21.46bc
Portici/M29C	14.36ab	19.29Ab	21.29ab
Primando/SJA	19.34a	22.76A	28.32a
Primaya/SJA	16.33ab	20.92a	35.02c
Rubista/M29C	13.09b	16.28ab	16.97bc
Vitillo/M29C	14.54ab	18.19ab	25.01bc
Average	14.39ab	18.26ab	23.00bc

Comparing the growth rate for SST in the Primaya/SJA variety between the two planting systems (Trident; 2.0 m) and (Bi-Baum; 1.5 m), it was observed the significantly higher values presented in the Trident system compared to the Bi-Baum (28.38/16.33 cm^2 - 2020; 34.83/20.92 cm^2 - 2021; 42.39/35.02 cm^2 - 2022).

Comparing the evolution of the Congat cultivar on the two rootstocks M29C and GF677 in the Bi-Baum planting system (19.35/15.53 cm^2 - 2020; 19.62/20.19 cm^2 - 2021; 25.26/22, 49 cm^2 - 2022) there was a more substantial increase in M29C in the first and last year of the study.

The cross-sectional area of the axis (SSB)

In analyzing this growth parameter, the average surface area of the axis section was taken into the analysis (two for Bi-Baum and three for Trident). In cultivars led with the Trident planting system, values ranged between 5.08 cm^2 (Farclo/SJA), 6.22 cm^2 (Farlis/M29C), and 11.38 cm^2 (Faralia/M29C) (similar value for Fartoly/SJA, Farclo/SJA, and Farclo/ M29C) in 2020; 5.52 cm^2 (Farclo/SJA) and 13.31 cm^2 (Fartoly/SJA) in 2021; 7.34 cm^2 (Farclo/SJA) and 16.23 cm^2 (Faralia/M29C) in 2022. M29C rootstock showed more vigorous growth than SJA in the three years studied in Farclo and Farlis cultivars.

In the series of cultivars Bi-Baum (2.0 m), cultivar Lido/M29C had the highest value of SSB in the three years studied, similar to cultivar Med Flo/M29C. Swired/M29C, Mikado/M29C, and Flopria/M29C showed the lowest increases each study year compared to the other variants. The values varied between 4.82 cm^2 and 12.44 cm^2 in 2020, 5.15 cm^2 and 13.57 cm^2 in 2021, 6.69 cm^2 and 16.46 cm^2 in 2022.

In the case of plants cultivated in the system Bi-Baum (1.5 m), SSB varied between 4.23 cm^2 (Rubista/M29C, similar to Bergeron/ M29C) and 8.42 cm^2 (Primando/SJA) in 2020; 5.57 cm^2 (Rubista/M29C, similar to Bergeron/M29C) and 11.30 cm^2 (Primaya/ SJA) in 2021; 5.53 cm^2 (Rubista/M29C) and 14.53 cm^2 (Primaya/SJA) in 2022.

Comparing the SSB values of the Primaya/SJA variant between the two Trident and Bi-Baum systems planting (8.77/7.44 cm^2 in 2020, 10.56/11.30 cm^2 in 2021, 14.18/14.53 cm^2 in 2022), similar values were observed in each year of the study.

Analyzing the influence of the two rootstocks M29C and GF677 on the SSB values of the Congat cultivar in the Bi-Baum planting system, 8.43/6.10 cm^2 in 2020, 9.14/7.95 cm^2 in 2021, 12.79/9.05 cm^2 in 2022, it was observed as in the case of SST, significantly higher increases induced by M29C rootstock compared to GF677.

Canopy volume study

In this study, the canopy volume was analyzed every year for each variant, even if the cultivation technology required annual shortening of the tree height by the needs of the space allocated to each plant, a fact that influenced the absolute values.

Following the application of the cultivation technology, in the series of varieties cultivated in the Trident system, the values varied between 1.91 m^3 (Fartoly/SJA) and 4.02 m^3 (Farbali/M29C) in 2020; 2.86 m^3 (Farely/SJA) and 3.83 m^3 (Farlis/M29C) in 2021; 3.61 m^3 (Farbali/SJA) and 5.99 m^3 (Primaya/SJA).

In the Bi-Baum (2.0 m) planting system, canopy volume values ranged between 1.48 m^3 (Flopria/M29C, similar to Mikado/M29C and Swired/M29C) and 2.95 m^3 (Lido/M29C) in 2020; 1.62 m^3 (Swired/M29C similar to Mikado/M29C and Flopria/M29C) and 3.35 m^3 (Milord/M29C, similar to Lilycot/M29C, Med Flo/M29C, Lido/M29C, and Wonder Cot/M29C) in 2021; 2.08 m^3 (Swired/M29C) and 4.98 m^3 (Med Flo/M29C).

The study of the response of the different variants in the Bi-Baum (1.5 m) planting system revealed a variation of tree canopy volume values between 1.96 m^3 (Portici/M29C) and 3.56 m^3 (Pisana/M29C) in 2020; 1.93 m^3 (Primando/SJA) and 4.10 m^3 (CMBU/M29C) in 2021; 1.88 m^3 (Portici/M29C) and 6.06 m^3 (Pisana/M29C) in 2022.

In the Primaya/SJA cultivar, the canopy volume in the two Trident and Bi-Baum systems varied between 2.33/2.76 m^3 in 2020, 3.74/2.95 m^3 in 2021, 5.99/5.33 m^3 in 2022.

The Congat cultivar, in the Bi-Baum system, was led on the two rootstocks M29C and GF677 at a canopy volume that varied between 1.97/2.21 m^3 in 2020, 2.76/2.55 m^3 in 2021; 3.85/2.73 m^3 in 2022.

Number of fruiting branches and annual growths

Being a more vigorous rootstock, M29C influenced the number of mixed and anticipated branches and total annual growth compared to SJA.

In the study of the different varieties, it was found that the variety Lido had the highest number of branches in both years of the study. Also, total annual growth and Congat cultivar had the lowest values (Bi-Baum, 2.0 m).

Comparison of the variants according to the dynamics of the SST and SSB

Comparing the resulting matrices with SST and SSB values in each variant, a similar development behavior was observed in some cultivars. Thus, in cultivars led in the Trident planting system (Figure 1), Anegat/M29C and Farlis/M29C showed similar growth behavior. Also, Farely/SJA and Primaya/SJA variants.

In the Bi-Baum (2.0 m) planting system, similarity in growth behavior was observed in Swired/M29C, Mikado/M29C, and Flopria/M29C; Milord/M29C and Lilycot/ M29C; Lido/M29C and Med Flo/M29C (Figure 2).

In the Bi-Baum (1.5 m) planting system, similarities in growth behavior were observed in Portici/M29C, Pisana/M29C, and Congat/GF677; Rubista/M29C and Bergeron/M29C (Figure 3).

Tree growth, assessed by trunk cross-section area (Kumar et al., 2014), was influenced by rootstock and planting systems in this study. In this study, plants grafted on M29C in the Trident variants resulted in higher SST and SSB values than SJA. The effect of the rootstock on the growth stages has been confirmed (Beckman et al., 1992; Layne, 1994).

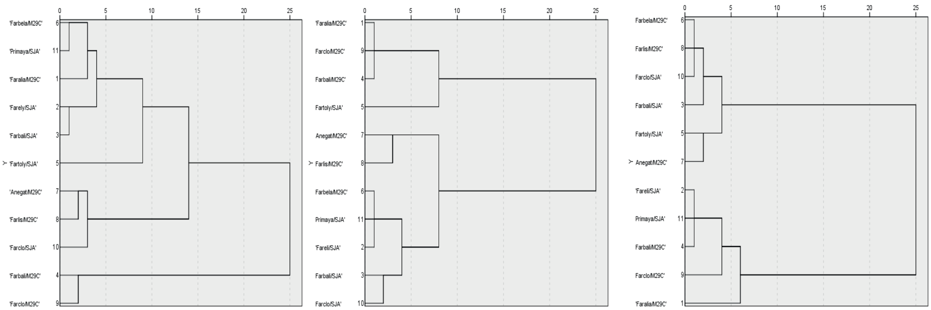

Figure 1. Variant clusters under the influence of SST and SSB in the Trident planting system (2020-2022)

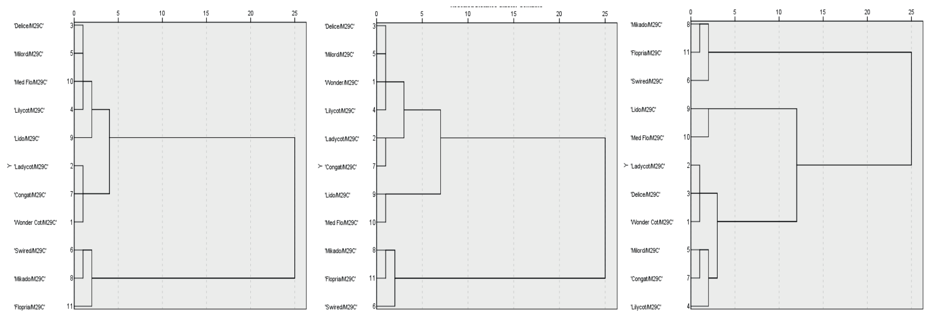

Figure 2. Variants cluster under the influence of SST and SSB in the Parallel-U, 2.0 m (2020-2022)

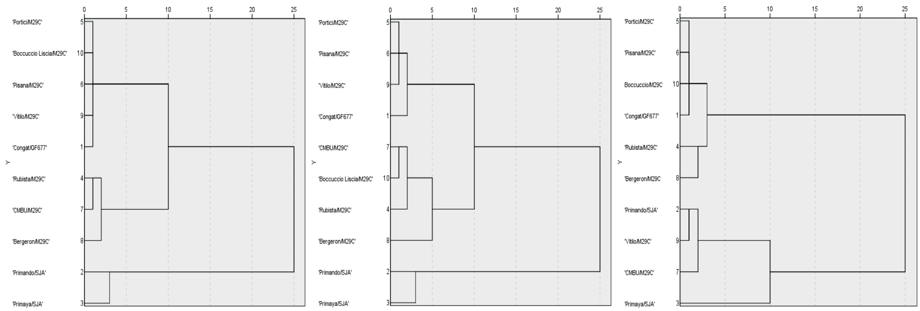

Figure 3. Variants clusters under the influence of SST and SSB in the Parallel-U, 1.5 m (2020-2022)

The choice of a suitable rootstock is one of the critical factors affecting orchard management. Plant growth, the quality of the fruits produced, and the plant's response to environmental conditions are affected by rootstocks. The effect of the rootstock on the plant also varies depending on the cultivar and the existing environmental conditions. It was explained that the rootstock influence on the growth parameters of the plant is stronger than the influence of the scion (Son & Küden, 2003; Egea et al., 2004; Sitarek & Bartosiewicz, 2011; Milošević et al., 2015; Milošević & Milošević, 2019; Pászti et al., 2022). According to the results of our research, the use of Myrobalan resulted in more significant increases in SST compared to St. Julien A, confirmed the Milošević & Milošević (2019) study results. The positive effect of Myrobalan on plant growth was also confirmed by Sosna & Licznar-Małańczuk, (2012) and Milošević et al. (2015).

In the planting system Bi-Baum (1.5 m), which used three rootstocks, M29C, SJA, and GF667, it was found that although SJA is known as a rootstock of medium vigor, in some variants, it caused growth higher compared to other rootstocks. This aspect is probably related to the shape of the canopy, Bi-Baum. The genetic code of the rootstock is efficient in plant growth. However, the different responses of the grafted variety in different rootstocks cannot be excluded (Hernández et al., 2010).

The trend to have higher densities in commercial apricot orchards has increased. Changing the number of vertical axes in each tree makes increasing or decreasing the cultivation density per unit area possible. In general, in commercial orchards, the presence of one or two axes is promoted (Dorigoni et al., 2011; Stănică, 2019).

Using the two planting systems, Bi-Baum and Trident, allows easier light penetration into the plant’s canopy, the production structure is easily renewed, the performance increases, and the quality of the fruits is improved. In addition, maintenance of the plant is more accessible. Also, the tree's growth power is distributed on three or two vertical axes, creating an appropriate balance in the canopy structure (Stănică & Eremia, 2014). The Bi-Baum system is one of the most efficient when using rootstocks with medium-high vigor (Wertheim, 1998). One of the advantages of dividing the plant's growth power into 2 or 3 axes is the reduction of pruning time and the control of tree growth. Another advantage is the acceleration of canopy formation (Musacchi, 2008). The increase in SSB, SST, and the canopy volume in cultivars driven by this form can be related to the number of axes and branches in the plant, which leads to a better distribution of compounds resulting from photosynthesis.

CONCLUSIONS

According to the results of this study, it was found that using different rootstocks produces a different response in the plant in terms of vigor and growth speed. Different planting systems led to varying effects on the biometric parameters, influencing plant growth indicators. The research showed that the canopy volume was influenced by the two culture systems, Trident and Bi-Baum. Similarities of growth were highlighted in different cultivars throughout the study period.

Overall, the research showed that among the rootstocks used in different cultivars, M29C significantly affected branch production in the tree compared to SJA, confirming the effect of higher vigor on the trees—also, the Trident canopy form led to higher vegetative growth than Bi-Baum.

Depending on the purpose of growing the plants and the climatic conditions of the cultivation area, it is good to use rootstocks and the corresponding cultivation system to obtain the best performance of the cultivars used.

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