

Growth characteristics and flowering stage of some *Digitalis purpurea* L. cultivars and *Gaillardia* sp. Foug. in the agro-ecological conditions in Kosovo

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Abstract

Perennial flowering plants are important parts of the urban green spaces with their beautiful flowers, colours and foliage. The purpose of the study was to evaluate the blooming stage and vegetative growth parameters for 12 perennials flowering taxa of *Digitalis purpurea* and *Gaillardia* sp. in the agro-ecological conditions of Kosovo. During the 2022–2023 growing periods, the object of research in our experimental field were totally 12 taxa. The experiment was 'Randomized block' type with four replications and 200 plants for each cultivar. All taxa were studied for: beginning and end of the flowering stage, features of petal fusion/ligules per flower head, flower opening stage, colour of flowers, dynamic of growth in length of flower stems, diameter of flower stems, number of flower stems per plant, fragrance of flowers. *Digitalis* cultivars and *Gaillardia* sp. have demonstrated high ornamentally and long period with flowers, good growing, leaves and flowers of different colours. Because of their good performance, studied taxa deserve more important place in public green spaces in the context of greater sustainability in urban landscape and should be included in the design and planting structure in Kosovo.

Key words: *Gaillardia aristata*, *Gaillardia pulchella*, *Gaillardia* × *grandiflora*, perennial flowering plants, vegetative growth parameters.

Introduction

Green spaces are becoming more important for the cities due to the increasing pressures of urbanization and climate change. Along with trees, shrubs and lawns, flower

beds are an important part of urban green spaces. Most flower beds in public spaces consist of annual, biennial and perennial flower species (Poje et al. 2023).

The improvement of living standard in the last two decades in the Republic

of Kosovo and the great development of various fields of construction (various social-cultural objects, city squares, residential houses, etc.), have influenced the increase in the demand for ornamental plants and implementing a modern landscape architecture (Balaj et al. 2022).

Most of the flower beds in public spaces in Kosovo consist of one-year and two-year flowers with beautiful colours, but to keep their aesthetic view during the summer, they require a lot of maintenance (Lushi et al. 2009).

Perennial flowering plants are used in the design of parks, flower gardens, private gardens, green spaces in cities, residential houses, etc. This group includes plants that in the climatic conditions of Kosovo are of high ornamental value, such as *Gaillardia aristata* Pursh, *Digitalis purpurea* L., *Antirrhinum majus* L., *Lavandula angustifolia* Mill., *Astilbe* × *arendsii* Arends, *Solidago virgaurea* L. (Dinga 1988).

Perennial flowering plants are important parts of green spaces with their beautiful flowers, colours and foliage (Almas and Conway 2016). They have a wide variety of colours and growth sizes and adapt to almost any landscape situation (Witting 1998).

The advantages of the combination of perennial plants depend on the diversity and heterogeneity, to have a beautiful appearance in the spaces of the parks, as well as to be attractive to their visitors (Lindemann-Matthies et al. 2010).

Digitalis purpurea is a member of Plantaginaceae family and is short-lived *perennial* plant growing 1 to 1.5 m in height, with bell-shaped flowers that hang down, with pink, red, white colours. The flowering period starts from late spring to mid-autumn. This species is used in gardens combined with several types of ornamental plants.

It is one of the most important medicinal plants in the world and is also favoured as a garden plant or cut flowers (Qualtrocchi 2000).

Genus *Gaillardia* Foug. is a member of Asteraceae family *G. aristata* is native to North and South America. Among the flowers used for domestic market, *gaillardia* is one of the important commercial flowers. Inflorescences are mono and bi-coloured in red, yellow and rusty brown, etc. It is used in the decoration of gardens in flower borders combined with other types of flowers (Wunderlin 1998).

Gaillardia pulchella Foug. is a short-lived perennial native to North America (Eastern and South-central US and Mexico). Corollas are usually reddish to purplish proximally, yellow to orange distally, rarely yellow, reddish, or purplish throughout. It prefers sandy or calcareous soils, often disturbed places, mostly in grasslands or open places, in the range 0–1800 m a.s.l. Cultivars of *G. pulchella* or of hybrids between *G. pulchella* and *G. aristata* are used horticulturally (Flora of North America 2024).

Gaillardia × *grandiflora* hort. ex Van Houtte is a tetraploid hybrid resulting from a cross between perennial *G. aristata* and *G. pulchella*, inheriting its perennial habit from the former and its long flowering period and rapid growth rate from the latter. It is perennial but generally short-lived. The stems and leaves are densely hairy. The flowers are often bicoloured and daisy-like in a wide variety of colour arrangements, but usually featuring yellow to orange to red rays with maroon to orange banding at the petal bases and dark burgundy centre disks. There are several cultivars available to extend the colour and height availability (North Carolina State University 2024).

The purpose of the study was to evaluate the blooming stage and vegetative

growth parameters for 12 perennials flowering taxa of *Digitalis purpurea* and *Gaillardia* sp. in the agro-ecological conditions of Kosovo.

Materials and Methods

During the 2022–2023 growing periods, the object of research in our experimental field were the following 12 perennial flowering taxa: six cultivars of *Digitalis purpurea* ('Polkadot Polly', 'Illumination Flame', 'Mountains Mixed', 'Rose Shades', 'Pam's Choice', and 'Excelsior Mix'); three cultivars of *Gaillardia aristata* ('Oranges and Lemons', 'Arizona Apricot', and 'Arizona Sun'); two hybrids – *Gaillardia* × *grandiflora* 'Summer Kiss' and *G. × grandiflora* hort.; and *Gaillardia pulchella*. Plans of all these 12 taxa were studied for the main growth characteristics and flowering stage: beginning and end of flowering stage, features of petal fusion based on number of protrusions on the corolla edge; flower opening stage, colour of flowers, dynamic of growth in length of flower stems (in cm, average value); diameter of flower stalk (in mm, average value), number of flower stems per plant (average) and fragrance of flowers. The results of the study are presented as an average for two growing periods (2022–2023).

The distillation method was used to determine the fragrance of flowers. The distillation method is a process used to extract the aromatic essence from flowers and plants. This method involves evaporating water, which extracts the essential oils from the plant materials, and then condensing the steam to separate the distilled oils from the water (Tisserand 2004).

The experiment was 'Randomized block' type with four replications and 200 plants for each cultivar. Plant seedlings

were produced in greenhouses and then planted in the ground in April 2022. Plant seedlings were 10 cm tall and had 3–4 leaves, without flower buds. The planting distance between the plants was 30 cm, while between the rows was 80 cm. The plants were planted in sandy soil and irrigated during the growth period by drip irrigation system.

The average monthly temperature during the growing period was in April (12.2 °C), May (17.7 °C), June (19.9 °C), July (23.0 °C), August (21.9 °C) and in September the average temperature was 18.9 °C. The precipitation amount during the growing period was 27.3 mm in April, 83.0 mm in May, 99.0 mm in June, 60.0 mm in July, 42.9 mm in August and in September the average of precipitation was 32.5 mm (HMIK 2022).

For all data, an analysis of variance was applied using the statistical package, Systat, Genstat, further analysed using rang test with a critical level (*P*-value) of 5% (Gomez and Gomez 1984).

The study was carried out in the urban space in Prizren, Republic of Kosovo, in two growing periods from April 2022 to October 2023, in an area 1200 m² (Fig. 1). Kosovo is located in the central part of the Balkans. It lies between 41°50'58" and 43°51'42" of northern geographic latitude and between 20°01'3" and 21°48'02" of longitude.

The municipality of Prizren has an area of 627 km² (5.94 % of the territory of Kosovo), which is located in the southwest of Kosovo with 76 settlements with about 175,000 inhabitants. The Prizren plain is located at an altitude of 400 m a.s.l., where some peaks of Sharri Mountain exceed the height of 2000 m a.s.l.

The climate of the city is moderate but extremely diverse in its different parts. In the lowlands, due to the influence of the

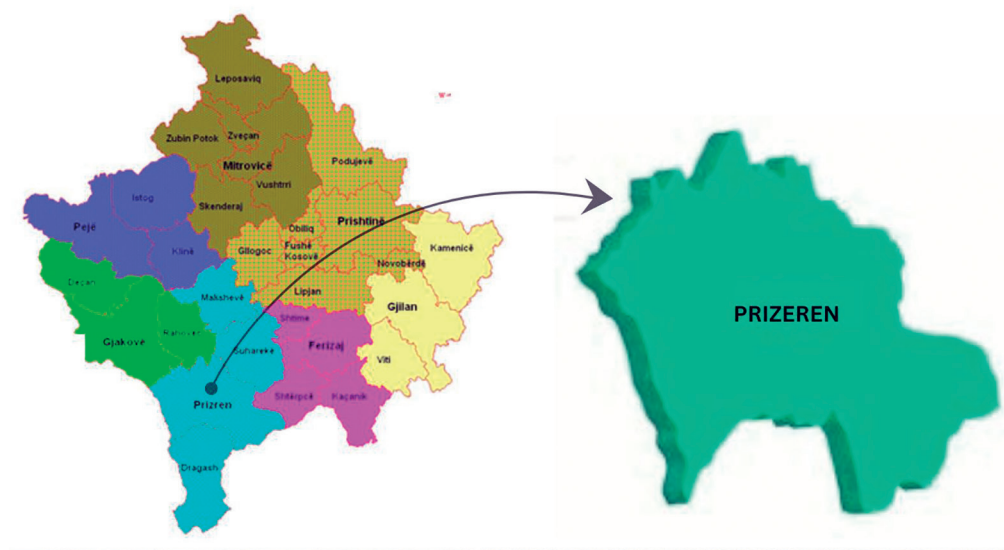


Fig. 1. Study area.

Mediterranean, there are very hot summers, with an average temperature of 28–32 °C during July and August and the harvests are among the first in South-Eastern Europe. In the mountainous regions, the climate of the Alps dominates, for this reason snow caps on peaks are visible until June.

Results and Discussion

The average results from the two years of the study (2022–2023) are shown below.

Flowering stage of *Digitalis purpurea* cultivars

The beginning and duration of flowering were different in the two years of the study, this was influenced by different meteorological parameters (temperatures and precipitation, which were different in the two growing periods). Dynamics of flowering stage of *Digitalis purpurea* cultivars during the May–October period was

analysed. For all studied cultivars flowering stage starts in mid of May and varies depending on cultivars. There is also a different number of flowers: 5–8 for each plant. Number of flowers in May was different depending on the cultivars. The highest was achieved at the cultivar 'Rose Shades' with 8 flowers per plant. The lowest, with 5 flowers was at the cultivar 'Illumination Flame'. Number of flowers per plant in this study begins to increase in June and the highest is achieved at the cultivar 'Polkadot Polly', 23 flowers per plant, while the lowest at the cultivar 'Illumination Flame' – 17 flowers per plant (Fig. 2).

Maximum number of flowers is achieved in July, depending on the cultivars. The peak was achieved at the cultivar 'Rose Shades' with 48 flowers per plant, whereas the lowest number of flowers – 44 was observed at the cultivar 'Pam's Choice'. The flowering period ends in late October depending on the decrease of temperature. The smallest number of flowers was achieved at the 'Illumination

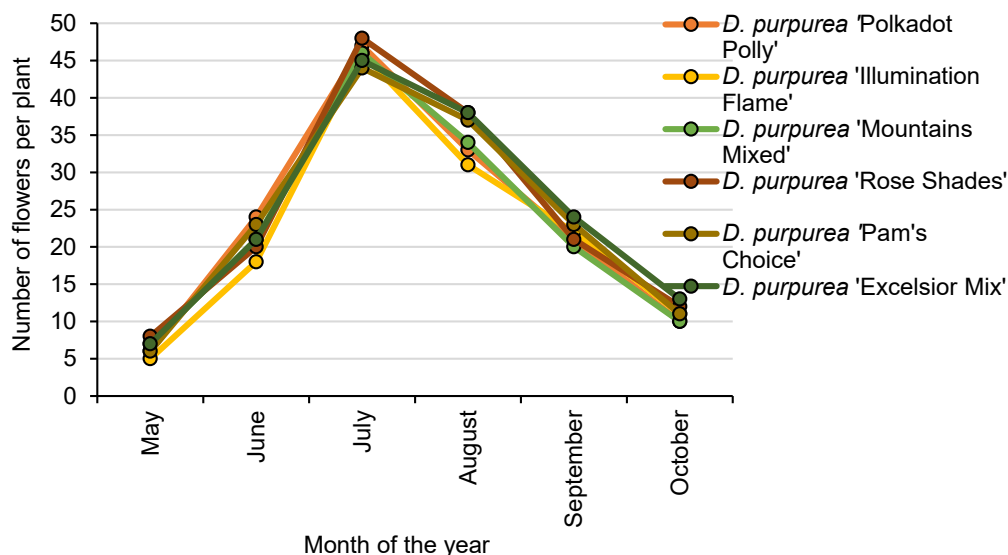


Fig. 2. Dynamic of flowering stage for the *Digitalis purpurea* cultivars.

Flame' with 10 flowers per plant and the highest at cultivar 'Excelsior Mix' with 13 flowers per plant.

Similar results concerning the number of flowers per plant were reported by Parkinson (2003), Pokorný et al. (2005), Bretzel and Pezzarossa (2010), Crespel et al. (2014).

Similar results were reported by Wolff et al. (2024), for the cultivar 'Rose Shades' which is famous cultivar for beautiful flowers. The author describes it as a tall plant that can reach up to 80–120 cm height and produces striking purple or pink flowers on tall spikes.

Flowering stage of *Gaillardia* sp.

The beginning and duration of flowering stage were different in the two growing periods (2022–2023), which were influenced by different meteorological factors, such as temperatures and precipitation. The flowering stage for all taxa in the study starts in the mid of May, the number

of flower heads was different depending on the cultivar. The highest was achieved at the cultivar *G. aristata* 'Oranges and Lemons' with 8 flower heads per plant. The lowest with 5 flower heads at the *G. aristata* 'Arizona Apricot'. The number of flower heads per plant begins to increase in June and the highest is achieved at the cultivar *G. aristata* 'Arizona Sun' 18, while the lowest one is observed at *G. pulchella*: 14 flowers per plant. The highest was achieved at the *G. × grandiflora* hort. with 32 flower heads per plant, the lowest one with 28 flower heads at *G. pulchella* (Fig. 3).

Flowering ends in late October depending on the decrease of temperature. The smallest number of flowers was achieved at the *G. × grandiflora* 'Summer Kiss' with 3 flower heads per plant and the highest at cultivar *G. aristata* 'Oranges and Lemons' with 5 flower heads per plant.

The results of the study for the flowering phase of *G. aristata* cultivars are in accordance with the studies of other au-

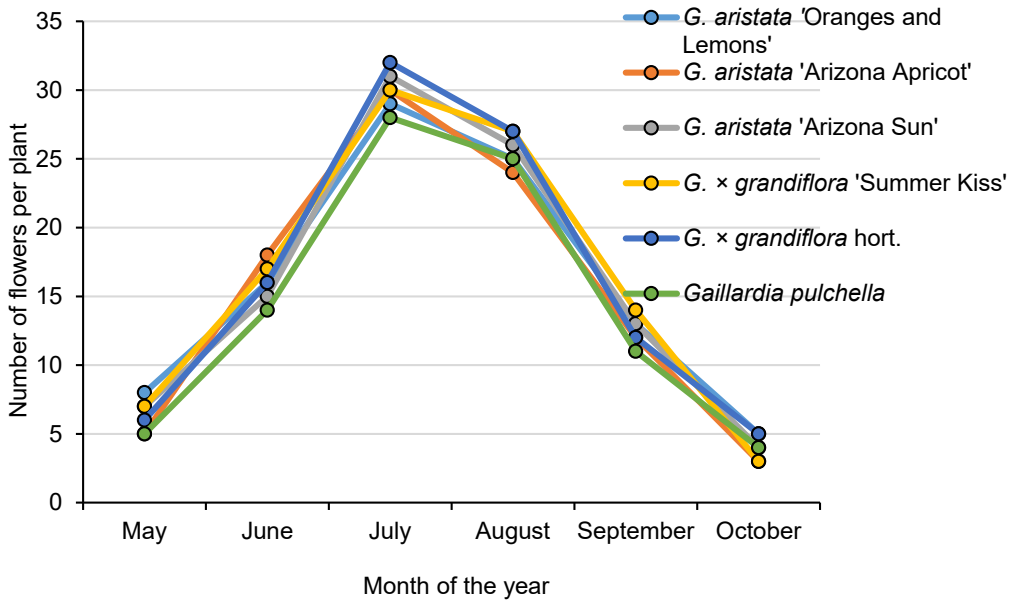


Fig. 3. Dynamic of flowering stage for the *Gaillardia* sp.

thors (Opler and Cranshaw 2008, Süle et al. 2023). The flower heads of *G. aristata* 'Arizona Sun' are radiating, showy, slightly solitary, with an outer series of ray florets and an inner set of disc florets. There are usually 13–17 flowers with yellow rays (belt-shaped), with a purple base (eFloras 2011).

Structure of petal fusion (number of protrusions on the corolla edge), flower colour and fragrance of *Digitalis purpurea* cultivars

Table 1 shows the visible protrusions on the corolla edge, colour and fragrance of flowers according to cultivars. Largest number of them per flower was recorded from the cultivar 'Rose Shades' (6.18) followed by 'Polkadot Polly' (5.18) and low number of petals was recorded from 'Pam's Choice' (4.11). This indicator is important especially when plants are perceived close up or used as a cut-flowers.

The colour of the flowers is different from white, red, pink, pink to white. The level of fragrance of the *Digitalis purpurea* cultivars was a low.

Number of ligules in the flower heads colour and fragrance of *Gaillardia* sp.

Table 2 shows the number of ligules (or ray flowers), flower colour and fragrance for the *Gaillardia* taxa in the study. Largest number of ligules per flower was recorded from the cultivar *G. aristata* 'Arizona Apricot' (25.45) followed by *G. x grandiflora* hort. (24.32) and low number of ligules was recorded from *G. x grandiflora* 'Summer Kiss' (19.34). The colour of the ligules is different from white, red, pink, pink to white. Three cultivars of *G. aristata* ('Orange and Lemon', 'Arizona Apricot' and 'Arizona Sun'), two hybrids – *G. x grandiflora* 'Summer Kiss' and *G. x grandiflora* hort., and *G. pulchella*, had fragrant flowers.

Table 1. Average number of petals, flower colour and fragrance of *Digitalis purpurea* cultivars.

<i>Digitalis purpurea</i> cultivars	Number of protrusions on the corolla edge	Flower colour	Fragrance of flowers
'Polkadot Polly'	5.23	Deep-pink apricot	Little fragrance
'Illumination Flame'	5.18	Orange and cream	Little fragrance
'Mountains Mixed'	4.26	Peach, rose, white	Little fragrance
'Rose Shades'	6.18	Rose-white	Little fragrance
'Pam's Choice'	4.11	White	Little fragrance
'Excelsior Mix'	5.45	Rose-white	Little fragrance

Table 2. Number of ligules, flower colour and fragrance of *Gaillardia* sp.

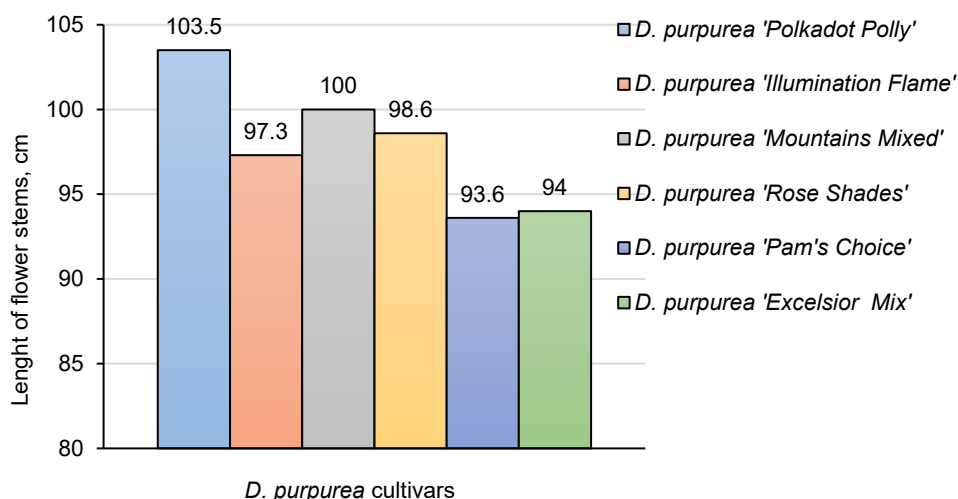
<i>Gaillardia</i> taxa	Number of ligules per flower heads	Flower ligules	Fragrance of flowers
<i>G. aristata</i> 'Oranges and Lemons'	23.33	Soft orange	With fragrance
<i>G. aristata</i> 'Arizona Apricot'	25.45	Apricot with yellow	With fragrance
<i>G. aristata</i> 'Arizona Sun'	22.21	Yellow-apricot	With fragrance
<i>G. × grandiflora</i> 'Summer Kiss'	19.34	Soft apricot-yellow	With fragrance
<i>G. × grandiflora</i> hort.	24.32	Yellow-apricot	With fragrance
<i>Gaillardia pulchella</i>	23.65	Apricot-yellow	With fragrance

Length and diameter of flower stems and number of leaves of *Digitalis purpurea* cultivars

The cultivar 'Polkadot Polly' produced the longest of flower stems (103.5 cm) fol-

lowed by 'Illumination Flame' (97.3 cm) and 'Pam's Choice' (93.6 cm) (Fig. 4).

The flower stems diameter with the highest values was recorded by 'Pam's Choice' (6.44 mm), followed by 'Illumina-

**Fig. 4. Length of flower stems of *Digitalis purpurea* cultivars.**

tion Flame' (6.13 mm), while the lowest values were recorded in cultivar 'Excelsior Mix' (5.91 mm). The maximum number of leaves per shoots was recorded in 'Polkadot Polly' (22.57), followed by 'Rose Shades' (19.72) and the lowest number of leaves was recorded in 'Mountains Mixed' (15.39). Similar results were also

reported by (Willis et al. 2000, Niu et al. 2007).

Statistical results for two years (2022–2023) are presented in Table 3. Analysis of variance confirms that *D. purpurea* cultivars are statistically different regarding the length of flower stalk and number of flowers.

Table 3. Analysis of variance of *Digitalis purpurea* cultivars.

Sources of variation	Length of flower stalk		Number of flowers per plant	
	Value <i>F</i>	Probability	Value <i>F</i>	Probability
Year of study	1412.21	0.000	2431.23	0.000
Cultivar	1021.03	0.000	345.26	0.000
Cultivar × Year	23.11	0.000	11.44	0.000

Length and diameter of flower stems and number of leaves of *Gaillardia* sp.

The cultivars *G. aristata* 'Arizona Sun' produced maximum of flower stems (60.52 cm) followed by *G. aristata* 'Arizona Apricot' (57.32 cm) and *G. pulchella* (51.64 cm). The flower stems diameter with the highest values was recorded by *G. aristata* 'Arizona Apricot' (3.58 mm), followed by *G. × grandiflora* 'Summer Kiss' (3.15 mm), while the lowest values

were recorded in *G. pulchella* (2.86 mm) diameter (Fig. 5).

The maximum number of leaves per shoots was recorded in *G. aristata* 'Arizona Sun' (14.21), followed by 'Oranges and Lemons' (12.25) and the lowest number of leaves was recorded in *G. × grandiflora* 'Summer Kiss' (11.21). Similar results were also reported by (Hermann 1996, Marlowe and Hufford 2007, Sonu et al. 2018, Xie et al. 2021, Zhuang et al. 2021) in *Gaillardia*. The *G. aristata* 'Arizona Sun' cultivar are

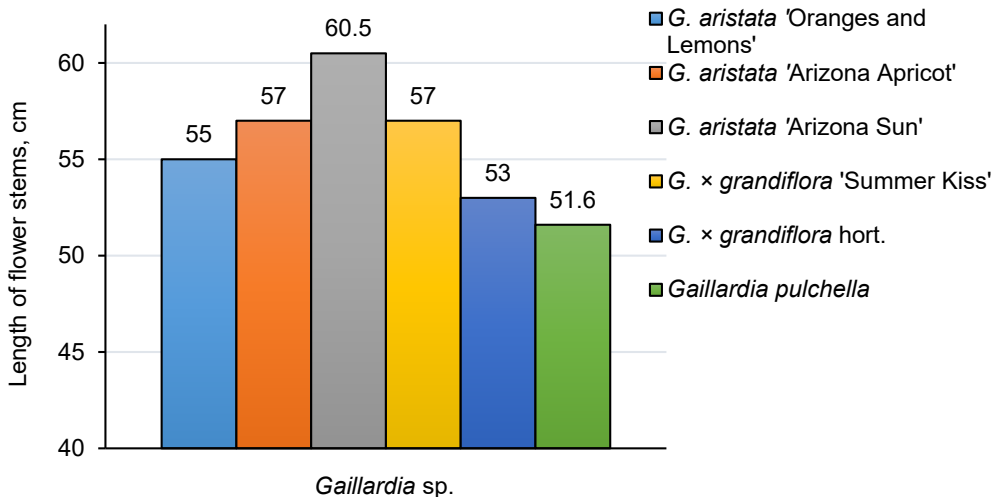


Fig. 5. Length of flower stems of *Gaillardia* sp.

reported to has masses of beautiful red daisy flowers with brick red eyes and yellow tips at the ends of the stems from early summer to mid fall, green leaves, which are most effective when planted in groupings (Kazemi and Jozay 2021).

Statistical results for two years (2022–2023) are presented in Table 4. Analysis of variance confirms that there are statistically differences regarding the length of flowerstalk and number of flowers of *Gaillardia* sp.

Table 4. Analysis of variance of *Gaillardia* sp.

Sources of variation	Length of flower stalk		Number of flowers per plant	
	F value	Probability	F value	Probability
Year of study	14351.41	0.000	2551.47	0.000
Cultivar	1033.22	0.000	324.38	0.000
Cultivar × Year	32.34	0.000	12.79	0.000

Conclusions

From the study and obtained results it is proved that the studied cultivars of *Digitalis purpurea* and *Gaillardia* sp. have a very good blooming and vegetative growth due to favourable climatic conditions in Kosovo, soil and moisture suitable for growth and development, which affected the growth, quality and colour of the flowers.

These perennial flowering plants and their cultivars deserve more important place in public green spaces, as their greater use is an important step towards greater sustainability in the urban landscape. The studied *Digitalis* cultivars and *Gaillardia* sp. differ from each other but all of them have demonstrated high ornamentality and long flowering period with flowers, steady growth, variety of leaves and flowers colouring (white, red, yellow, pink). The cultivars with the best performance are *D. purpurea* 'Rose Shades' and *G. aristata* 'Arizona Sun'.

Perennial flowering plants are more ecologically effective and less expensive to maintain, and are therefore more sustainable. For a good architecture and sustainability of the urban landscape, we recommend the studied cultivars to be

included in the design and planting structure in Kosovo.

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