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# Growth, decorative and nutritional values of ornamental cabbage (*Brassica oleracea* L.) in flowerbed conditions

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**Abstract:** Ornamental cabbages are cultivars of cabbages grown for decorative purposes due to the varied shape and colour of their internal leaves. The aim of the study was to determine the course of growth and to assess the decorative and nutritional value of two cultivars of ornamental cabbage ('Pigeon Red', 'Coral Prince') grown in a flowerbed along with annual plants: the French marigold (*Tagetes patula nana* L.) and flossflower (*Ageratum houstonianum* Mill.), using a pine bark mulch. The impact of the marigold and flossflower on the cabbage height and foliage changed with the plant growth. Cabbages growing without the proximity to the other species had the smallest diameter and formed the least leaves; and the plant's height was lower in September. The cabbage height, foliage and leaf colour were modified by the weather in the subsequent years of research. The proximity of the marigold or flossflower and mulching of the soil with bark did not affect the colour of the leaves. The nutritional value of the ornamental cabbage was high, and the content of the mineral components in the leaves depended largely on their colour. The coloured leaves were more abundant in nitrogen, phosphorus, potassium and magnesium, while the green leaves contained more calcium and sulfur, and slightly more dry matter.

**Keywords:** intercropping; marigold; flossflower; mulching; chemical composition

Ornamental cabbages are cultivars of cabbages grown for decorative purposes due to the varied shape and colour of their internal leaves. In gardens and parks, they are planted in flowerbeds. They are also used in floristry and floral design. They are perfect for autumn decorations because they reach their full decorative value during this time. Their high resistance to low temperatures is noteworthy. It is most commonly believed that cabbage cultivars that form a rosette of coloured leaves are derived from *Brassica oleracea* L. var. *acephala* Auct., however, some associate their origin with *Brassica oleracea* L. var. *capitata* L. and savoy cabbage *Brassica oleracea* L. var. *sabauda* L. Decorative forms of cabbages were grown in Japan, where they were subsequently exported to the USA and, in 1936, they started to appear in seed catalogues as fall garden decoration plants. In the 90s of the last century, many attractive varieties were bred, from the flowerbed through used for cut greenery (Whipker et al. 1998; Chmiel 2000; Liu et al. 2017).

The requirements of ornamental cabbages and the rules for their cultivation are similar to other brassica vegetables. Specificity of the species is the colouring of leaves, which determines their decorative value. The colour of the leaves is largely determined by the growing conditions, especially the thermal conditions. The leaf colour at low temperatures is caused by the cessation of the chlorophyll production by the plant (Gibson, Whipker 2003; Greer et al. 2003). In field cultivation, the colour of the leaves depends primarily on the temperature and begins when the nights are cooler. Usually, after a few nights at a temperature of 7–10 °C, the leaves already become partially coloured. In Poland, the period of the

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greatest demand for colourful cabbage rosettes is from September to November. The cabbages stay decorative for a long time due to their high cold resistance, even until December (Gibson, Whipker 2001). It is usually believed that at temperatures below 12.7–13.0 °C, the fertilisation of the plants (especially with nitrogen) should be stopped, as this may cause the inhibition of rosette staining (Galinat 1995), while Gibson and Whipker (2003) proved that fertilisation until the end of the cultivation period did not adversely affect the colour of ornamental cabbages. However, it is recommended to monitor the nutritional status of the plants (Cardarelli et al. 2015; Dunn, Goad 2015). High summer temperatures cause excessive stem growth and weaker colouration, therefore, growth regulators, that affect not only the height of the plants, but also the diameter and size of the coloured rosette, are often used for cabbage growing (Whipker et al. 1998; Gibson, Whipker 2001; Mello et al. 2010).

Ornamental cabbages, unlike the vegetable species of *Brassica oleracea* L., are planted in flowerbeds in the vicinity of other ornamental plant species. Most often, the basic criteria for the selection of a species in a flowerbed are their decorative values and, to a lesser extent, the relationships that occur between them, therefore, the main purpose of the research was to determine the impact of growing ornamental cabbages with other flowerbed plants. Soil mulching with pine bark is often used in green areas, therefore, soil mulching with this material was chosen as the second factor. The aim of the study was to determine the course of growth and to assess the decorative and nutritional value of two cultivars of ornamental cabbage grown in a flowerbed along with annual flowerbed plants using a pine bark mulch.

## MATERIAL AND METHODS

The field experiment was carried out in 2010–2011 at the Felin Experimental Farm of the University of Life Sciences in Lublin, on a lessive soil developed from a medium silty clay (BN-178/9180-11). The experimental plant was the ornamental cabbage (*Brassica oleracea* L.). The following factors were taken into account in the experiment: I. cultivar: 'Pigeon Red', 'Coral Prince'; II. soil mulching: control – no bark, pine bark mulch; III. cabbage accompanying the plant: control – cabbage in homogeneous cultivation without any accompanying plants, French marigold (*Tagetes patula nana* L.) 'Petit Gold', flossflower (*Ageratum houstonianum* Mill.).

The experiment was established using a randomised block method in four replications. Each replicate consisted of a 1.5 × 1.5 m plot with 25 plants growing 30 × 30 cm apart. The plants were planted in five rows on each plot. The plants were grown from seedlings prepared in the greenhouse. The cabbage seeds were sown on April 16, 2010 and April 1, 2011. The plant emergence took place 4–7 days after sowing. After 4 weeks, the seedlings were pricked into multi-plates with a cell diameter of 85 mm (May 4, 2010 and April 30, 2011). The marigold and flossflower seedlings were produced similarly, with seeds being sown 3 weeks later than cabbage ones. The plants were planted into the field on May 25, 2010 and May 20, 2011. Azofoska fertiliser [NPK ($MgO + SO_3$) 13.6-6.4-19.1 (4.5 + 23.0) and 0.045 B, 0.18 Cu, 0.17 Fe, 0.27 Mn, 0.04 Mo, 0.045% Zn] (in the amount of 1.5 kg/10 $m^2$) was applied before planting. The pine bark mulch was spread (layer about 6–8 cm) on half of the plots (according to the experimental design) after planting the plants. The plots were weeded by hand until the soil was shaded by the cabbages and irrigated as needed. The following plant protection products were used: Talstar 100EC (bifenthrin), Fastac 100 EC (cypermethrin), Amistar 250 SC (azoxystrobin). At the end of each month (May to October), biometric measurements of the cabbages were made. In September, when the plants were well stained, leaf samples were taken for the chemical analyses. The dry mass of the leaves was determined by the drying-weighing method. The total nitrogen was determined by the Kjeldahl method and, after dry combusting at 550 °C, the phosphorus (with ammonium metavanadate) and S-$SO_4$ (with barium chloride) were determined colorimetrically, while the potassium, calcium and magnesium were determined by atomic spectrophotometric absorption (ASA). The results were statistically analysed by an analysis of variance (ANOVA). The significance of the differences was determined by Tukey's test at $P = 0.05$ and 0.01.

The weather course during the vegetation period of the ornamental cabbage in 2010–2011 is shown in Table 1.

## RESULTS AND DISCUSSION

At the time of planting, the cabbages were 10–15 cm tall and had 6–9 leaves each. After a month of vegetation, the plants reached an aver-

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Table 1. Mean air temperatures and amount of precipitation in ES Felin during the experiment in 2010–2011

| | Year | Month and decade | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | IV | V | | | VI | | | VII | | | VIII | | | IX | | | X |
| | | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 |
| Average decade temperature (°C) | 2010 | 10.2 | 13.6 | 14.5 | 15.2 | 19.0 | 17.9 | 17.1 | 20.2 | 24.0 | 20.7 | 22.9 | 18.1 | 17.1 | 11.7 | 13.2 | 12.5 | 6.1 |
| | 2011 | 13.6 | 8.8 | 15.8 | 17.9 | 21.1 | 17.5 | 17.2 | 16.6 | 21.0 | 17.6 | 18.5 | 19.0 | 19.0 | 15.4 | 16.3 | 14.0 | 12.2 |
| Mean monthly for 1951–2005 | | 7.4 | | 13.0 | | | 16.2 | | | 17.8 | | | 17.1 | | | 12.6 | | 7.8 |
| Amount of precipitation (mm) | 2010 | 3.0 | 39.7 | 106.7 | 10.3 | 34.6 | 30.2 | 0.8 | 15.3 | 9.8 | 75.9 | 65.6 | 6.9 | 60.3 | 80.4 | 10.6 | 28.0 | 1.5 |
| | 2011 | 8.6 | 20.4 | 9.8 | 12.0 | 26.4 | 19.9 | 21.5 | 60.7 | 53.7 | 74.6 | 10.3 | 52.8 | 2.2 | 4.2 | 1.1 | 0.1 | 17.7 |
| Mean monthly for 1951–2005 | | 40.2 | | 57.7 | | | 65.7 | | | 83.5 | | | 68.6 | | | 51.6 | | 40.1 |

age of 30.7 cm in height and already had an average of 20.7 leaves (Tables 2 and 3). In July, the plant growth averaged 4.2 cm, and in August, cabbage increased its height the most (by 11.8 cm on average). Over the following months, the number of leaves more than doubled and, in September, they amounted to 112.4 leaves on average. The 'Coral Prince' cultivar produced higher (54.4 cm on average), more leafy plants (139.3 leaves) than the 'Pigeon Red' cultivar (respectively: 43.4 cm, 88.4 leaves) with a larger rosette diameter. Also, in the study of Gibson and Whipker (2001), 'Coral Prince' formed taller plants with a larger diameter than 'Pigeon Red' (31.6 cm and 40.9 cm vs 27.8 cm and 36.1 cm, respectively).

Soil mulching with the pine bark did not significantly affect the height and diameter of the cabbage rosettes, and the beneficial effect of mulching on the foliage did not appear until September (Tables 2–4). Dębicz and Bąbelewski (2010) noticed the different reactions of perennials to mulching depending on the species, while in the study by Błażewicz-Woźniak, mulching the soil with pine bark had a positive effect on almost all the characteristics of the growth and flowering of sage (*Salvia splendens*), the Spanish bluebell (*Hyacinthoides hispanica*) and also bear garlic (*Allium ursinum*) (Błażewicz-Woźniak et al. 2011, 2012, 2018). The mulch protects the soil from overheating and drying out during the full summer (Konopiński et al. 2001; Błażewicz-Woźniak et al. 2015). Summer 2010 and 2011 were relatively rainy, therefore, the impact of bark mulching on the soil moisture and temperature stabilisation was not so visible and did not significantly affect the cabbage growth. Growing cabbages along with marigolds and flossflowers had an impact on the height and

Table 2. The height of the ornamental cabbages (cm) depending on the cultivar, mulching, accompanying species, date of measurement and year of experiment

| | | Height of plant (cm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month and year of measurement | | 6/2010 | 6/2011 | mean | 7/2010 | 7/2011 | mean | 8/2010 | 8/2011 | mean | 9/2010 | 9/2011 | mean |
| Cultivar | 'Pigeon Red' | 25.8 | 22.3 | 24.1 | 28.4 | 26.5 | 27.4 | 44.9 | 40.2 | 42.6 | 46.0 | 40.9 | 43.4 |
| | 'Coral Prince' | 37.2 | 38.2 | 37.7 | 38.7 | 46.5 | 42.6 | 53.9 | 48.1 | 51.0 | 54.6 | 54.1 | 54.4 |
| Mulch | without mulch | 30.8 | 30.6 | 30.7 | 33.6 | 35.8 | 34.7 | 49.2 | 44.0 | 46.6 | 50.8 | 46.8 | 48.8 |
| | pine bark | 32.1 | 29.2 | 30.3 | 33.4 | 37.2 | 35.3 | 49.6 | 44.0 | 46.6 | 49.8 | 47.7 | 48.5 |
| Accompanying species | control | 32.3 | 30.9 | 31.6 | 33.1 | 34.9 | 34.0 | 48.4 | 43.1 | 45.7 | 49.4 | 45.9 | 47.7 |
| | marigold | 31.1 | 30.7 | 30.9 | 33.9 | 37.4 | 35.6 | 49.5 | 44.3 | 46.9 | 50.0 | 47.3 | 48.7 |
| | flossflower | 31.1 | 28.0 | 29.5 | 33.7 | 35.8 | 35.7 | 50.4 | 44.6 | 47.5 | 51.6 | 48.5 | 50.0 |
| Mean | | 31.5 | 29.9 | 30.7 | 33.6 | 36.3 | 34.9 | 49.4 | 44.0 | 46.7 | 50.3 | 47.2 | 48.8 |
| $LSD_{0.05}$ for: | cultivar | 0.92** | 1.04** | 0.56** | 0.81** | 1.33** | 0.71** | 1.60** | ns | 1.26** | 1.45** | ns | 1.37** |
| | mulch | 0.92** | ns | ns | ns | 1.33* | ns | ns | ns | ns | ns | ns | ns |
| | accompanying species | 1.16* | ns | 0.82** | ns | 1.80* | 1.04** | ns | ns | ns | 2.13* | ns | 2.01** |
| | year | | | 0.56** | | | 0.71** | | | 1.26** | | | 1.37* |

ns – no significant differences

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Table 3. Diameter of the ornamental cabbage rosettes depending on the cultivar, mulching, accompanying species, date of measurement and year of the experiment

| Experimental factors | | Diameter of the rosette (cm) (month/year fo the experiment) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6/010 | 6/2011 | mean | 7/2010 | 7/2011 | mean | 8/2010 | 8/2011 | mean | 9/2010 | 9/2011 | mean |
| Cultivar | 'Pigeon Red' | 34.0 | 31.3 | 32.6 | 41.8 | 33.9 | 37.9 | 29.9 | 31.6 | 30.8 | 32.5 | 29.1 | 30.8 |
| | 'Coral Prince' | 43.8 | 38.2 | 41.0 | 58.4 | 46.8 | 52.6 | 44.3 | 45.0 | 44.6 | 45.2 | 48.0 | 46.6 |
| Mulch | without mulch | 38.8 | 35.3 | 37.0 | 50.4 | 39.0 | 44.7 | 37.6 | 38.4 | 38.0 | 39.0 | 39.9 | 39.4 |
| | pine bark | 38.9 | 34.0 | 36.1 | 49.8 | 40.9 | 44.9 | 36.6 | 37.3 | 36.4 | 38.6 | 36.3 | 37.0 |
| Accompanying species | control | 36.9 | 34.4 | 35.6 | 45.7 | 37.0 | 41.4 | 34.0 | 33.8 | 33.9 | 35.7 | 33.8 | 34.7 |
| | marigold | 39.8 | 34.9 | 37.3 | 51.6 | 42.8 | 47.2 | 38.0 | 39.8 | 38.9 | 40.1 | 41.3 | 40.7 |
| | flossflower | 40.0 | 34.5 | 37.3 | 53.1 | 40.0 | 46.5 | 39.3 | 39.9 | 39.6 | 40.7 | 39.2 | 39.9 |
| Mean | | 38.9 | 34.6 | 36.7 | 50.1 | 39.9 | 45.0 | 37.1 | 37.8 | 37.5 | 38.8 | 38.1 | 38.5 |
| $LSD_{0.05}$ for: | cultivar | 1.19** | 1.45** | 0.78** | 1.72** | 2.74* | 1.47** | 1.68** | ns | 1.30** | 1.65** | 2.26** | 1.22** |
| | mulch | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns | 2.26* | ns |
| | accompanying species | 1.75** | ns | 1.15** | 2.53** | ns | 2.16** | 2.47** | ns | 1.90** | 2.43** | 3.07* | 1.78** |
| | year | | | 0.78** | | | 1.47** | | | ns | | | ns |

ns – no significant differences

foliage of the plants. In June, the cabbages growing without these species was the highest. In the subsequent two months, the marigolds and flossflowers had no effect on the height of the cabbages, but, in September, the height of the cabbages growing without the other species was the lowest, while they were the highest when grown next to the flossflower. Throughout the vegetation period, the cabbages growing without the other species had the fewest leaves and the smallest diameter. Kim et al. (2018) found that a higher density of ornamental cabbage plants resulted in an increase in its height and reduction in the diameter of the rosette and leaf area. In the studies of Błażewicz-Woźniak et al. (2012), the proximity of the sage to the marigold and flossflower caused a smaller mass of sage but did not have any significant impact on the height of the plants, the number of whorls

Table 4. Number of leaves of the ornamental cabbages depending on the cultivar, mulching, accompanying species, date of measurement and year of the experiment

| Experimental factors | | Number of leaves of 1 plant (pcs) (month/year) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6/2010 | 6/2011 | mean | 7/2010 | 7/2011 | mean | 8/2010 | 8/2011 | mean | 9/2010 | 9/2011 | mean |
| Cultivar | 'Pigeon Red' | 19.8 | 20.5 | 20.1 | 56.3 | 50.6 | 53.4 | 101.9 | 76.6 | 89.3 | 96.4 | 80.3 | 88.4 |
| | 'Coral Prince' | 20.2 | 22.4 | 21.3 | 48.5 | 59.0 | 53.8 | 115.6 | 118.7 | 117.2 | 131.3 | 147.2 | 139.3 |
| Mulch | without mulch | 20.1 | 21.1 | 20.5 | 50.3 | 55.5 | 52.9 | 106.4 | 95.6 | 101.0 | 109.9 | 108.3 | 109.1 |
| | pine bark | 20.0 | 21.8 | 20.8 | 54.4 | 53.6 | 54.2 | 111.1 | 96.3 | 103.4 | 117.7 | 113.7 | 113.7 |
| Accompanying species | control | 19.4 | 20.7 | 20.0 | 48.1 | 47.3 | 47.7 | 90.7 | 83.3 | 87.0 | 93.7 | 82.1 | 87.9 |
| | marigold | 20.6 | 22.4 | 21.5 | 54.5 | 59.1 | 56.8 | 112.2 | 100.6 | 106.4 | 120.5 | 125.9 | 123.2 |
| | flossflower | 20.1 | 21.3 | 20.7 | 54.6 | 57.3 | 55.9 | 123.4 | 104.0 | 113.7 | 127.4 | 125.0 | 126.2 |
| Mean | | 20.0 | 21.4 | 20.7 | 52.4 | 54.5 | 53.5 | 108.8 | 95.9 | 102.3 | 113.9 | 111.0 | 112.4 |
| $LSD_{0.05}$ for | cultivar | ns | 0.98* | 0.53** | 2.16** | 4.44** | ns | 5.75** | 9.28** | 5.01** | 8.50** | 12.24** | 4.56** |
| | mulch | ns | ns | ns | 2.16** | ns | ns | ns | ns | ns | ns | ns | 4.56* |
| | accompanying species | 0.75** | ns | 0.78** | 3.18** | 6.03* | 3.50** | 8.45** | 12.62* | 7.33** | 12.50** | 16.65* | 9.67** |
| | year | | | 0.53** | | | 2.39* | | | 5.01** | | | ns |

ns – no significant differences

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Table 5. Percentage share of the colourful diameter of the ornamental cabbage rosettes depending on the cultivar, mulching, accompanying species and year of experiment

| Experimental factors | | Share of the colorful rosette diameter (%) (month and year of measurement) | | |
|---|---|---|---|---|
| | | 9/2010 | 9/2011 | Mean |
| Cultivar | 'Pigeon Red' | 61.6 | 30.5 | 46.1 |
| | 'Coral Prince' | 58.5 | 30.4 | 44.4 |
| Mulch | without mulch | 60.8 | 29.7 | 45.2 |
| | pine bark | 58.8 | 31.4 | 45.1 |
| Accompanying species | control | 59.2 | 33.8 | 46.5 |
| | marigold | 59.9 | 29.9 | 44.9 |
| | flossflower | 60.5 | 28.2 | 44.4 |
| Mean | | 59.8 | 30.5 | 45.1 |
| LSD 0.05 for: | cultivar | ns | ns | ns |
| | mulch | ns | ns | ns |
| | accompanying species | ns | ns | ns |
| | year | | | 4.07 |

ns – no significant differences

and flowers in the inflorescence. The flossflowers and marigolds were not in competition with the cabbages. However, they could have beneficial effects by reducing the occurrence of pathogens, especially the marigolds. Jankowska et al. (2009, 2010) showed that the cultivation of cabbages with marigolds resulted in a decrease in the population of cabbage aphids, fleas, diamondback moths and butterfly larvae. Intercropping with marigolds or their mulch restricts the multiplication of nematodes, which means that plants grow better (Hooksa et al. 2010; Błażewicz-Woźniak, Wach 2011).

The cabbage height and foliage were modified by the year of the experiment (Tables 2–4). In 2010, the cabbages were taller and had more leaves. In June and July 2010, the diameter of the leaf rosettes was significantly larger than in the corresponding months of 2011. The weather also affected the colour of the leaves. In Poland's weather conditions, the greatest decorativeness of ornamental cabbages, related to the colouring of leaves, persists from September to the end of vegetation period, with the beginning of the colouring already being recorded in late August. In 2010, the diameter of the colourful rosettes represented an average of 59.8% of the total, while, in 2011, it was only 30.5% (Table 5). In order to achieve full decorative qualities, the effects of low temperatures should last about 2–3 weeks (Whipker et al. 1998; Gibson et al. 2001). In September 2011, the average 10-day temperatures were: 15.4, 16.3 and 14.0 °C (Table 1). Thus, it was relatively warm. Galinat (1995) believes that the rosette staining is inhibited when the temperature rises above 12.8 °C at night. Mulching the soil with bark and the company of flossflowers or marigolds did not modify the colour of the leaves. There were also no varietal differences in this feature (Table 5). In the study of Gibson and Whipker (2001), the colourful rosettes of 'Pigeon Red' constituted 33.24% of the plant diameter, while that of 'Coral Prince' was 40.59%.

Ornamental cabbages can be consumed just like many *Brassicaceae* species. They taste similar to kale or savoy cabbages, and the taste depends on the variety and colour of the leaves. The tested cultivars contained, in the dry matter of the leaves, on average (%): 3.97 N total, 0.413 P, 2.83 K, 2.56 Ca, 0.189 Mg and 0.541 S-$SO_4$, with an average dry matter (DM) content of 13.11% (Table 6).

In the leaves of black cabbage (*B. oleraceae* L. var. *acephala* DC.), Ayaz et al. (2006) determined, on average (mg/g DM): Ca 19.7 ± 0.6; Mg 2.4 ± 0.4; K 13.5 ± 0.7; P 5.73 ± 0.9. The dry matter content of the ornamental cabbage leaves was comparable to that of Brussels sprouts, which contain approximately 13.09–13.86% DM (Gębczyński 2002), but it was larger than the white head cabbage (8.75–9.14%) (Jabłońska-Ceglarek, Rosa 2002) or the red cabbage (6.61–8.44%) (Wojciechowska et al. 2007; Majkowska-Gadomska, Wierzbicka 2008). Kale leaves have a dry matter content of over 17% (Łata, Wińska-Krysiak 2006; Sikora, Bodziarczyk 2012). The ornamental cabbages grown on plots mulched with bark accumulated more dry matter in the leaves than

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Table 6. Content of dry matter and selected nutrients in the leaves of the ornamental cabbages depending on the cultivar, mulching, accompanying species and colour of the leaves

| Experimental factors | | Content of nutrient (% DM) | | | | | | Dry matter (%) |
|---|---|---|---|---|---|---|---|---|
| | | $N_{tot}$ | P | K | Ca | Mg | $S\text{-}SO_4$ | |
| | | | | | **Coloured leaves** | | | |
| Cultivar | 'Coral Prince' | 4.79 | 0.590 | 3.57 | 1.67 | 0.193 | 0.417 | 12.63 |
| | 'Pigeon Red' | 5.30 | 0.577 | 2.99 | 1.13 | 0.193 | 0.304 | 13.23 |
| Mulch | without mulch | 5.12 | 0.578 | 3.31 | 1.30 | 0.192 | 0.333 | 12.68 |
| | pine bark | 4.98 | 0.589 | 3.25 | 1.50 | 0.195 | 0.388 | 13.18 |
| Accompanying species | control | 4.79 | 0.593 | 3.48 | 1.48 | 0.194 | 0.396 | 12.74 |
| | marigold | 5.09 | 0.609 | 3.22 | 1.39 | 0.191 | 0.334 | 13.14 |
| | flossflower | 5.27 | 0.549 | 3.15 | 1.33 | 0.195 | 0.351 | 12.93 |
| Mean | | 5.05 | 0.583 | 3.28 | 1.40 | 0.193 | 0.360 | 12.93 |
| | | | | | **Green leaves** | | | |
| Cultivar | 'Coral Prince' | 2.93 | 0.230 | 2.52 | 3.95 | 0.177 | 0.748 | 12.93 |
| | 'Pigeon Red' | 2.87 | 0.255 | 2.23 | 3.49 | 0.192 | 0.694 | 13.63 |
| Mulch | without mulch | 2.95 | 0.253 | 2.36 | 3.73 | 0.188 | 0.748 | 12.70 |
| | pine bark | 2.85 | 0.232 | 2.39 | 3.71 | 0.181 | 0.694 | 13.86 |
| Accompanying species | control | 2.63 | 0.224 | 2.40 | 3.76 | 0.173 | 0.673 | 13.38 |
| | marigold | 2.97 | 0.246 | 2.33 | 3.70 | 0.189 | 0.726 | 12.50 |
| | flossflower | 3.10 | 0.258 | 2.39 | 3.69 | 0.191 | 0.764 | 13.96 |
| Mean | | 2.90 | 0.243 | 2.37 | 3.72 | 0.184 | 0.721 | 13.28 |
| | | | | | **Mean** | | | |
| Cultivar | 'Coral Prince' | 3.86 | 0.410 | 3.04 | 2.81 | 0.185 | 0.582 | 12.78 |
| | 'Pigeon Red' | 4.09 | 0.416 | 2.61 | 2.31 | 0.193 | 0.499 | 13.43 |
| Mulch | without mulch | 4.04 | 0.415 | 2.83 | 2.52 | 0.190 | 0.540 | 12.69 |
| | pine bark | 3.91 | 0.410 | 2.82 | 2.60 | 0.188 | 0.541 | 13.52 |
| Accompanying species | control | 3.71 | 0.408 | 2.94 | 2.62 | 0.183 | 0.534 | 13.06 |
| | marigold | 4.03 | 0.428 | 2.78 | 2.54 | 0.190 | 0.530 | 12.82 |
| | flossflower | 4.18 | 0.403 | 2.77 | 2.51 | 0.193 | 0.558 | 13.44 |
| Mean | | 3.97 | 0.413 | 2.83 | 2.56 | 0.189 | 0.541 | 13.11 |
| $LSD_{0.01}$ for | colour A | 0.084** | 0.158** | 0.679** | 0.786** | 0.010* | 0.183** | ns |
| | cultivar C | 0.084** | ns | 0.679* | 0.786* | 0.010* | 0.183* | ns |
| | mulch D | 0.084** | ns | ns | ns | ns | ns | 0.826* |
| | accomp. sp. E | 0.140** | ns | ns | ns | 0.018* | ns | ns |
| | A × C | 0.190** | ns | ns | ns | 0.024* | 0.413* | ns |
| | A × D | ns | ns | ns | ns | 0.024* | ns | ns |
| | A × E | ns | ns | ns | ns | 0.035* | ns | ns |

ns – no significant differences

those grown without the litter. The 'Coral Prince' cultivar contained more potassium, calcium and sulfur in the leaves, but less nitrogen and magnesium.

Significant differences in the content of the nutrients were found depending on the colour of the leaves. Coloured leaves contained almost twice as much total nitrogen (5.05% DM on average) and more than twice as much phosphorus (regardless of the cultivar, i.e., both white and red leaves) and more potassium, while more than two times less calcium and sulfur than the green leaves, in which an average of 3.72% Ca and 0.721% $S\text{-}SO_4$ was determined. The cabbages growing in the vicinity of the flossflowers or marigolds had accumulated more nitrogen and magnesium in the leaves, but slightly less potassium and calcium. The coloured leaves were more abundant in nutrients than the leaves of the red cabbage, in which Majkowska-Gadomska and Wierzbicka (2008) determined 2.40 N, 0.37 P, 0.13 Mg and 0.56% Ca

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in dry matter. The green leaves contained more nitrogen, calcium and magnesium compared to the leaves of the white cabbage (2.75 N, 0.72 Ca and 0.147% Mg DM), with similar amounts of phosphorus and potassium (0.27 and 2.26% DM) (Jabłońska-Ceglarek and Rosa 2002) and much more sulfur than that determined by Domagała-Świątkiewicz and Sady (2011) (0.28%). The total nitrogen content in the coloured leaves of the ornamental cabbages is similar in this respect to the Brussels cabbage, which contains about 5.57% $N_{tot}$ in dry matter (Gębczyński 2002).

## CONCLUSION

The impact of marigolds and flossflowers on the cabbage height and foliage changed with the plant growth. Cabbages growing without a proximity to the other species had the smallest diameter and formed the least number of leaves, and, in September, the plant it was lower in height.

The cabbage height, foliage and leaf colour were modified by the weather in the subsequent years of research. The proximity of the marigolds or flossflowers and mulching of the soil with bark to the cabbages did not affect the colour of the leaves.

Cabbages grown on plots mulched with pine bark produced more leaves in September and accumulated more dry matter in them than those grown without any litter.

The nutritional value of the ornamental cabbages was high, and the content of the mineral components in the leaves depended largely on their colour. The coloured leaves were more abundant in nitrogen, phosphorus, potassium and magnesium, while the green leaves contained more calcium and sulfur, and slightly more dry matter.

The accompanying plants were not in competition with the cabbages growing in their vicinity, instead they were conducive to free growth and at the same time, constituted an effective background for the coloured rosettes.

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