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EFFECT OF INTERCROPPING ON KALE GROWN IN A HIGH TUNNEL FOR WINTER-SPRING PRODUCTION

Gergana MLADENOVA, Milena YORDANOVA

University of Forestry, Faculty of Agronomy, 10 KlimentOhridski Blvd, 1797, Sofia, Bulgaria

Corresponding author email: g.mladenova@ltu.bg

Abstract

The main goal of the experiment was to test the effect of intercropping on kale with other cold-resistant vegetable crops for winter-spring cultivation in a high tunnel. The experiment was conducted on the territory of the experimental field of the University of Forestry - Sofia (42° 7′ N, 23° 43′ E), during the period 2022-2023. Kale, variety "Common Curly", was selected as the main crop, the seedlings of which were planted at a distance of 30x30 cm, during the first ten days of December. As a companion plants were selected: onion, variety "Stuttgarten" (with sets) and lettuce (with seedlings), variety "Lolo rosa". Three variants have been developed: 1) kale - control (KC), 2) kale+onion (K+O), 3) kale+lettuce. (K+L) Biometric measurements were made during the harvest of the produce (April). It was found that in kale, intercropping affects the leaf rosette, leaf size and dry matter content. The plants have a more compact leaf rosette, the leaves are shorter but wider and accumulate a higher percentage (9.5-13.5%) of dry matter compared to the control (8.5%).

Key words*: intercropping, kale, onion, lettice, biometry.*

INTRODUCTION

Kale is considered a superfood with many beneficial properties for human and animal health. It is a rich source of fibers and minerals, prebiotics, unsaturated fatty acids and vitamins, and other biologically active substances in high concentrations (Satheesh and Workneh Fanta, 2020). The plant is tolerant of drought and high temperatures, but it develops best in moderate and low temperatures and regular watering (Cutler, (Ed.). 1995; Naik and Gupta, 2010; Reda et. al., 2021).

The popularity of kale in Bulgaria is growing. It finds a place mainly in private gardens, in urban gardening, as well as in the production range of small family farms, mostly organic, where it occupies a relatively small share of the total production (Silva et al., 2022). In such gardens, it is extremely important to ensure a rich biodiversity for security, sustainability, as a measure against crop failure, plant protection and prevention, and also from an ecological point of view (Marković, 2013).

As a typical representative of the *Brassica* family, kale has limited opportunities to occupy part of the crop rotation for a number of reasons related to the phytosanitary background, soil fertility and economic efficiency (Rana & Mamatha, 2017; Guerena, 2006). Therefore, producers must search for alternative solutions for compaction of areas and crop rotation in time and place.

According to De Pailhe (2014), kale is suitable for inclusion in an intercropping system, especially when its composition is based on the above ground and underground architecture of the plants. In the 2000-2001 project "Companion cropping for organic field vegetables" by Wolfe and Cormack (2002), it was found that kale gave higher yields when grown in mixed crops, along with beets, spinach, and Swiss chard. The team identified these crops as suitable combinations for intercropping, while *Alliacea* crops (onions and leeks) were unsuitable due to the lower yields reported, although their phytoncidal and repellent properties were taken into account.

Intercropping is not considered a necessity, but farms that practice it reap several benefits, at least in terms of plant protection and economic efficiency, as long as it is implemented thoughtfully. It has a strong influence on crop rotation planning (Baldwin, 2006).

When analyzing photosynthesis and carbonization efficiency de Araujo Hendges et

al. (2017), found that kale did not stand out as an aggressive participant in an intercropping system with coriander, Welsh onion, basil, parsley. This experiment is further evidence that the leafy vegetable is suitable for mixed cultivation. Polyethylene greenhouses are used by producers to maximize the time for plants to grow and obtain a harvest (Bruce et al., 2018). Crops that fill the winter months in Bulgaria are usually lettuce, onions, and garlic for greens, radishes, less often arugula, and other leafy greens.

The present study examined how kale behaved when grown alone and in a mixed system with green onions and lettuce, for which no data were found in the scientific literature.

MATERIALS AND METHODS

The experiment was carried out in 2022-2023 in an unheated high tunnel with dimensions of 18.40 by 4.20 m at the Educational-Experimental Field of the University of Forestry in the Vrajdebna district, Sofia, Bulgaria (42° 7′ N, 23° 43′ E).

Kale, variety "Common Curly", was selected as the main crop, the seedlings of which were planted at a distance of 30 x 30 cm in plots 1,50 x 1,50 m in size, during the first ten days of December.

As a companion plants were selected:

1. onion, variety "Stuttgarten" (with sets) planted in the interrows of the kale with a distance of 5 cm between the bulbs.
2. lettuce (with seedlings), variety "Lolo rosso" planted in the interrows, chess-like of the main crop.

Three variants have been developed:

1. kale – control (KC);
2. kale + onion (K+O);
3. kale + lettuce. (K+L);

During the growing season, agrotechnical measures are the same for all variants. They are mainly expressed in watering and weeding. At the beginning, after transplanting the plants until they take root, regular watering is carried out. With a permanent decrease in temperatures in the high tunnel (around 0°C), watering is stopped, which coincides with the development phase of the kale, a rosette with 5-6 leaves.

In the spring, with warming weather, watering is renewed. One weeding is carried out. Fertilization is not carried out. By mid-March, they form an average of 20-25 leaves with excellent taste qualities.

During the last ten days of April, biometric data were taken for all variants - plant height and rosette diameter (10 plants per variant and repetition), leaf length and width (on average 10 leaves per variant and repetition), fresh weight of 10 leaves per variant.

As quality indicators, fresh and absolute dry weight, sugar, and nitrates content were examined. The determination of absolutely dry matter was carried out by weight method in a laboratory dryer at a constant temperature of 60°C until a constant value of the sample was reached. Sugar content (Brix, %) was measured by refractometer, model - Digital refractometer 32145, manufactured by B & C Germany;

Nitrates in leaves were measured by nitrochek meter Boeco.

The collected data were analyzed by ANOVA and were expressed as mean ± standard deviations.

RESULTS AND DISCUSSIONS

Intercropping affects the growth of plants from the main crop - kale, with more pronounced differences in diameter than in plant height. In both variants with intercropping - the combination kale + onion (K + O) and kale + lettuce (K + L) the plants are taller compared to the control (KC), but the differences are not large - on average about 6 cm (Figure 1).

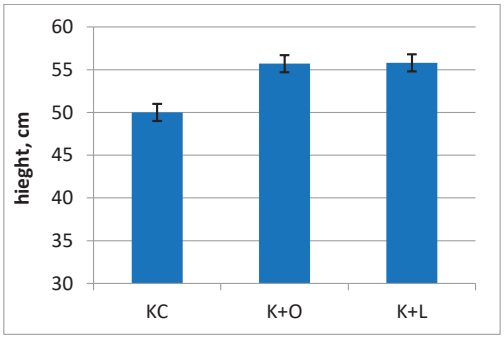

Figure 1. Plant height by variants, cm

The differences in plant diameter are larger - in the variants with intercropping (K + O and K + L) the rosette diameter is smaller compared to the diameter of plants from the control variant

with independent cultivation (Ck), on average about 10 cm (Figure 2). For this indicator, the differences are statistically proven F (2, 36) = 10.15; p <.05.

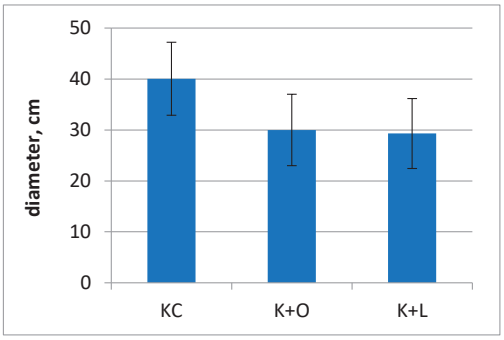

Figure 2. Plant diameter by variants, cm

Those two parameters show that the competetion between the different crops is working and is affecting the plants' architecture above ground.

Also, the spacing between the crops in mono and intercropping systems impacts kale. When kale is grown alone, its average height is low, and its average width is greater. When kale is in an intercropping system, the height is greater, and the width is less.

The influence of intercrops has been studied not only on the whole plant, but also on the leaves, and it is expressed differently in the size of the leaf petioles and the leaf blades.

In the three variants, the length of the leaf petioles is almost the same, with a small difference between those in the intercropping of kale with salads (9.7 cm), in which the leaf petiole is about 2 cm higher (Figure 3).

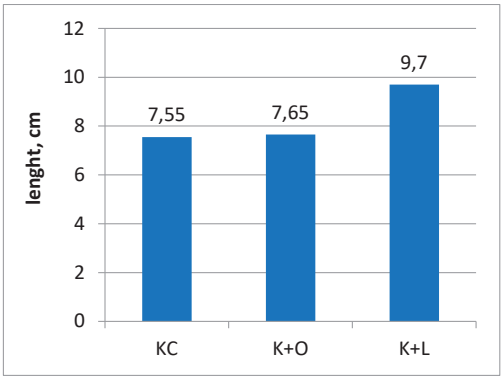

Figure 3. Leaf petioles length by variants, cm

The of the leaf petioles (1 cm) is greater, in the control variant with monocropping compared to those in the variants with intercropping (Figure 4).

Since the differences between the individual variants are relatively small, they are not statistically proven.

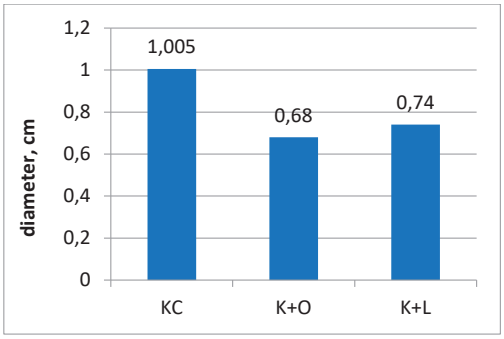

Figure 4. Leaf petioles diameter by variants, cm

In the average results of measuring the width and length of the leaf petioles, intercropping shows a different trend. In terms of leaf petiole length, intercropping with lettuce (K+L) gives better results (17.4 cm) than the other two options, while in intercropping with onion (K+O) the leaf petioles are shorter (16.45 cm), (Figure 5).

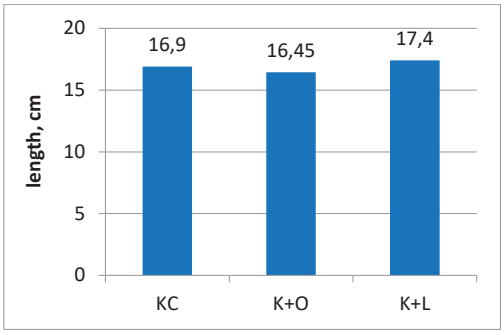

Figure 5. Leaf blade length by variants, cm

The results are similar for leaf blade width. Wider leaf blades (11 cm) for kale when grown in intercropping with lettuce (K+L) and narrower (9.45 cm) when grown in intercropping with onion (K+O). The sizes of the leaf blades in the control variant are close to those of the leaf blades in the variant with intercropping lettuce (Figure 6).

Although the leaf blade sizes of the control variant (KC) are close to those of the kale intercropping with lettuce (K+L), they are inferior in size. The largest are those in the lettuce intercropping, while the leaves in the onion intercropping (K+O) are inferior in size.

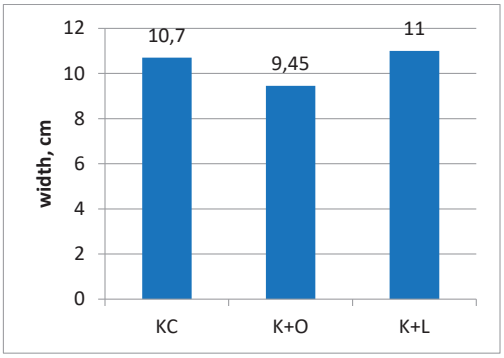

Figure 6. Leaf blades width by variants, cm

During the growing season, the fresh weight of 10 leaves was monitored for the individual variants, as kale is marketed in bundles of 10 leaves or per kilogram.

The data shows that there is very little difference in the weight of the final product when kale is grown alone (KC) compared to when it is grown in intercropping with onions or lettuces (K+O and K+L). The control (KC) and the lettuce variant (K+L) are very close in weight - 62.73 g to 61.78 g. Only the kale + onion variant (K+O) is lighter by 12.59 g than the control (Figure 7).

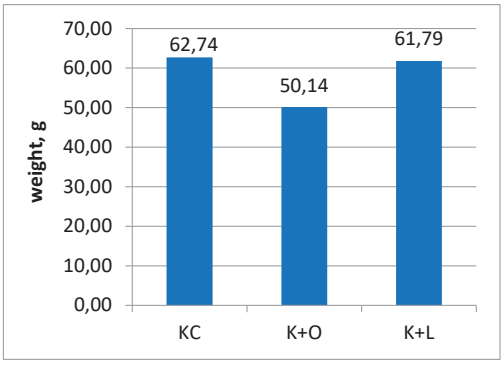

Figure 7. Weight of 10 leaves, g

This indicator shows that growing kale with lettuces does not significantly affect the fresh weight of the leaves, while when growing it with onions, the leaves are slightly smaller and, accordingly, this also affects the average weight of fresh leaves.

Dry matter content is a quality indicator that shows the nutritional value of the plant product, but also how plants use water. In this experiment, the highest dry matter content was observed in kale leaves grown in intercropping with lettuce (K+L) – 13.5%, followed by kale and onion intercropping (K+O) and lastly, the control (KC) (Figure 8).

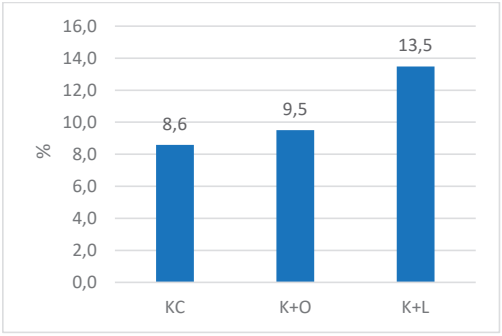

Figure 8. Absolute dry matter, %

There may be several reasons for this:

1. Both kale and lettuce are large consumers of water. The higher dry matter content in kale in this variant may be due to competition between it and lettuce.
2. In the intercropping of kale + onion (K+O), the dry matter in kale is less – 9.5%. The reason for this is most likely due to the biological characteristics of onions to use water rationally, as well as the waxy coating that prevents transpiration losses.

Statistical processing of the data shows that there are proven differences $F(2, 9) = 19.18$; $p < .05$.

Two other quality indicators that were monitored were the content of sugars and nitrates.

As shown in Figure 9, in kale grown in monoculture (KC), the sugar content in the leaves is on average 6.9 brix %.

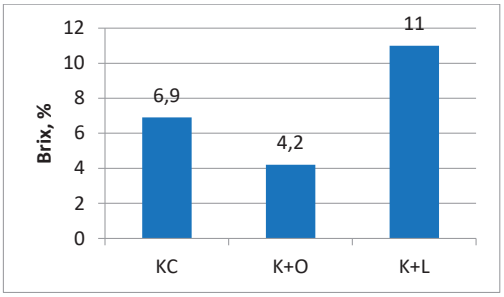

Figure 9. Sugar contend in leaves, brix %

The highest content in this indicator is in the variant kale + lettuce (K+L) – 11 brix %. It is lowest in kale + onion (K+O) – 4.2%.

The explanation of these results is that the higher dry matter content can also lead to a higher concentration of sugars.

Kale is a leafy crop and if grown at low temperatures, it may have a tendency to accumulate nitrates if the nitrogen in the soil is high. According to this indicator, the leaves of all three variants have a low nitrate content, with the results being the same for kale + onion (K+O) – 106 mg/kg and kale control (KC) – 107 mg/kg, and higher data are available for kale + lettuce (K+L) – 186 mg/kg (Figure 10).

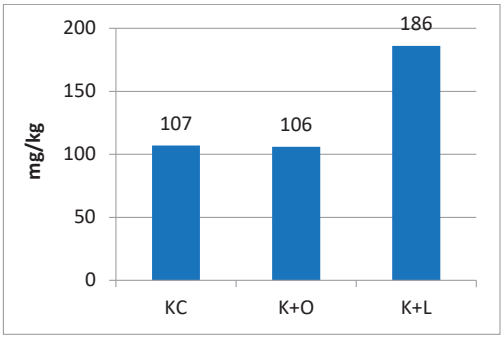

Figure 10. Nitrates contend in leaves, mg/kg

The lower soil temperature, as a result of its denser biomass cover (cabbage and lettuce leaves) and the weak warming in the early spring period, can lead to more difficult absorption of nutrients from the soil, as well as more difficult assimilation of nutrients. This results in a higher nitrate index when growing the kale + lettuce (KL) variant together. However, nitrates are normal.

CONCLUSIONS

Based on the conducted experiment, it can be concluded that the effects of intercropping kale grown in a high tunnel for winter-spring production affected:

1. Rosette height and diameter;
2. Dry matter content;
3. Sugar content;
4. Nitrate content.

It can be confirmed that the competition effect works when kale is grown in intercropping with green onions and lettuce, with a greater effect on qualitative than on quantitative indicators.

Intercropping would have a positive effect on farmers if they grew the three crops together, as in the experiment.

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