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EFFECT OF INTERCROPPING ON THE GROWTH AND YIELD OF CABBAGE

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Abstract

The aim of the research was to test how different plant species affect the growth and yield of cabbage when they are intercropped. The experiment was carried out in the experimental field of the University of Forestry - Sofia, in 2022. Five combinations were selected: cabbage+leek, cabbage+green beans, cabbage+dill, cabbage+tagetes, cabbage+"Weleda" seed mix, which were compared cabbage as sole crop. The seedlings of cabbage were planted in the period 25-29.07.2022 on the block method with four replications. The other crops were sown or planted at the same period. Compared to intercropping, sole crop cabbage has a smaller height and diameter of the product part. With the highest weight per cabbage is the combination of cabbage + green bean, while the lowest is the cabbage + Weleda seed mix, followed by cabbage + dill.

Key words*: biometry, cabbage, green bean, intercropping, yield.*

INTRODUCTION

Growing two or more plants together at the same time is called intercropping (Gliessman, 1985; Singh et al., 2013; Maitra and Gitari, 2020). Several varieties of intercropping have been described: row intercropping, strip intercropping, mixed intercropping, and relay intercropping (Gliessman, 1985; Gallaher, 2009; Mousavi and Eskandari, 2011).

The increase in crop biodiversity, thanks to the mixed cultivation of two or more crops, makes intercropping a suitable practice for organic production (Lithourgidis et al., 2011; Yildirim and Ekinci, 2017; Maitra and Gitari, 2020; Mala et al., 2020).

Hailu (2015), in his review article, summarizes the advantages of intercropping, namely that it positively affects the microclimate in crops as well as reduces pest development.

As for the development of the plants and the yields obtained, the conclusions of the scientists are different. In some of the experiments, plants in intercropping developed better and obtained better yields compared to the sole cultivation of the crops (Hailu, 2015; Yildirim and Ekinci, 2017; Maitra et al., 2021), while in others there was no difference between the two systems or poorer results were obtained (Hailu, 2015; Maitra et al., 2021).

Cabbage is one of the main vegetable crops of the Brassicaceae family. In intercropping, it can be grown as a main crop or as a companion crop due to its large rosette of leaves covering a large part of the area. Neupane al. (2021) selected cabbage and mustard as companion crops in growing potatoes and testing different planting schemes. They found that in the intercropping of potatoes and cabbage, with and without the participation of mustard in the plantations, an increase in the height of the potato and cabbage plants was obtained, resulting in a higher yield of both crops, as well as an improvement in the cabbage cover. When growing a main crop of maize with an intercrop of cabbage, the highest yield of both crops was obtained when the cabbage was grown in between the maize rows (Khanum et al., 2019).

When cabbage is the main crop, usually inter-row combinations are sown with companion species, and the results can be different. For example, Guvenc and Yildirim (2006) found that growing radishes in between cabbage rows had an adverse effect on cabbage yield. On the other hand, Kumari et al. (2021) proved that when growing cabbage in combination with radishes, good results were obtained both in terms of yield in both crops and in terms of biometric indicators of cabbage heads (height and diameter, weight, and total soluble sugars).

Mixed cultivation of cabbage with legumes also shows different results. A combination of green beans with spring forms of cabbage produced the highest yields of both crops (Shanmugam et al., 2022). In the intercropping of cabbage with peas, although the yield of cabbage is second to that of solely cultivated cabbage, the equivalent yield is higher because of the higher yield of the companion crop, the green pea (Choudhuri and Jana, 2012). On the other hand, Bavec et al. (2011) recorded low yields of cabbage in combination with bush beans.

High yields were also obtained in the mixed cultivation of cabbage with leafy vegetables: mixed cultivation of cabbage with leaf lettuce or cos lettuce (Guvenc and Yildirim, 2006; Bavec et al., 2011); good yields were also obtained in mixed cultivation with spinach because of the three realized harvests of spinach (Kumari et al., 2021).

The paper presents the results of a field intercropping experiment with a main crop of cabbage and five companion crops, which is the first year of the PhD thesis experiment.

MATERIALS AND METHODS

The experiment was carried out in 2022 at the experimental field "Vrazhdebna" (42° 7′ N, 23° 43′ E, and 552 m above sea level) at the Faculty of Agronomy of the University of Forestry on fluvisol.

The climate is moderately continental, and the weather conditions during the experimental period were favorable for plant development (Figures 1 and 2).

The main crop is cabbage (*Brassica oleracea* L. var. *capitata*), cv. "Balkan", a traditional cultivar for Bulgaria, intended for late field production. The accompanying crops are leek (*Allium porrum* L.), cv. "Starozagorski", green bean (*Phaseolus vulgaris* L. var. *nanus*), cv. "Saksa", dill (*Anethum graveolens* L.), cv. "Mesten", French marigold (*Tagetes patula* L.), and a mix of seeds from flowering honey plants of the "Weleda" company (buckwheat, marigold, dill, borage, cornflower, and phacelia). Six variants have been developed: V1: solely grown cabbage as the control; V2: cabbage + leeks; V3: cabbage + green bean; V4: cabbage + dill; V5: cabbage + French marigold; V6: cabbage + seed mix.

The experiment was carried out in the last ten days of July, according to the block method, in four replications, with the size of the experimental plots being 3.5 m x 5 m, and the recultivated plots - 2.1 m x 4 m. Cabbage, leeks, and French marigold are planted as seedlings, while beans, dill, and seed mix are sown directly. Cabbage was planted according to the standard scheme of 0.70 m x 0.50 m on previously prepared furrows. Between the rows of cabbage were planted: leeks, according to the scheme 0.70 m x 0.20 m (V2), and French marigolds, according to the scheme 0.70 m x 0.25 m (V5), and were sown: green beans, according to a scheme of 0.70 m x 0.30 m (V3). Dill (V4), and a mix of seeds (V6), were sown thinly between cabbage rows.

The agrotechnical practices during the growing season (sprinkler irrigation and cultivation) were the same for all variants.

During harvesting, measurements of the height, diameter, and weight of the product parts of the cabbage were taken, with the measurements for an average of 10 heads of variants and replications. Samples were taken from the production, including variants and replications, to establish the dry matter content. Yields are calculated per ton per hectare based on average head weight.

The dry weight of the cabbage heads was determined by taking average samples by variant and replication (from 4 heads of each variant). The samples were taken from the edible parts of the head (leaves) and from the internal core of head.

The collected data were analyzed by ANOVA.

RESULTS AND DISCUSSIONS

The meteorological conditions during the vegetation period of the plants are typical for the area. The highest average daily temperatures are recorded at the end of July (26 and 27.06. - 28°C), during the early stages of plant development. In August, the average daily temperature is up to 25°C, then a warm autumn follows, and only in the third ten days of November do the temperatures fall around or below 5°C (Figure 1)

Precipitation during the experimental period was distributed in August, September, and October, with higher amounts recorded mostly

in September (147.5 mm), while amounts in August and October were almost the same, 61.3 mm for August and 58.7 mm for September, respectively (Figure 2).
The largest amount of rain (40 mm) fell at the end of September (the evening of the 28-th, 2022), started by a hailstorm that also caused a drop in temperatures (Figures 1 and 2). Regardless of the rainfall that fell and its relatively good distribution in time, in terms of quantity, most of them were insufficient, and it was necessary to carry out sprinkler irrigation every week..

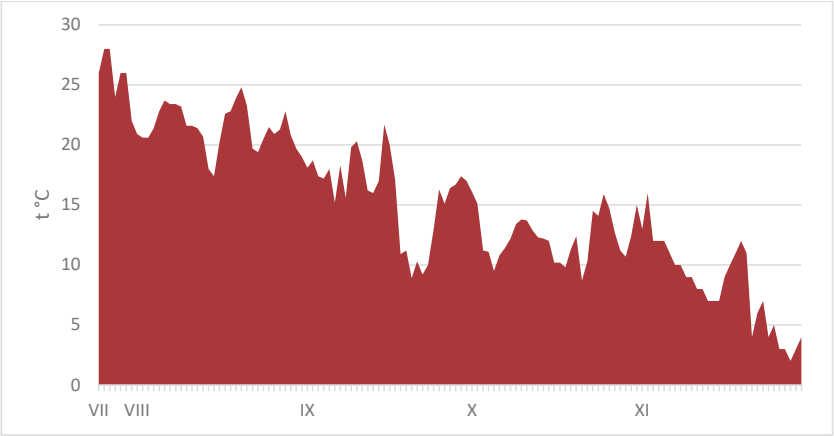

Figure 1. Average daily temperature during the experimental period at Vrazhdebna experimental field, 2022

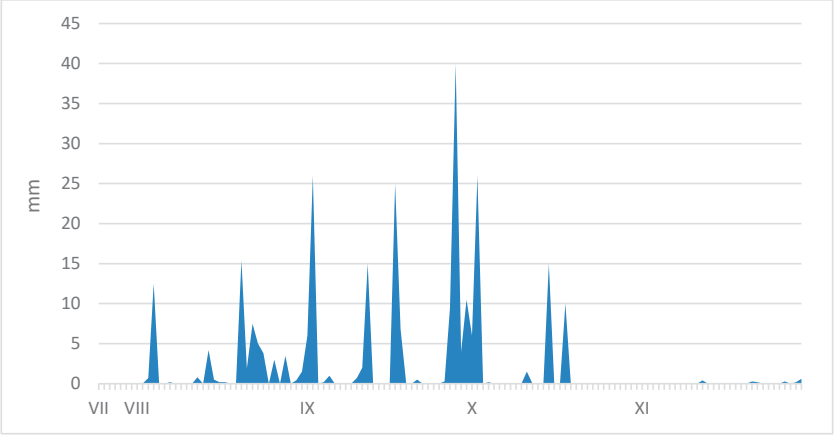

Figure 2. Precipitation during the experimental period at Vrazhdebna experimental field, 2022

The first harvest occurred on October 25, 2022. The harvests continued until the end of November. Simultaneously with the harvesting of the produce, the height and diameter of the product part of the cabbage were measured.
In general, in all variants with mixed cultivation, the values of the height of the cabbage heads were greater compared to the control variant (sole cultivation).
The highest height was measured in the cabbage + French marigold combination (18.24 cm) and the smallest in the cabbage + seed mix combination (16.85 cm). With a slight difference (16.53 cm) from the last combination is the control variant (Figure 3)
When arranging the combinations in descending, they are ordered as follows: cabbage + French marigold > cabbage + dill = cabbage +

green beans > cabbage + leeks > cabbage + seed mix > and sole cabbage (Figure 3)

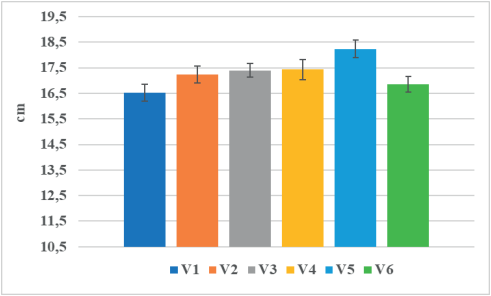

Figure 3. High of cabbage head, cm (means ± SEM)

According to the indicator of cabbage head diameter, again the variants with intercropping exceeded the control with minimum differences (1.15 cm).

However, again the largest diameter was the variant cabbage + French marigold (21.35 cm) and the smallest was the control (20.2 cm), but when arranging the variants in descending order to assess their influence, the order was different: cabbage + French marigold > cabbage + green beans > cabbage + leeks = cabbage + seed mix > cabbage + dill > and sole cabbage (Figure 4)

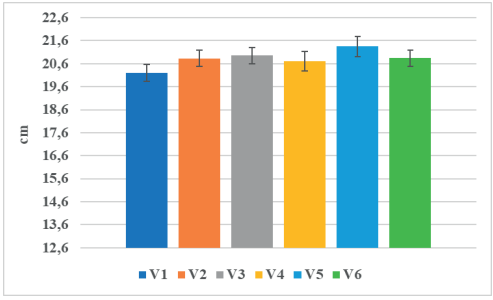

Figure 4. Diameter of cabbage head, cm (means ± SEM)

Regardless of the small differences, the influence of mixed cultivation on the height and diameter of the cabbage heads is outlined, and in both indicators, the cabbage + French marigold combination exceeds the others.

According to Neikov (2003) the limits of both indicators of the size of the cabbage head (height and diameter) for this cultivar, are 16-25 cm height and 15-20 cm diameter. Comparing these values with the obtained data, it can be seen that, according to the diameter indicator, all variants are within and above the limits, with the control being close to the standard and the other variants being above.

The results obtained at this stage for both indicators are in contrast to the data from Guvenc and Yildirim (2006), where the sole cabbage has a larger diameter and height of the cabbage heads compared to the intercropping options.

Although the intercropping of cabbage with green beans (V3) is slightly behind the previous indicators of intercropping with French marigold (V5), according to the indicator of average fresh weight per head, it is first (Figure 5).

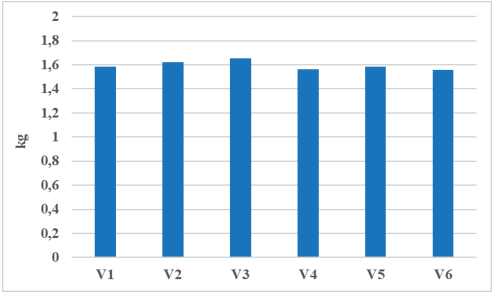

Figure 5. Fresh weight of cabbage head, kg/plant

The average fresh weight of one head of cabbage for variant cabbage + green bean is 1.652 kg, and the lowest weight (1.557 kg) is for the variant cabbage + seed mix (Figure 5).

There are no significant differences between the variants, which confirm the result obtained from Guvenc and Yildirim (2006).

Although the differences in the dry matter content, of the edible part of the cabbage head, are not significant, two variants have a higher percentage: variant 2: intercropping cabbage + leeks (8.2%); and variant 4: intercropping cabbage + fennel (8.1%). The intercropping with green beans has the lowest dry weight (7.6%) of the edible part (Figure 6).

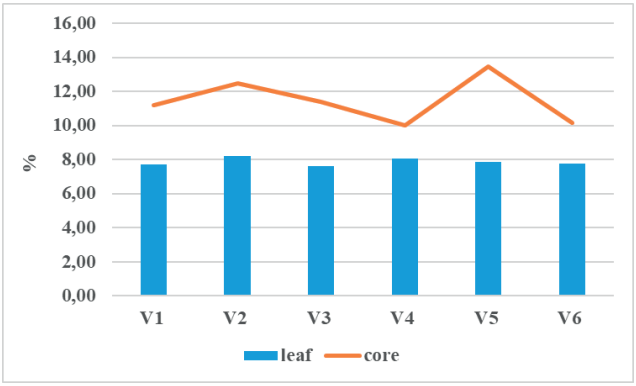

Figure 6. Dry weight of cabbage head, %

The dry matter of the inner core of the cabbage showed different results than the edible part. Cabbage + French marigold intercropping has the highest dry weight percentage of the core (13.5%), followed by variant 2: intercropping cabbage + leeks (12.5%). With the lowest dry weight are: variant 4: intercropping cabbage + fennel (10%) and variant 6: intercropping cabbage + seed mix (10.2%).

Yield is calculated in tons per hectare. The yields of all variants are within the limits of the average yield for the cultivar used, as indicated by Neikov (2003).

Although the differences in yields are small, the variants can be divided into three groups. The first group includes only V3, which has the highest yield (47.6): intercropping cabbage + green beans (Figure 7).

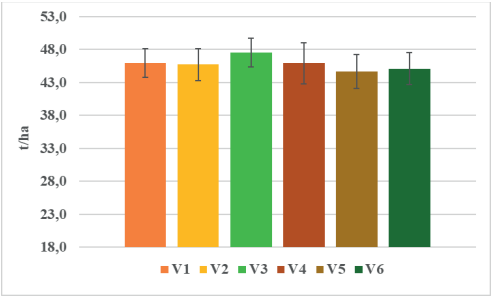

Figure 7. Average yield of cabbage, t/ha (means ± SEM)

In the second group, there are three variants with an average yield of cabbage (45.9-45.7 t/ha): sole cabbage (V1), intercropping cabbage + dill (V4), and intercropping cabbage + leek (V2).

In the third group are the last two variants: variant 6 (45.1 t/ha) intercropping cabbage + seed mix and the variant with the lowest yield (44.7 t/ha) intercropping cabbage + French marigold.

The low yield of variant 5 (intercropping cabbage + French marigold) is contrary to the results obtained by Mrnka et al. (2023), who obtained high yields from intercropping cauliflower with French marigold.

CONCLUSIONS

The results of this stage of the experiment revealed that the option of intercropping with green beans had the most complex effect on the reported indicators of cabbage heads and cabbage yield. This variant exceeded the control variant (sole cabbage) in all indicators.

According to the presented indicators, in comparison to sole cabbage, two other companion crops (leek and fennel) also showed better or comparable results.

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REFERENCES

Bavec, M., Brozovic, B., Mlakar, S. G., Robacer, M., Jakop, M., & Bavec, F. (2011). Yield and nutrient uptake of white cabbage affected by differen intercrops. In *Proceedings. 46th Croatian and 6th International Symposium on Agriculture. Opatija-Croatia* (pp. 66-70).

Choudhuri, P., & Jana, J. C. (2012). Effect of intercropping on yield and economics of cabbage. *Journal of crop and weed*, *8*(1), 155-157.

Gallaher, R. N. (2009). Multiple cropping systems. *Management of agricultural, forestry, and fisheries enterprises*, *1*, 254-265.

Gliessman, S. R. (1985). Multiple cropping systems: A basis for developing an alternative agriculture. In *US Congress Office of Technology Assessment. Innovative biological technologies for lesser developed countries: workshop proceedings. Congress of the USA. Washington, DC, USA* (pp. 67-83).

Guvenc, I., & Yildirim, E. (2006). Increasing productivity with intercropping systems in cabbage production. *Journal of Sustainable Agriculture*, *28*(4), 29-44.

Hailu, G. (2015). A review on the comparative advantage of intercropping systems. *Journal of Biology, Agriculture and Healthcare*, *5*(7), 28-38.

Khanum, M. M., Bazzaz, M. M., Ahmed, B., Huda, M. S., & Hossain, M. A. (2019). Intercropping of cabbage with maize. *Bangladesh Agronomy Journal*, *22*(1), 115-120.

Kumari, P., Deepanshu**,** Bahadur, V., (2021). Effect of Intercropping on yield of red cabbage with leafy vegetables and root crops. *The Pharma Innovation Journal*; 10(9): 1680-1684

Lithourgidis, A. S., Dordas, C. A., Damalas, C. A., & Vlachostergios, D. (2011). Annual intercrops: an alternative pathway for sustainable agriculture. *Australian journal of crop science*, *5*(4), 396-410.

Maitra, S., & Gitari, H. (2020). Scope for adoption of intercropping system in Organic Agriculture. *Indian J. Nat. Sci*, *11*(63), 28624-28631.

Maitra, S., Hossain, A., Brestic, M., Skalicky, M., Ondrisik, P., Gitari, H., Brahmachari, K., Shankar, T., Bhadra, P., Palai, J. B., Jena, J., Bhattacharya, U., Duvvada, S. K., Lalichetti, S. & Sairam, M. (2021). Intercropping—A low input agricultural strategy for food and environmental security. *Agronomy*, *11*(2), 343.

Mala, M., Mollah, M. M. I., & Baishnab, M. (2020). Importance of intercropping for biodiversity conservation. *Journal of Science, Technology and Environment Informatics*, *10*(02), 709-716.

Mousavi, S. R., & Eskandari, H. (2011). A general overview on intercropping and its advantages in sustainable agriculture. *Journal of Applied Environmental and Biological Sciences*, *1*(11), 482-486.

Mrnka, L., Frantík, T., Schmidt, C. S., Baldassarre Švecová, E., & Vosátka, M. (2023). Intercropping of Tagetes patula with cauliflower and carrot increases yield of cauliflower and tentatively reduces vegetable pests. *International Journal of Pest Management*, *69*(1), 35-45.

Neupane, R. B., Karn, R., Bhusa, S., Paudel, S., & Dahal, B. R., Jha, R. K. (2021). Influence Of Mixed Cropping Of Cabbage And Mustard On Weed Dynamics And Yield Of Potato (Solanum tuberosum). *Food and Agri Economics Review (FAER)*, *1*(2), 64-76.

Neykov, S. (2003). Quality of Bulgarian cabbage cultivars. Report of a Working Group on Brassica. *compilers.*, pp. 22-23.

Shanmugam, S., Hefner, M., Pelck, J. S., Labouriau, R., & Kristensen, H. L. (2022). Complementary resource use in intercropped faba bean and cabbage by increased root growth and nitrogen use in organic production. *Soil use and management*, *38*(1), 729-740.

Singh, R. P., Pande, P., Solankey, S. S., & Chatterjee, A. (2013). Cropping Systems in Vegetables. *Book: Olericulture-Fundamental of Vegetable Production*, *1*, 347-373.

Yildirim, E., & Ekinci, M. (2017). Intercropping systems in sustainable agriculture. *Ziraat Fakültesi Dergisi*, *12*(1), 100-110.

Yildirim, E., & Guvenc, I. (2005). Intercropping based on cauliflower: more productive, profitable and highly sustainable. *European Journal of Agronomy*, *22*(1), 11-18.