DOI: 10.22620/agrisci.2022.34.008

INFLUENCE OF COMBINED FERTILIZATIONON MORPHOLOGICAL AND PRODUCTIVE QUALITIES OF CABBAGE AND BROCCOLI

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Abstract

The trails were conducted in the experimental field of the Maritsa Vegetable Crops Research Institute (MVCRI), Plovdiv with head cabbage variety Bilyan and broccoli variety Marathon F1. The crops were grown according to the scheme 100+60/60cm (2083 plants/da). Two variants have been studied in the experiment: optimal mineral fertilization - 50kg/da phosphate fertilizer, 40kg/da potassium fertilizer and 30kg/da nitrogen fertilizer (control) and combined fertilization with Stimak P - organic soil fertilizer (0,500-1,5kg/da), Stimak - foliar fertilizer (200ml/da) and Simargal - microbial fertilizer (0,5 ml/plant).Cole crops grown for late field production with drip irrigation technology were found to respond positively to combined fertilization with microorganisms and organic fertilizers through the drip system and foliar fertilizer together with the treatment of plants with plant protection products. As a result of combined fertilization the yield, in comparison to the optimal mineral fertilization, was increase with 31,01% and 46,85% Bilyan and Marathon F_1 varieties of cabbage and broccoli, respectively.

Keywords: broccoli, cabbage, combined fertilization

INTRODUCTION

Cabbage, one of the main vegetable crops for the country ranks fifth in production after potatoes, tomatoes, peppers, cucumbers and gherkins while broccoli is a less frequently grown crop. According to agrostatistics data, over the last 10 years (Agrostatistics, 2011-2020) there is a general tendency to reduce the area of cultivated vegetables in Bulgaria and cabbage and broccoli are no exception to this trend. Cabbage areas decreased from 26157 ha (2010) to 1460 ha (2020) while in broccoli cultivation area has significantly decreased from 1919 ha (2012) to 72 ha (2018), which in turn reduced to insignificant in 2020 and it has been listed together with Brussels sprouts as "Other vegetables of the genus Brassica". The total amount of cabbage production decreased from 78939 t to 32066 t whereas broccoli production decreased from 1918 t to 551 t.

Cabbage and broccoli production with integrated use of mineral and organic fertilizers has been found to be beneficial, which has been proved in several studies (Chand et al. 2006; Kaur et al. 2005; Islam et al., 2017). Combination of fertilizers improves soil quality and increases the yield while reduces the need of additional inorganic fertilizer.

Ray et al., (2018) found that the favourable combination of microorganisms and organic fertilizer on the cabbage productivity and Samar et al., (2017) recommended mixed treatment of mineral fertilizer (75%), organic fertilizer and inoculation with effective microorganisms, which improves productivity and product quality in broccoli. Hashem and Abd-Elrahman (2016) documented that liquid organic fertilizers had a promoting effect on the growth, yield and nutrient content of broccoli

plants. Application of organic fertilizers also has a beneficial effect in cabbage crop establishment (Todorova, Boteva. 2015., Dintcheva, 2013). However, in other studies, it was found that the type of fertilization (mineral, organic-mineral and organic) does not have a significant effect on cabbage parameters and yield while the site selection is crucial for cabbage production (Dumicic et al., 2014).

Nutrients are essential for plant growth, healthy food production, and sustainable agriculture. Increasing crop yields largely relies on the use of fertilizers to supplement essential plant nutrients. They can be either mineral, organic and microbial fertilizers, which have their advantages and disadvantages in terms of crop growth and soil fertility (Chen, 2006). Good fertilization management should aspire the improvement and protection of the environment; therefore, a balanced fertilization strategy that combines the use of mineral, organic and microbial fertilizers should be developed and evaluated.

The aim of the present study was to determine the influence of combined fertilization with Stimak, Stimak P and Simargal on morphological characters and productivity of cabbage and broccoli grown for late production in open field irrigated by drip irrigation.

MATERIALS AND METHODS

The experimental work was carried out on the experimental field of Maritsa Vegetable Crops Research Institute (MVCRI) with cabbage variety Bilyan and broccoli variety Marathon F1. The crops were grown according to the scheme 100+60/60 cm (2083 plants/da). The experiment has two variants:

• Control – optimal mineral fertilization - 50 kg/da triple superphosphate, 40 kg/da potassium sulphate, 30 kg/da calcium nitrate and 30 kg/da ammonium nitrate.

• Combined fertilization with microorganisms, organic and foliar fertilizer. **Microbial fertilizer - Simargal** (*Trichoderma asperellum* T6 – 50%, *Bacillus amyloliquefaciens* 2/7A – 25%, *Pseudomonas fluorescens*TUR12.2 – 25%); **amino acid fertilizers** - soil organic fertilizer **Stimak P** (organic matter of plant origin 83%, biodegradable polymer 3%, total nitrogen (N) 3%, total phosphorus (P_2O_5) 1.4%, potassium (K_2O) 0.4%); **leaf fertilizer Stimak** - (dry matter not less than 44% of which: organic matter - 82%, amino acids - 15.6%, total nitrogen - 3.8%, total phosphorus (P_2O_5) - 4%, potassium (K_2O) – 4.4%)

The mineral fertilizers were applied in the soil, according to the following scheme (Figure 1):

• ½ of the nitrogen fertilizer, with the first hoeing of the plants, 10 days after planting

• ½ of the phosphorus and potassium fertilizer with the second hoeing of the plants, 17 days after planting

• ½ of the nitrogen fertilizer with the third hoeing of the plants, 24 days after planting

• ½ of the phosphorus and potassium fertilizer with the fourth hoeing of the plants, 30 days after planting

• 30kg/da calcium fertilizer with the fifth hoeing of the plants, 37 days after planting

Combined fertilization - two-time soil application of **Simargal**, twice - 32 days and 54 days after planting by drip system in a dose of 0.5ml/plant (10.415 L for 2083 plants); soil fertilizer **Stimak P** - three times by drip system - 40, 62 and 73 days after planting, respectively in a dose of 0.500kg/da, 1kg/day and 1.5kg/day; foliar fertilizer **Stimak**, twice - 34 and 54 days after planting, in a dose of 200ml/da together with plant protection products (Figure 2).

With the main treatment of the place in June, 25 kg/da of triple superphosphate and 20 kg/da of potassium sulphate were applied into the soil.

The experiment was carried out according to the method of long plots, in four replicates with the size of the experimental area 16 m^2.

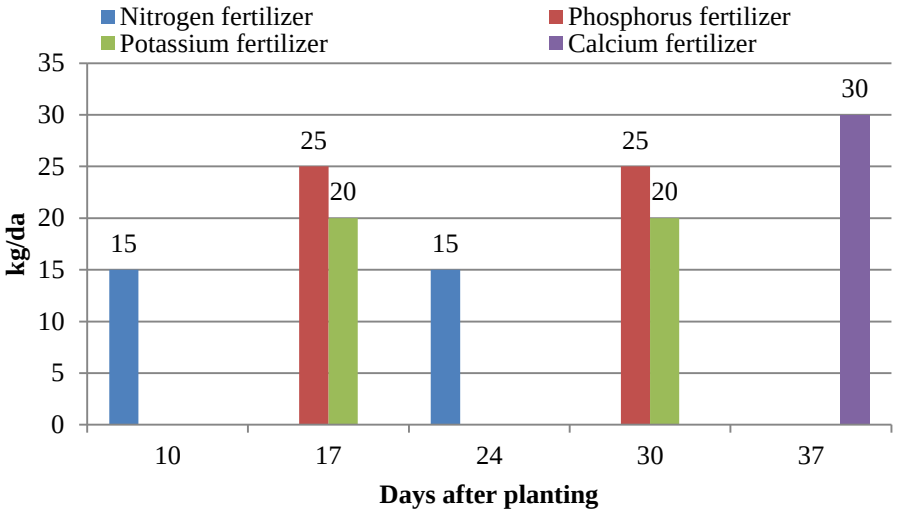

Figure 1. Scheme of mineral fertilization

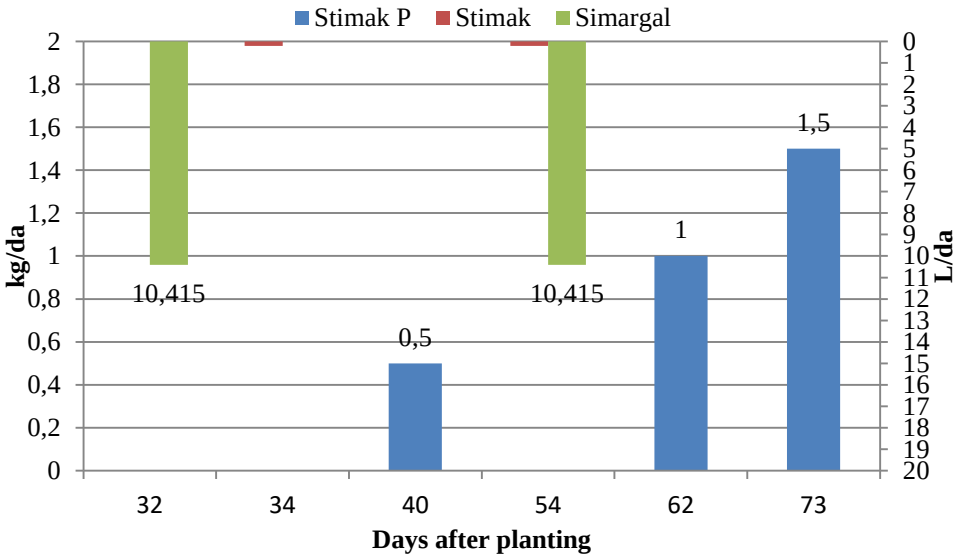

Figure 2. Scheme of combined fertilization

The experiment was carried out after fallow land on alluvial-meadow soil, which is characterized by the content of the main nutritional elements: N – 100 ppm, K_2O – 99.6 ppm, mobile phosphatesP_2O_5 – 16.5 ppm; Ca – 48.0 ppm; Mg – 43.2 ppm, pH – 6.40 and EC - 0.29 $mScm^{-1}$. The sample was taken at the beginning of the growing season after major fertilization of the crops.

Cabbage and broccoli seedlings were grown on beds covered with a 1:1 v/v peat: perlite substrate. The seeds were sown on 18.06, and the plants were planted on 23.07. 2020. The harvest of both crops was carried out in the first half of October.

The studied indicators were:

1. **Cabbage** - size of the leaf rosette, (cm); weight of cabbage head, (kg); average diameter of cabbage head, (cm); inner cob of cabbage - height and width, (cm); density of a head of cabbage (visually according to a five-point system 1-5); yield (kg/da).

2. **Broccoli** - leaf rosette size, (cm); stem height, (cm); central flower head – weight, (kg);

height, (cm), average diameter (cm); average diameter of stalk, (cm).

Plant protection against diseases and enemies was pests out in cabbage and broccoli with appropriated products.[1]

The obtained results were processed statistically using the Paired Sample T test (SPSS software).

RESULTS AND DISCUSSION

Climatic conditions

Climatic conditions during the period July - October are extremely unfavourable for the growth and development of cabbage crops grown according to late field production technology in open field. The period from planting the plants to harvest is characterized by high average day-night temperatures and very little rainfall (from 9 L/m^2 to 2 L/m^2 per month) except for October when the first ten days had the rainfall of 50 L/ m^2, and in total for the month 100 L/m^2 (Figure 3).

Irrigation, by drip system failed to provide sufficiently high atmospheric humidity, which reflected unfavourably on the product part of the cabbage crops. Despite the unfavourable climatic conditions and the poorly manifested productive qualities of the investigated crops differences in the effect of fertilization were found.

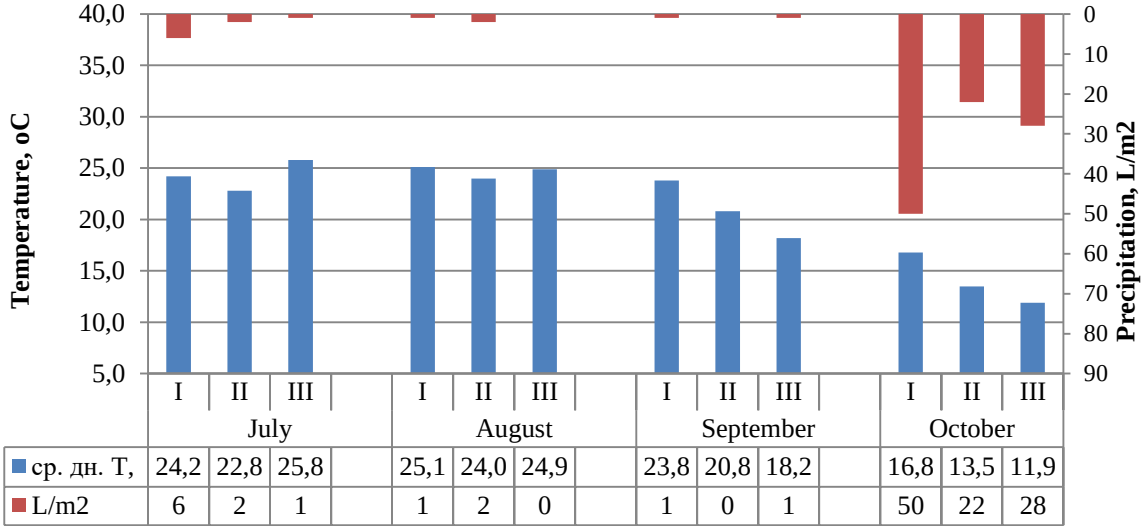

Figure 3. Climatic conditions for the growing season, 2020 year

Cabbage

Morphological indicators

Leaf rosette size values showed no differences between plant treatments (Table 1) and no effect of fertilization on this parameter could be established.

As a result of the use of combined fertilization with microorganisms, organic and foliar fertilizer, the plants formed a product part with higher values of the indicators than the control, where granular mineral fertilizers were used. Under the influence of liquid fertilizers applied by drip system and foliar treatment together with plant protection products plants formed cabbages with a 29.85% greater weight and 9% greater diameter compared to the

[1]**INFINITO SK** - 160 ml/da (*Peronospora parasitica*); **SUMI ALFA 5 EK**-25 ml/da (*Mamestra brassicae*); (*Plutella maculipennis*); **DEKA EK** - 30 ml/da (*Mamestra brassicae*); **RIDOMIL GOLDRVG** – 500 g/da (*Peronospora spp*.); **SKOR 250 EK** – 50 ml/da (*Alternaria spp.*). Against diseases and pests in broccoli are used: **SUMIALFA 5 EK**-25 ml/da (*Mamestra brassicae*); (*Plutella maculipennis*); **DIFKOR 250 EK** – 50 ml/da (*Alternaria brassicae*, *Mycosphaerella brassicicola*); **AVANT 150 EK**– 17 ml/da *(Pieris brassicae), (Mamestra brassicae).*

control (Table 1). The differences in the values of the reported indicators for the two fertilizing variants are statistically proven.

The indicators of the inner cob height and width were distinguished by insignificant differences in the variants; however, they were statically proven in the second indicator. Density of a head of cabbage is an important indicator of its consumption qualities, which is not significantly affected by the fertilization variant, the differences are small and statistically unproven.

Table 1. Morphological features of cabbage

Variants	***D***	***Mean***	***±SD***	***±SEM***
Size of the leaf rosette, cm				
Control	0,500 ns	46,500	4,227	1,220
Combined fertilization		46,000	3,908	1,128
Weight of cabbage, kg				
Control	-0,208**	0,673	0,098	0,028
Combined fertilization		0,880	0,166	0,048
Average diameter of cabbage, cm				
Control	-1,204**	12,246	0,626	0,181
Combined fertilization		13,450	0,727	0,210
Height of inner cob of cabbage, cm				
Control	-0,225 ns	5,958	1,495	0,431
Combined fertilization		6,183	0,997	0,288
Width of inner cob of cabbage, cm				
Control	-0,275*	2,408	0,211	0,061
Combined fertilization		2,683	0,298	0,086
Density of a head of cabbage				
Control	-0,208 ns	4,708	0,450	0,130
Combined fertilization		4,917	0,195	0,056

D – Paired differences; ±SD – Std. deviation; ±SEM – Std. error mean; ns – not significant

Yield

The yield of cabbage from the control variant (13964.78kg/ha) was significantly lower than the combined fertilization (18287.00 kg/ha), and the statistical evidence of the results confirmed the positive effect of the combined fertilization on the productivity of the crop (Table 2).

Table 2. Yield of cabbage, kg/ha

Variants	***D***	***Mean***	***±SD***	***±SEM***
Control	-4322,23**	13964,78	2081,32	600,83
Combined fertilization		18287,00	3464,37	1000,08

D – Paired differences; ±SD – Std. deviation; ±SEM – Std. error mean; ns – not significant

The yield was increased by 31.01% as a result of the use of liquid fertilizers applied to the soil by a drip system and foliar during the crop vegetation (Figure 4)

Broccoli

Morphological indicators

The height of the broccoli plants ranged from 35.43cm to 36.43cm, and the differences among the variants were in significant (Table 3). A more significant difference in the growth manifestations was found in the characteristic size of the leaf rosette, which was from 77.93 to 81.93cm with a significantly greater effect of mineral fertilization and a statistically proven

difference.

The decisive importance of fertilization is the influence on the consumable part and its parameters. Central flower heads of the plants grown in the variant with combined fertilization have a greater mass - 0.358 kg, which exceeded those from the variant with mineral fertilization by 46.73% (0.244 kg).The central flower head of plants of this variant was 46.72% larger in weight and 25.82% larger in diameter compared to the control (Table 3).

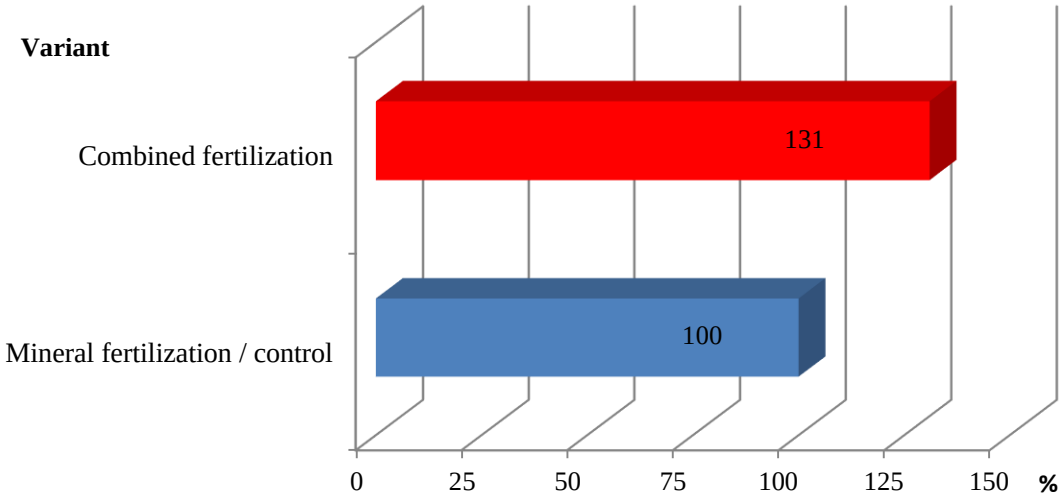

Figure 4. Cabbage yield (%)

Table 3. Morphological features of broccoli

Variants	***D***	***Mean***	***±SD***	***±SEM***
Stem height, cm				
Control	-1,000 ns	35,433	3,545	0,915
Combined fertilization		36,433	4,271	1,102
Leaf rosette size, cm				
Control	4,000*	81,933	7,600	1,962
Combined fertilization		77,933	5,371	1,387
Weight of central flower head, kg				
Control	-0,115***	0,244	0,061	0,016
Combined fertilization		0,358	0,078	0,020
Height of central flower head, cm				
Control	-1,360*	14,113	1,029	0,266
Combined fertilization		15,473	1,250	0,323
Average diameter of central flower head, cm				
Control	-2,430***	9,410	1,159	0,299
Combined fertilization		11,840	1,300	0,335
Average diameter of stalk, *cm*				
Control	-0,337*	4,020	0,253	0,066
Combined fertilization		4,357	0,366	0,095

D – Paired differences; ±SD – Std. deviation; ±SEM – Std. error mean; ns – not significant

According to the indicator of average diameter of stalk, a proven positive effect of the combined fertilization option is again observed.

The differences in the values of the reported indicators of the product part have been statistically proven, which confirms the positive

influence of the combined fertilization of liquid fertilizers applied in soil and foliar in broccoli.

Yield

Broccoli responded positively to the combined fertilization during the growing season. Yields reached to 7463,64 kg/ha and were significantly higher than the control variant - 5083,59 kg/ha (Table 4). The data was statistically proven, which confirms the positive influence of the tested fertilization scheme on the productivity of this crop.

As a result, the use of liquid fertilizers applied to the soil by a drip system and foliar treatment resulted in a significant increase in broccoli yields, which was 46.85% higher than the control variant with mineral fertilization (Figure 5).

Table 4. Yield of broccoli(kg/ha)

Variants	***D***	***Mean***	***±SD***	***±SEM***
Control	-2380,05***	5083,59	1271,47	328,29
Combined fertilization		7463,64	*1608,21*	415,24

D – Paired differences; ±SD – Std. deviation; ±SEM – Std. error mean; ns – not significant

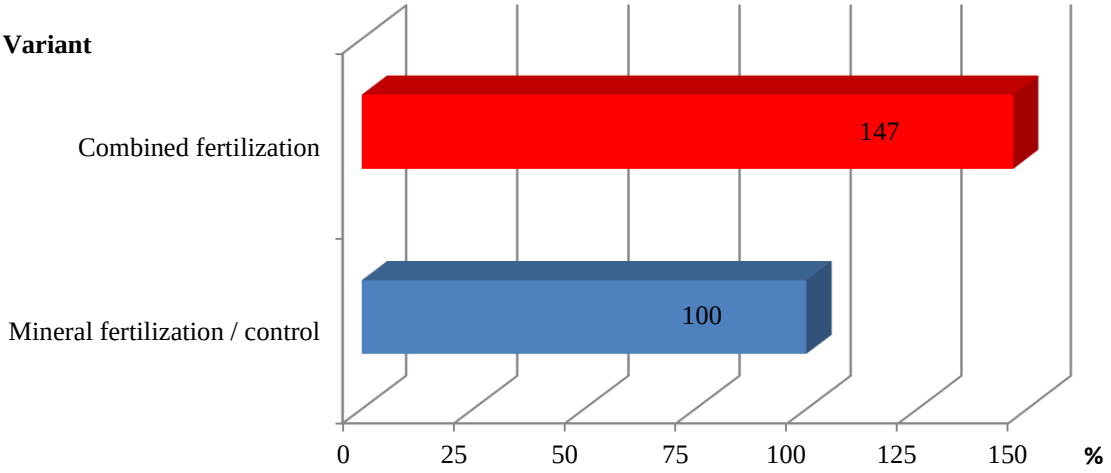

Figure 5. Broccoli yield (%)

CONCLUSION

It was found that cabbage crops grown for late field production and drip irrigation responded positively to the combined fertilization with Stimak, Stimak P and Simargal**.** A more significant effect was found in broccoli.

The effect of combined fertilization on the morphological characteristics of the product part of cabbage crops has been proven. Cabbage weight and diameter were higher by 30.76% and 9.89%, respectively as compared to mineral fertilization. In broccoli, the most significant effect of combined fertilization was on weight and diameter of the central flower head where the increase was 46.73% and 25.83%, respectively. The influence on height of the central flower head is weaker by slight increase of 9.64%.

As a result of combined fertilization of cabbage crops - with the introduction of mineral fertilizers with the main tillage and top-up fertilization with liquid fertilizers applied by soil and with foliar treatment during the growing season an yield was increasedby 31.01% was reported for cabbage variety Bilyan (18920 kg/ha) and 46.85 % for broccoli variety Marathon F1 (7460 kg/ha) as compared to optimal mineral fertilization.

REFERENCES

Agrostatistics (2011), Bulletin №172/2011 (Bg). Retrieved fromhttps://www.mzh.government.bg/media/filer_public/2018/02/21/ra172-publicationvegetables2010.pdf

Agrostatistics (2012), Bulletin №183/2012 (Bg). Retrieved fromhttps://www.mzh.government.bg/media/filer_public/2018/02/21/ra183_publicationvegetables2011-new.pdf

Agrostatistics (2013), Bulletin №252/2013 (Bg). Retrieved fromhttps://www.mzh.government.bg/media/filer_public/2018/02/21/ra252_publicationve_2012.pdf

Agrostatistics (2014), Bulletin №266/2014 (Bg). Retrieved fromhttps://www.mzh.government.bg/media/filer_public/2018/02/21/ra266_publicationvegetables2013.pdf

Agrostatistics (2015), Bulletin №288/2015 (Bg). Retrieved fromhttps://www.mzh.government.bg/media/filer_public/2018/02/21/ra288_publicationvegetables2014.pdf

Agrostatistics (2016), Bulletin №308/2016 (Bg). Retrieved fromhttps://www.mzh.government.bg/media/filer_public/2018/02/22/ra308-publicationvegetables2015.pdf

Agrostatistics (2017), Bulletin № 325/2017 (Bg). Retrieved fromhttps://www.mzh.government.bg/media/filer_public/2018/02/22/ra325_publicationvegetables2016.pdf

Agrostatistics (2018), Bulletin № 340/2018 (Bg). Retrieved fromhttps://www.mzh.government.bg/media/filer_public/2018/05/18/ra340_publicationvegetables2017.pdf

Agrostatistics (2019), Bulletin № 357/2019 (Bg). Retrieved fromhttps://www.mzh.government.bg/media/filer_public/2019/04/22/ra357_publicationvegetables2018.pdf

Agrostatistics (2020), Bulletin № 371/2020 (Bg). Retrieved fromhttps://www.mzh.government.bg/media/filer_public/2020/04/27/ra371_publicationvegetables2019.pdf

Agrostatistics (2021), Bulletin № 386/2021 (Bg). Retrieved fromhttps://www.mzh.government.bg/media/filer_public/2021/05/20/ra386_publicationvegetables2020.pdf

Chand, S., Anwar, M., & Patra, D.D. (2006). Influence of long-term application of organic and inorganic fertilizer to build up soil fertility and nutrient uptake in mint-mustard cropping sequence. *Communications in Soil Science and Plant Analysis*, 37, 63-76.

Chen, J.H., (2006). The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soil fertility. Proceedings of the International Workshop on Management of the Soil-Rhizosphere System for Efficient Crop Production and Fertilizer Use, October 16-20, 2006, Bangkok, Thailand, 1-11

Dintcheva, Ts., (2013).Yield of some varieties of broccoli, influenced by bioproducts for fertilization. *Ecology and the Future*, Year XII, № 2, 38-44 (Bg)

Dumicic, G., Vukobratovic, M., Vukobratovic, Z., Urlic, B., Zanko, M.,& Kudic, K. (2013). Effect of fertilization on cabbage yield characteristics. EgeÜniversitesiZiraatFakültesiDergisi 2013 No. Special Issue 2, 399-403.

Hashem, F. A., & Abd-Elrahman, S. H. (2016). Soil chemical characteristics and growth of broccoli and cauliflower plants as affected by liquid organic fertilizers and irrigation water levels. *Global J. of advanced Research*, 3(10), 881-895.

Islam, M.A., Ferdous, G., Akter, A., Hossain, M.M., & Nandwani, D. (2017). Effect of organic, inorganic fertilizers and plant spacing on the growth and yield of

cabbage. *Agriculture*, *7*(4), 3

Kaur, K., Kapoor, K. K., & Gupta, A.P. (2005). Impact of organic manures with and without mineral fertilizers on soil chemical and biological properties under tropical conditions. *Journal Plant Nutrition and Soil Science*, 168, 117-122.

Ray, P.K., Adarsh, A., & Chaudhary, A. (2018). Effect of organic and inorganic fertilizers on yield and economics of cabbage (*Brassica oleracea* var. *capitata*). Journal of *Pharmacognosy and Phytochemistry*, 7(5), 1967-1970

Samar, M., Doklega, A., & Abd El-Hady, M. A. (2017). Impact of organic, mineral and bio-fertilization on broccoli. *J. Plant Production*, Mansoura Univ., Vol. 8(9), 945 – 951

Todorova, D.,& Boteva, H. (2015). Effect of feeding with organic poultry manure during vegetation on yield and quality of cabbage. *Plant science*, 3, 52-57 (Bg)