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Agroclimatic conditions for cabbage production

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Summary: Cabbage is one of the most commonly produced vegetable crops worldwide due to its ability to adapt to a range of climatic conditions and soil types. As an intensive vegetable crop, cabbage can be produced all year round. Regarding the fact that cabbage needs optimum agroclimatic conditions during growing period for better yielding results, the paper aims to clarify and define the specific agroclimatic requirements, such as temperature, water, light and soil, suitable for cabbage production. Cabbage production should take place on a seasonal basis, as an early, summer, autumn, or winter production. Production goals should take into consideration whether the cabbage is intended for fresh consumption, pickling, storage or another specific method of consumption or processing. Growing the same cultivar in two different temperatures during one year should be avoided. The combination of suitable production conditions, intensive cultivation practices and mechanisation, can boost the genetic potential of the cabbage cultivars. Local climate conditions greatly affect cabbage production, primarily plant growth, occurrence and development of diseases, harmful insects, and weeds. Production planning must take into consideration both the regional (mean annual temperatures and precipitation) and the local climate conditions (frost occurrence). Cabbage is currently produced in the open field throughout the year, but we may be forced to change the course of cabbage production due to the increase of extreme local climate change. For this reason, the aim of this paper was to give recommendations of agricultural practices that could minimize the detrimental effects of climate change in cabbage production.
Keywords: cabbage, cultivation, light, soil, temperature, water

Introduction

Cabbage is a biennial plant which forms heads in the first growing season and generative organs in the second growing season. Cabbage producers consider the first growing season more important due to the yield formation process occurring in the first season. Cabbage is now produced throughout the whole year as the early- and summer-type, and used for fresh consumption or fermentation. Despite its ability to adapt to different climatic and soil conditions, cabbage prefers cold and humid growing regions, as well as cooler seasons, while reacting favourably to optimum temperatures in all growing stages (Červenski and Medić-Pap, 2018; Rashid et al., 2020).

Optimum cabbage crop development occurs under more or less precisely determined environmental conditions. Unsuitable growing conditions cause stress and affect plant growth and productivity. Some abiotic stresses can be minimized by irrigation and fertilization, but others such as variable air temperatures, are more difficult to overcome. Temperature variations are the fundamental triggers of plant phenological events. Vernalization is a well-known physiological process initiated by plant exposure to low temperatures. Seasonal changes in temperatures promote numerous developmental processes, such as flowering, germination and grain filling. On the other hand, temperature conditions also limit spatial distribution and productivity of many important crops (Rodríguez et al., 2015).

Local climate conditions greatly affect cabbage production, primarily plant growth, occurrence and development of diseases, harmful insects, and weeds. Production planning must take into consideration both the regional (mean annual temperatures and

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precipitation) and the local climate conditions (frost occurrence) (Medić-Pap et al., 2019).

Serbian local conditions allow cabbage production throughout the whole year, whether in the open-field or, less frequently, in greenhouses.

According to Mutavdžić and Novković (2006), cabbage has an important place in the Serbian vegetable crop sowing plan. The authors stated that, regardless of the application of modern cultivation practices, total annual cabbage production depends on the environmental, above all climate conditions. The development of cultivation practices may reduce, but never completely eliminate the effect of environmental conditions on cabbage production.

Cabbage is currently produced in the open field throughout the year, but we may be forced to change the course of cabbage production due to the increasing extreme local climate change. The optimum agroclimatic conditions must be taken into consideration before cabbage production. For this reason, the aim of this paper was to point recommendations of agricultural practices that could minimize the detrimental effects of climate change in cabbage production.

Cabbage temperature requirements

Cabbage production or growing is most often determined by how the produced cabbage will be used - fresh or processed. For this reason, cabbage production can be distinguished as early, summer, late, or winter production. Each seasonal production is highly dependent on the climate conditions during the growing season (Červenski and Medić-Pap, 2018).

During the course of their vegetation, species such as *B. oleracea* are exposed to summer temperatures, reaching as high as or even exceeding 40°C, as well as winter sub-zero temperatures. Extreme temperatures (exposure to cold and heat) affect cabbage photosynthetic activity and yield formation mainly due to cabbage oxidative stress as the most common culprit. The *Capitata* group (cabbages) is more tolerant to low temperatures (Soengas et al., 2018).

Although adapted to different climate and soil conditions, cabbage favours the colder and more humid growing areas as well as colder seasons, while favourably reacting to optimum temperatures in all stages of development (Matotan, 2006)

According to literature sources optimum temperature for the head formation phenophase are from 17.7 to 20ºC (Howe and Waters, 1994); 16 to 20°C (Criddle et al., 1997; Hara and Sonoda, 1982); 15 to 18˚C (Lešić et al.,2004); 17.2 to 19.9ºC (Žnidarčič et al., 2007); 14 to 24ºC (Toth et al., 2011); 16.1 to 16.8ºC (Kołota et al., 2015); 17°C and 22°C Nurhidayati et al., (2016); 17.5-19.1°C (Paranhos et al., 2016); 15 to 18ºC (Červenski and Medić-Pap, 2018).

Temperatures that can cause heat stress and adversely affect cabbage head formation and yield are moving above 25ºC (Matotan, 2006; Červenski and Takač, 2012); above 30ºC (Červenski and Medić-Pap, 2018); above 19°C (Everaats, 1990; Gvozdenović et al., 2007); above 24ºC (Kahn et al., 2007; Radovich et al., 2004);

The opposite situation from the above can appear in the autumn period. If the technologically mature cabbage crop with formed heads is subjected to low air temperatures (below -5ºC) during several days, cabbage heads undergo freezing and defreezing process that causes deterioration, first of the outer and then the inner leaves (Matotan, 2006; Gvozdenović et al., 2007).

Measures to alleviate temperature stress in cabbage production

When producing early cabbage in the open or protected space, we must be ready to reduce the impact of low temperatures in a timely manner with certain cultivation practices. In the winter-spring period, low temperatures can range from 0 ° C to even below -10° C, with weaker or stronger frosts. Such low temperatures can have a negative impact on sown or transplanted early cabbage in an unheated sheltered area, or even in the open field, from the partial damage to individual plants to complete crop decay. Cabbage production in a protected area, during the winter-spring period requires reheating in combination with the use of double-layer cover foils inside the greenhouse and agrotextiles.

Mulching is an important factor for successful cabbage production. Natural mulch helps add organic matter to the soil, while artificial mulch increases soil temperature, preserves soil moisture and reduces weed competition. The effects of mulching depend on the growing season. Covering the soil with black polyethylene foil is recommended if springs are cold and wet. Black polyethylene absorbs heat from solar radiation, increases soil temperature and helps increase the production of cabbage, especially in the winter season. Furthermore, it retains moisture in the soil and prevents sunlight from reaching the soil, which inhibits weed growth by reducing the physiological functions of weeds, such as germination, root, shoot and stem growth, and ultimately reduces production costs (Farjana et al., 2019; Ponjičan et al., 2020; Adamović, 2020).

If production takes place in a protected space, the cover layers have a dual function - blocking infrared radiation and allowing for solar radiation much needed for plant growth. For year-round cultivation, optimal conditions should be provided by a combination of natural ventilation, evaporative cooling and shading. In this way, air temperature in a protected space can be reduced by 10°C and relative humidity can be increased by 20%. Also, by using cover layers, solar intensity can be reduced by up to 40%. Shading can be effective in reducing the transmission of solar radiation and lowering the greenhouse air temperature, especially when combined with other cooling techniques such as whitewashing, netting, natural ventilation and evaporative cooling. Groundwater use can increase the efficiency of indirect-direct evaporative cooling more than direct evaporative cooling. This system can reduce the air temperature in greenhouses by up to 12°C. An effective method of shading can be a combination of rotating photovoltaic panels and mirrors with high reflection, which also produces energy on the spot. Electricity from the so-called hybrid system, consisting of mains-connected solar photovoltaic panels and a heat pump, can satisfy 33.2%-67.2% of greenhouse demands in summer (Ghoulem et al., 2019).

Cultivation of cabbage in greenhouses during spring and autumn requires average daily temperatures of 15–25°C and 10–30°C, respectively (Xianbing et al., 2020).

Low temperatures in spring can prolong the time of transplanting early cabbage. In conditions of low temperatures, the plant primarily reacts by closing the stoma, reducing the intensity of one of the basic physiological processes - photosynthesis. Before taking the early seedlings to the open field, the seedlings must be tempered, i.e. gradually exposed to external weather conditions, unpredictable situations and temperature fluctuations, in order to strengthen the plant as much as possible (Červenski and Medić-Pap, 2018).

In warmer years, plastic spreading foils can excessively raise the soil temperature in the zone of the root system, which negatively affects plant growth and yield. For that reason, plastic foils should not be used under a high level of solar radiation (Adamović, 2020).

Ponjičan et al. (2020) proposed the use of environmentally-friendly biodegradable plastic foils for mulching. Macroalgae can be used as a viable alternative for the production of large-scale biopolymers. In addition, colonies of microorganisms capable of degrading the existing plastic waste may be another alternative. Ghoulem et al. (2019) stated that plastic waste can be reduced fivefold-tenfold by the use of ethylene tetrafluoroethylene copolymer films.

Cabbage water requirements

Cabbages have high water requirements due to their morphological features. Cabbage contains over 90% of water, consumes high amounts and uneconomically discards excess water in soil during growth and development (Červenski and Takač, 2012).

Bute et al. (2021) stated that among the various factors influencing cabbage growth, irrigation is one of the leading components that can be adjusted and controlled. It is essential to develop irrigation planning strategies in local climates in order to make more efficient use of limited water resources. Cabbage is classified as moderately sensitive to water stress, with the head formation phase being more sensitive than the previous growth phases.

Soil layer from 30 to 50 cm in depth houses 90% of the root mass, characterized by low pressure of cell sap and weak suction force. Leaf area of one cabbage plant can vary between 1.5-2.0 m^2 and 2.4-4.0 m^2, which affects high transpiration and water requirements, while cabbage leaf surface index is about 3.96. Large leaves and tissues with large cells cannot conform to economical water consumption and waxy coating offers poor protection against intense evaporation. The lack of water in any given period of plant development reduces the yield; therefore, cabbage requires high soil moisture throughout the growing season and, as a result, cabbage production focuses on irrigation (Dragović et al., 2006).

Cabbage water requirements depend on the development of the plant and weather conditions during late production. Since cabbage is transplanted at the beginning of July, high soil moisture must be maintained by irrigation from the very beginning of production. In order to achieve high yields, cabbage must be watered regularly after transplanting. Water requirements also depend on the time and place of cabbage production; the highest are during the hot days of July and August. Heads are formed at lower temperatures and higher humidity, which reduces transpiration and evaporation from soil (Bošnjak, 2003).

Long-term research conducted from 1990 to 2016 by Domuta et al. (2017) showed that autumn cabbage production depends on high amounts of water. Due to annual pedological droughts, autumn cabbage production relies on the optimum daily water intake supplied by irrigation. Long-term mean annual precipitation was 622.7 mm for the examined period. Irrigation provided 47%, total precipitation 46%, and soil water reserves 7% of the total water supply in the period from planting to harvest. Irrigation statistically significantly increased average cabbage yield by 153%, from 21 t/ha without irrigation to 53 t/ha in irrigation. Water intake efficiency statistically significantly increased by 60%, from 6.91 kg/m^3 to 11.8 kg/m^3. In view of maintaining soil water reserves between easily accessible water content and field capacity, an average irrigation rate of 2,410 m^3/ha was used throughout the test period, with a range of variation between 1330–4600 m^3/ha.

Cabbage forms large above-ground mass, while its root system is shallow, poorly developed and has weak suction capacity. Water requirements are conditioned by the growth phase; the highest are during transplanting, intensive growth of rosette leaves, and head formation. At an average yield of 30 t/ha of late cabbage, water productivity is 150 m^3/t, but twice as high at 60 t/ha because 1t of yield (75 m^3/t) requires half as much watering. The values are significantly higher in early and medium-early production, ranging from 100 to 175 m^3 (Karagić, 1998; Maksimović et al., 2008).

Yield of 60-64 t/ha of cabbage can be produced by transplanting at the beginning of the third 10-day period of June or the beginning of the first 10-day period of July, with the consumption of 390-410 mm of water for evapotranspiration. The highest irrigation norm was established during planting on 20 June, when 9 waterings were performed using the irrigation norm of 40 mm. The irrigation norm in the period of cabbage planting was 360 mm, as specified above (Karagić, 1998; Karagićet al., 2001). The highest yield was achieved by transplanting within the specified period in the pre-irrigation soil moisture of 70 to 75% of soil field water capacity (FWC) as the minimum for late cabbage production (Maksimović et al., 2006). The lower limit of the optimum moisture level before the beginning of head formation is 80% FWC, followed by 70% FWC after the onset of head formation.

Žnidarčič and Ban (2010) carried out a study with 20 cabbage varieties in the open field and during the study years (2005 and 2006) precipitation ranged from 387 mm and 556 mm. Authors stated that agro-climatic conditions for growing cabbage for fresh consumption, as well as for pickling and processing were suitable.

Toth et al. (2011) suggested that if precipitation is well distributed during cabbage cultivation in the summer and autumn period, there is no need for supplemental irrigation.

An experiment was carried out on a clay-type soil to reveal the impact of irrigation on cabbage yield (Erken and Yildirim, 2019). Mean annual precipitation sum of the examined area was 650 mm, not optimally distributed during the period of cabbage production. The results revealed that different moisture content in the root affected the yield and sugar content. Cabbage yields significantly increased after irrigation. However, water stress that exceeded 30% during cabbage production significantly decreased the yield and quality of cabbage. The authors therefore emphasized the importance of planning irrigation strategy which should include increasing the efficiency of irrigation, reducing the costs of irrigation and saving water resources.

Practices for reducing water stress in cabbage production

In order to achieve higher yields, excessive use of water has become a standard practice in the production of cabbage. This practice not only extracts nutrients from the soil surface into deeper layers, thereby reducing plant ability to use water and nutrients, but it can also cause soil degradation. Cabbage cultivation requires soil moisture of 75-80% even 90% during growth and maturation of cabbage heads, and relative humidity of 85-90%. The optimum yield of cabbage is achieved by providing at least 400 m^3/ha^{-1} of water using sprinkler and furrow irrigation. The amount of water used for drip irrigation should be approximately 125-150 m^3/ha^{-1} with an interval of six days between individual irrigations. It is also important to take into account the amount of precipitation during the entire vegetation period and the climate of the area where cabbage is grown. It is important not to skip the critical stages of irrigation when cabbage seedlings have 6-7 leaves and at the beginning of head formation (Bute et al., 2021).

Hamad et al. (2022) stated that cabbage producers often use high amounts of nutrients and water to increase yields. Excessive irrigation and application of N-fertilizers can lead to environmental problems, including greenhouse gas emissions. Drip irrigation is a more efficient method of water management than other irrigation methods. It has many advantages including water savings, easy fertigation, less surface runoff and deep seepage. Different irrigation methods have different effects on the distribution of soil moisture and on the N_2O emissions. Drip irrigation with emitters placed at the appropriate depth can mitigate N_2O emissions and increase the yield of cabbage grown in a protected area. Yield and efficiency of water use were significantly higher in drip irrigation, with emitters at a depth of 15 cm, than at other depths (5 cm and 10 cm). Irrigation at this depth also contributed to lower N_2O emissions. During the study, the average temperature in the protected area was 21.0°C, and the average relative humidity was 58%.

Büyükcangaz (2018) reported that cabbage water requirements range from 380-500 mm depending on climatic conditions and vegetation length. He also concludes that drip system is suitable for unheated greenhouse cabbage production. Xianbing et al. (2020) recommended drip irrigation in greenhouse cabbage production, using a system placed under mulch with approximately 114.7-125.0 mm of water. During spring and autumn cultivation of cabbage in greenhouses, the average daily levels of relative humidity were 30-60% and 50%-90%, respectively.

Suitable agroclimatic conditions and cultivation practices result in successful cabbage head formation and prevent the occurrence of loose heads. Another negative effect on cabbage head formation comes from over-watering at daily temperatures above 25-30ºC. If cabbage production takes place in dry periods at temperatures above 30ºC (during July and August), soils should be irrigated every 8–12 days, with a water norm of 30–40 mm. One irrigation every ten days is enough. Frequent watering (every 4-6 days) at high temperatures (above 30ºC) can contribute to the formation of loose cabbage heads; a higher amount of water in combination with high average daily temperatures contributes to the formation of cabbage heads with loose and curled leaves, which reduces the market value (Červenski et al., 2008; Červenski and Medić-Pap, 2018).

According to Terefa (2017), sprinkler irrigation should be conducted every six days for optimal cabbage growth.

Cabbage soil requirements

Soil conditions are particularly important for successful vegetable production. The most favourable are flat terrains or terrains with a slight slope (1-2%) that allow normal drainage of excess water, as steep slopes can lead to erosion. In addition, it is important to maintain a favourable soil structure for the faster and more uniform germination and rooting, which is certainly important for plant health and overall appearance (Medić-Pap et al., 2019).

Cabbages require fertile soil, and can be grown successfully on all soil types with good soil moisture and air properties, with the exception of extremely light and sandy soils. Medium-heavy soils, alluvial, alluvial humus, sandy, clayey, deep soils with good air and water properties and sufficient nutrient content, are most suitable for cabbage production (Gvozdenović et al., 2011; Červenski and Medić-Pap, 2018).

Paranhos et al. (2016) pointed out to a possibility of uneven moisture distribution if cabbage is grown on sandy soils. During heavy rainfall, soluble nutrients can move into inaccessible soil layers, increasing the possibility of reduced cabbage yield.

Importance of soil type in cabbage production is evident in Červenski and Takač (2012), who confirmed that cabbage can be produced in various soil types, from the medium-heavy, alluvial humus, to sandy clay deep soils with a pH reaction of 5.5-6.5 to 6.5-7.5. However, light, loose, easily-heated soils are better for production of early cabbages intended for fresh consumption. Late cabbages, red cabbage and kale are better produced on medium to heavy soils with higher water capacity. Cabbage varieties grown for fresh use require lighter soils, whereas cabbage for storage need to be produced on medium-heavy soils.

Cabbage grows well on soils with high groundwater levels, but does not tolerate excessive amounts of surface water. Cabbage is also not suitable for extremely heavy soils that are impermeable to water, with a low content of organic matter (Červenski, 2010).

Farmers must conduct appropriate soil management in order to produce healthy crops and establish healthy soil microenvironment. This includes soil microorganisms, nutrients and soil structure. Crop rotation is a necessary practice for soil quality improvement and soil organic matter increase. Increase in soil organic matter helps retain and store carbon and other micronutrients essential for healthier crop growth, as well as increasing crop resistance to pests and diseases (Nurhidayati et al., 2016).

Soils with a neutral to slightly acidic reaction (pH 5.5–6.5 / 6.5–7.5) are the most favorable for successful cabbage production. Cabbage should not be grown on acidic soils (pH less than 5.5), because of certain disease incidence in more acidic environments. One of the diseases infecting cabbage grown on acidic soils is the root neck disease. Soils that have a lower pH value should be calcified before cabbage cultivation (Matotan, 2006).

Long-term intensive production of vegetables on the same soil disrupts its nutritional structure and microecological balance, which can significantly reduce yields and even lead to crop failure. Beneficial soil microorganisms are an important part of the soil microenvironment because they help the transformation of soil nutrients and organic matter decomposition, and participate in a number of biochemical reactions in the soil (Cheng et al., 2020).

Cabbage is a calcicolous plant which contributes to soil acidification and thus enables a possibly faster spread of *Plasmodiophora brassicae* Wor., the cause of the cabbage hernia (Todorović et al., 2009). At the traditional cabbage cultivation localities, where this plant species is usually grown in monoculture, the presence of the mentioned pathogen is recorded every year (Todorić et al., 2017).

The results obtained by Vlajić et al. (2018) confirm that raising soil pH to 7.2 and above is the standard recommendation for the control of cabbage hernia caused by *Plasmodiophora brassicae* (Woronin), a significant pathogen found in intensive cabbage cultivation areas, especially in temperate climate. Alkaline soil reaction prevents the development of the mentioned pathogen and reduces the appearance of tumors at the root. For this reason, soil agrochemical analysis is necessary in order to accurately determine soil pH value prior to cabbage production.

In order to predict the yield of cabbage in temperate climate conditions of Europe, a model was developed on a clay loam soil with clay content of about 29%, classified as Ruptic Haplic Cambisol (loess deposit of the Upper Triassic) (Übelhör et al., 2015).

Cabbage light requirements

Light plays a key role in plant vegetation, determining the intensity of photosynthesis and photomorphogenesis (Avercheva et al., 2009). Different light spectra affect plant physiological processes. The two main approaches to regulating light exposure during the initial vegetable growth stages are the application of polymeric materials for lining of the protected areas, including the materials that transform light oruse different light emission spectra (Max et al., 2012), and the use of artificial light (Avercheva et al., 2009). Cabbage is a long-day plant with moderate demands, which are increased during the initial growth and development stages (Červenski and Gvozdenović, 2000).

Plant growth was increased during a growing season with higher levels of solar radiation. While a reduction in solar radiation availability by 66% significantly reduced cabbage yields (Paranhos et al., 2016). Due to this, artificial LED light is used in the cultivation of seedlings in order to improve their quality.

To increase plant productivity, the radiation spectrum can be corrected by increasing the proportion of red or blue components, depending on plant species and environmental conditions (Khramov et al., 2019). Red light in the wavelength range of 650-700 nm participates in photosynthesis most effectively. Mizuno et al. (2011) stated that red light increases the concentration of anthocyanins in cabbage. Therefore, to improve plant growth, the use of predominantly red component of the spectrum is recommended (Ivanyuk et al., 2020).

The blue and purple spectrum (380–490 nm) participate in photosynthesis, stimulate protein production, and affect the processes associated with plant development (Petroutsos et al., 2016). In a study by Ying et al. (2020) cabbage plants grown under 15% blue light had the highest fresh produce yield. The same authors concluded that 15% of blue light has the greatest impact on overall yield. According to Li et al. (2012) increasing the time of exposure to the blue light spectrum resulted in an increased chlorophyll concentration in cabbage seedlings.

Conclusion

Cabbage is an important vegetable crop, both in terms of its high production and consumption. It can be grown all year, but also has an optimum growing season. Cabbage production should take place on a seasonal basis, as an early, summer, autumn, or winter production. Production goals should take into consideration whether the cabbage is intended for fresh consumption, pickling, storage or another specific method of consumption or processing. Growing the same cultivar in two different temperatures during one year should be avoided. The success of cabbage production under specific agro-climatic conditions largely depends on the correct choice of cultivar. Cabbage production is guided by the rules, followed in order to reach the production goal - high yield and good quality of the product. High yield of cabbage largely depends on the specific environmental conditions; therefore, a well-known variety or hybrid is chosen and produced in a familiar environment (climate conditions, pathogens) using complete agricultural practices and mechanization. By taking this approach, we can contribute to the better realization of genetic potential of cabbage varieties grown under different climatic conditions.

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Agroklimatski uslovi za proizvodnju kupusa

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Sažetak: Kupus je jedno od najpopularnijih povrća na svetu zbog prilagodljivosti širokom rasponu klimatskih uslova i vrsti zemljišta. Predstavlja povrtarsku vrstu koja može da se proizvodi tokom cele godine. Da bi se ostvarili što veći prinosi, kupus mora imati optimalne agroklimatske uslove tokom vegetacione sezone. Iz tog razloga u radu smo hteli da približimo i definišemo potrebe kupusa za agroklimatskim uslovima proizvodnje, kao što su temperatura, voda, svetlost i zemljište. Proizvodnja kupusa treba da se odvija po principu sezonskog karaktera, kao rana, letnja, jesenja, ili zimska. Sledeći kriterijum treba da bude cilj proizvodnje, tj. da li je kupus namenjen svežoj potrošnji, kišeljenju, lagerovanju ili određenom načinu potrošnje/prerade. Trebalo bi izbegavati proizvodnju jedne iste sorte u dve temperaturno različite sezone tokom godine. Uspešnost proizvodnje u određenim agro-klimatskim uslovima u velikoj meri zavisi upravo od pravilnog odabira sorte. Pravilnom kombinacijom uslova proizvodnje, intenzivne agrotehnike i odgovarajuće mehanizacije možemo doprineti boljem ostvarivanju genetskog potencijala sorte kupusa. Lokalni klimatski faktori su bitan činilac u proizvodnji kupusa, kako sa aspekta razvića samih biljaka, tako i sa apekta pojave i razvoja bolesti, štetnih insekata i korova. Prilikom planiranja proizvodnje potrebno je uzeti u obzir regionalne (srednja godišnja temperatura i količina padavina) i lokalne (opasnost od mraza) klimatske uslove. Kupus se trenutno proizvodi na otvorenom polju tokom cele godine, ali zbog sve većih ekstremnih lokalnih klimatskih promena možemo biti primorani da koriujemo određeni deo proizvodnje kupusa. Iz tog razloga, cilj ovog rada bio je da ukaže na preporuke poljoprivredne prakse koje bi mogle da minimiziraju štetne efekte klimatskih promena u proizvodnji kupusa.

Ključne reči: gajenje, kupus, svetlost, temperatura, voda, zemljište