Quantitative Analysis of Greenhouse Kohlrabi (*Brassica oleracea* var. *gongylodes* L.) Growing

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ABSTRACT---- ***This study were carried out to of different sowing time in order to determine the effects on plant growth of kohlrabi cultivation under Samsun condaitions during the autumn growing periods in unheated greenhouse. Four different seed sowing times (1st September, 15th September 1st October, 15th October), two different kohlrabi cultivars (Kolibri F_1 and Korist F_1) and two mulch applications (mulch covered and uncovered) were used in this study.***

The plant growth parameters analyzed (total plant dry weight, leaf area ratio, specific leaf area, net assimilation rate and relative growth rate) were found statistically significant ($p<0.05$). The highest total plant dry weight (114.1 g) was obtained from mulch application and 1st September seed sowing time. The highest leaf area ratio value were obtained in both mulch application the Kolibri F1 variety grown on October 15th. The highest net assimilation rate (0.65 g cm^{-2} day^{-1}*1000) and relative growth rate (0.0090 g g day^{-1}) were obtained from mulch covered plants grown in Kolibri varieties during September 1st. As a result, in this study higher dry matter accumulation was achieved by 1st September seed sowing times in vegetable growing in the last season in the greenhouse. In this way, the plants have successfully grown up and increased their productivity by entering the winter months, when the temperature and light intensity are decreasing.

Keywords--- Kohlrabi cultivars, sowing time, growth, mulch

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1. INTRODUCTION

Production and consumption are not widely used in the kohlrabi country which is one of the important vegetables of the Brassica group. However, it is reported that kohlrabi has healing properties such as beta carotene, folic acid, vitamin C, vitamin A and asthma, cancer, cataract, high blood pressure, kidney stone, nervous system diseases and paralysis [1]. Kohlrabi, a type of vegetable that can be preferred in terms of growing techniques as well as nutritional value, is a type of vegetable with advantages for greenhouse vegetable producers because it can be produced in the green without short heating period (about two months) [2]. Kohlrabi, according to summer vegetables, early varieties which are very resistant to cold are used as pre-culture in all foreign countries. After kohlrabi, cauliflower, chinese cabbage, medium early carrot, bean, leek or similar varieties can be grown. It can be used as an alternate plant since it allows to buy two products from a certain area [3]. It is of great importance to determine the optimum seedling and plant growth conditions according to the regions for the production of kohlrabi plant which has advantages in terms of production and consumption.

In order to minimize the risk of production in greenhouse vegetable growing, production is started with seedling planting rather than directly seeding. Seedling cultivation has many advantages such as reducing seed loss, entering production more healthily, evaluating the production season better and reducing labor costs [4]. Besides seed sowing with quality seedling, the most important factors affecting the yield in plants are the light intensity and temperature that they are exposed to, so seed sowing and seedling planting period need to be adjusted well. Especially in annual plants, production factors such as seeds and seedlings and planting times should be taken into account considering the climatic conditions in each region. The conditions under which the dry matter will be more consumed in the consumed parts of the cultivated plants shall be determined by the investigations to be carried out [5]. In determining the effects of environmental conditions on plant growth and in the analysis of growth, it is necessary to understand some of the concepts related to temperature and light. Some of these concepts represent the relative growth rate (RGR), net assimilation rate (NAR), specific leaf area (SLA) and leaf area ratios (LAR). The use of these sub-models will ensure that

proper seed sowing time is determined, and planting, irrigation, fertilization, pruning and other processes are carried out in a timely and efficient manner [6].

In this study, it were aimed to determine the best seed sowing time and cultivation technique by revealing the effect of different seed sowing times on kohlrabi cultivation in the last seasons by quantitative analysis depending on light and temperature in the growth of mulch and uncovered without heat in the plastic greenhouse.

2. MATERIALS AND METHODS

The present study was conducted at plastic greenhouses without heat of Ondokuz Mayıs University Agricultural Faculty Horticulture Department (36°C 12' east, 41°C 22' North latitudes and longitudes) during the two years. Experimental greenhouses are 6 m wide and 20 m long (120 m^2). The side walls are 3 m high and the greenhouse is covered with anti-fog, antivirus, infrared and ultraviolet supplemented PE cover. The greenhouses have natural ventilation from one long side and arc roof.

As a vegetal material, Kolibri F1 type with green color Korist F1 type and purple color type body were used in the research. In this study, 4 different seed sowing times (1 September, 15 September, 1 October and 15 October), two kohlrabi cultivars (Kolibri F1 and Korist F1) and two mulch (mulch covered and uncovered) applications were used in greenhouse. Seeding was performed to peat-filled viols (45 cells; 5x5cm) on four sowing times of both years. The experiment was carried out with 3 replications according to random application blocks (2 kohlrabi species x 4 sowing time x 2 applications) and 18 plants in each plots. The dates of sowing and planting of varieties are presented in Table 1 in detail according to years.

Raised beds in greenhouse were 1 m wide, 18 m long and 20 cm high. Farmyard manure was spread over the seed beds at 2 kg m^{-2} ratio and mixed into 10-15 cm soil layer. Then top of the seedbeds were leveled with mixed. Double drip lines with 25 cm dripper intervals were placed over the seedbeds for irrigation. Seedbeds were then covered with polyethylene (PE) mulch (1.30 m wide and 0.03 mm thick, black in bottom and black color on top). Other applications were used for the uncovered and the soil surface was left open. Prepared raise beds, seedlings (Korist F1 and Kolibri F1) were planted in 40 cm on-row spacing, 40 cm row spacing and 90 cm wide spacing.

After the planting of the seedlings in the research, cultural processes were carried out regularly. As a result of analysis in soil samples, it was determined that the pH of the soil was neutral (6.72), the phosphorus level was very high (24.6 kg da^{-1}), the organic matter was poor and the lime was poor. Fertilization program was established according to soil analysis results, half of nitrogen and phosphorus were mixed with soil before planting and the other half was given 3 weeks after planting. Temperature (^oC) was measured (Greenhouse inside and 20 cm soil depth) using data logger (KT100, Kimo, France). The temperature (^oC) values obtained are given in Table 2 as the highest, lowest and average in Figure 1, the average temperature is given.

For the quantitative analysis in the experiment, randomly selected three plants were root-removed after 20-40 days from seedling planting from each variety and one cycle were planted extensively [6]. After the roots of the plants were thoroughly washed on a fine sieve, the root, stem and leaves of each plant were separated and dried at 80^0C for 48 hours. The plant dry weights obtained were weighed on a 0.001 grit sensitive digital scale and the leaf areas were determined with a digitizer planimeter (Sokisha KP-90). Parameters were determined according to the calculation models given in Table 3 using plant dry weights and leaf area values [6].

The experiments were carried out in a randomized block design. Statistical significance was determined by the univariate analysis of variance using SPSS 17.0 statistical software (SPSS Inc, Chicago, USA). Differences between treatments were estimated by the Duncan multiple range test at $P< 0.05$. There were no statistically significant difference between years or a significant interaction between years and treatments when data for two years was combined. Mean data for two years are presented in the tables and figures. In drawings the graph of the growth parameters 'Microsoft Office Excel 2010' program was used.

3. RESULTS AND DISCUSSION

In the study, it was determined that the total plant dry weight values were increased in both applications in kohlrabi varieties ($P<0.05$). The highest total plant dry weight value in the survey was 114.1 g on 1 September at the Kolibri F1 variety grown with mulch. The lowest total plant dry weight value was determined on the Kolibri F1 variety grown on October 15 as 0.016 g in same applications (Figure 2). In many studies, total plant dry weight has confirmed that increasing air and soil temperatures reduce total plant dry weight, which supports our results in the study [6,7,8,9].

In the study, the range of leaf area ratios (LAR) varieties varied between 0,11 $cm^2\ g^{-1}$ and 0.50 $cm^2\ g^{-1}$ according to the planting periods and applications ($P<0.05$). The highest LAR value in mulch application was 0.47 $cm^2\ g^{-1}$ and the Kolibri F1 variety grown on Octeber 15^{st}; while the highest value of the un-covered applications was 0.50 $cm^2\ g^{-1}$ in the Kolibri F1 variety grown on Octeber 15^{st} (Figure 3). Özbakır et al., [8] It was determined that the highest LAR in both types (Kolibri F1 and Korist F1) were in September 15^{th}. Picken and Stewart (1986), on the dry matter distribution in

plants, indicating that the increase in light intensity and LAR are significantly reduced. The data obtained in the study support this literature. In addition, Uzun [10], with increasing temperature increase, the increase of LAR.

It has been found that in the range of Kolibri F1, the specific leaf area (SLA) values vary from 81.510 cm^2g^{-1} to 132.334 cm^2g^{-1} for all sowing times and from 62.519 cm^2g^{-1} to 124.453 cm^2g^{-1} for Korist F1 varieties ($P<0.05$). In both types (Kolibri F1 and Korist F1), it was determined that the value of SLA, which is low in the first sowing period, increased during the research period (figure 4). It was determined that the value of SLA was higher in the plants grown without mulch and lower in the plants grown in the mulch. Uzun [6] reported that plant specific leaf areas vary greatly depending on the plant environment, as well as plant species and cedar, indicating that SLA varies with temperature and inversely proportional to light in many plant species. Björkman [11], explains that plants can adapt to low light conditions by increasing their SLA. This literature supports the fact that the SLA values are higher than the other planting periods during the late October periods when light intensity decreases in the study

Net assimilation rate (NAR) is defined as growth rates for each unit leaf area of plants [6]. The application of kohlrabi varieties and the variations of NAR during the growing season during all sowing periods ($P<0.05$) compared to the sowing periods are presented in Fig. 5. NAR is generally found to be higher in plants grown with mulch during the growth period. Özbakır et al. [8], Öztürk and Demirsoy [9], reported that decreasing temperature and light reduced NAR. Conversely, Heuvelink [12] reported that temperature generally has very little effect on NAR, but that non-optimal temperature gradients cause significant changes in net assimilation rate. It is also reported that plants grown in high light have more photosynthesis rate in low light and this increases the NAR [10]. The decrease in the NAR values, which were high in September 1th sowing time, with decreases in light intensity and temperature, is similar to the literature.

According to the application and planting periods of the kohlrabi varieties, changes in the relative growth rate (RGR) are statistically significant ($P<0.05$). RGR showed a similar change to the NAR change over the growing period according to the applications. As a result, mulch grow plants have higher RGR value.

The highest relative growth rate; RGR (0.0090-0.0091 g g day^{-1}) was obtained from plants grown in both Kolibri and Korist varieties during September 1st (Figure 6). Increasing light intensity is known to increase the RGR value [6]. Kandemir [13] found that RGR decrease under low light and temperature conditions, increases at high light and temperature (24 ° C) conditions, and decreases over time with RGR. Özbakır et al. [8] ıt is reported that RGR is very low in late sowing times periods under specific light intensity. In our study, it was also found that RGR decreased due to the intensity of light and the decline in temperature.

4. RESULTS

The influence of environmental factors on the growth and development of different plant species in greenhouses vegetable cultivation is also different. It is necessary for the stress conditions to not occur before the plants reach a specific size, especially before the temperature values fall in winter season vegetable growing in the greenhouse. It is possible to catch the right time with the study of different sowing dates. In this way, the fulfillment of the appropriate conditions for each type with quality and healthy seedlings and strong growing plants will be obtained. In this study, higher dry matter accumulation was achieved by different seed sowing times in vegetable growing in the last season in the greenhouse. In this way, plants have successfully grown their growth in the winter months when the temperature and light intensity have decreased. As a result, increase in efficiency is achieved.

This study quantitatively examined the effects of planting periods and applications (mulch covered and uncovered) on the growth of Kolibri F1 and Korist F1 Kohlrabi varieties. In the study, it was determined that the seed sowing times had significant effects on Kohlrabi cultivation in the last season ($P<0.05$). According to the results obtained in the research, it is determined that the highest net assimilation rate and the relative growth rate are September 1st seed sowing times. It has been determined that the Kolibri F1 variety among the Kohlrabi varieties grown in greenhouse shows higher performance than the examined parameters. It has also been found that the application of mulch influences growth by preventing quick changes in soil temperature.

5. ACKNOWLEDGEMENTS

We would like to thank Prof. Dr. Sezgin UZUN for his valuable help in the preparation of this manuscript.

6. REFERENCES

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Tables

Table 1. Sowing and seedling planting times of kohlrabi varieties

	Years			
	First		Second	
	Sowing Times	Planting Times	Sowing Times	Planting Times
I.	1 September	30 October	1 September	23 October
II.	15 September	03 November	15 September	5 November
II.	1 October	28 November	1 October	25 November
IV.	15 October	28 December	15 October	26 December

Table 2. The soil (mulch covered, uncovered) temperature (^oC) at 20 cm depth and weather temperature in greenhouse.

	Temperature (^oC)		
	Weather	Soil (mulch covered)	Soil (uncovered)
Minimum	-0.47	1.51	-1.01
Maximum	32.58	31.55	30.04
Average	14.05	13.42	12.51

Table 3. Formulas used in plant growth parameters and calculation

PARAMETERS	DETERMINATION METHODS
Total plant dry	Root dry weight (g) + Stem dry weight (g) + Leaf dry weight (g)
Leaf area ratio (LAR)	Leaf area (cm^2) / Total plant dry weight (g)
Specific leaf area (SLA)	Leaf area (cm^2) / Leaf dry weight (g)
Net assimilation rate (NAR)	$[W_2(g)- W_1(g) / A_2(cm^2)- A_1(cm^2)]/(t_2-t_1)$ (g cm^{-2} day^{-1})
Relative growth rate (RGR)	Net assimilation rate (NAR) x Leaf area ratio (LAR) (g g^{-1} day^{-1})

W_1: Leaf dry weight of the first quantitative analysis; **W_2:** Leaf dry weight of the second quantitative analysis; **A_1:** The total leaf area of the first quantitative analysis; **A_2:** The total leaf area of the second quantitative analysis; **$T_{1,2}$:** Time between two quantitative analysis

Figures

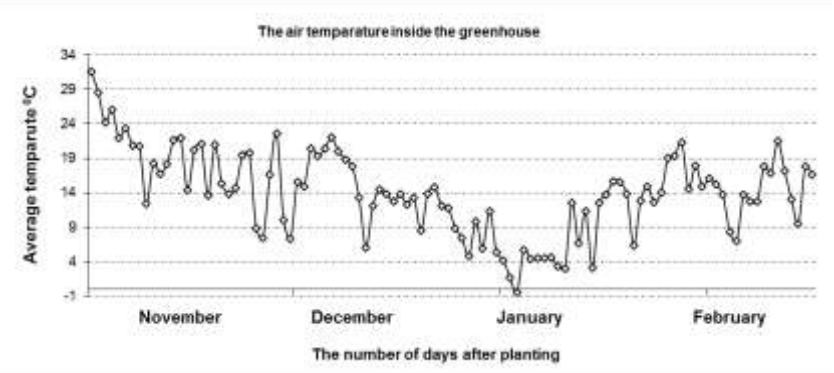

Figure 1. The air temperature inside the greenhouse

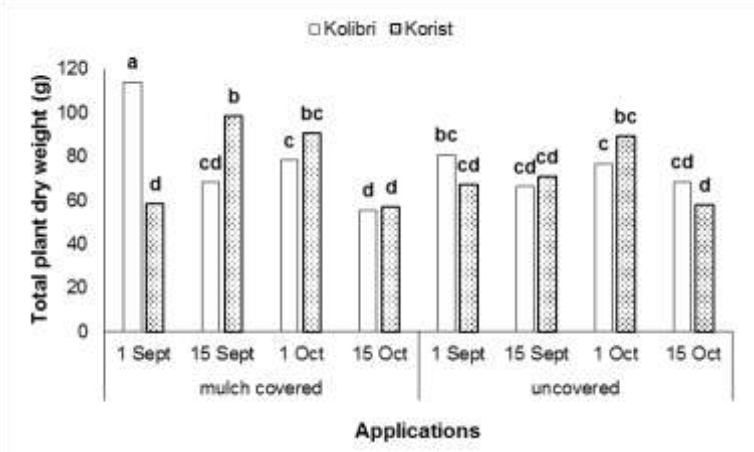

Figure 2. The effects of four different sowing times (I, II, III and IV), two different kohlrabi cultivars (Kolibri F1 and Korist F1) and two mulch applications (mulch covered and uncovered) on total plant dry weight (P<0.05).

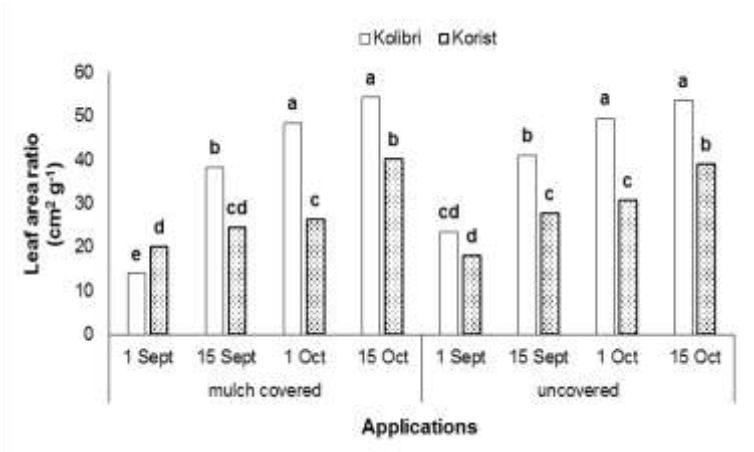

Figure 3. The effects of four different sowing times (I, II, III and IV), two different kohlrabi cultivars (Kolibri F1 and Korist F1) and two mulch applications (mulch covered and uncovered) on leaf area ratios (LAR; $cm^2\ g^{-1}$) (P<0.05).

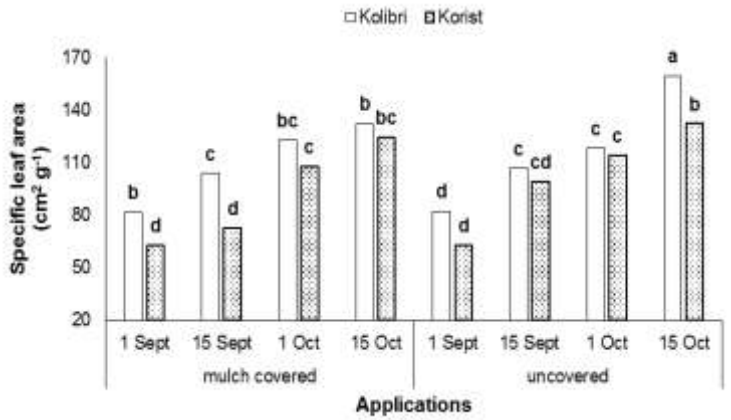

Figure 4. The effects of four different sowing times ((I, II, III and IV), two different kohlrabi cultivars (Kolibri F1 and Korist F1) and two mulch applications (mulch covered and uncovered) on specific leaf area (SLA; cm^2 g^{-1}) (P<0.05).

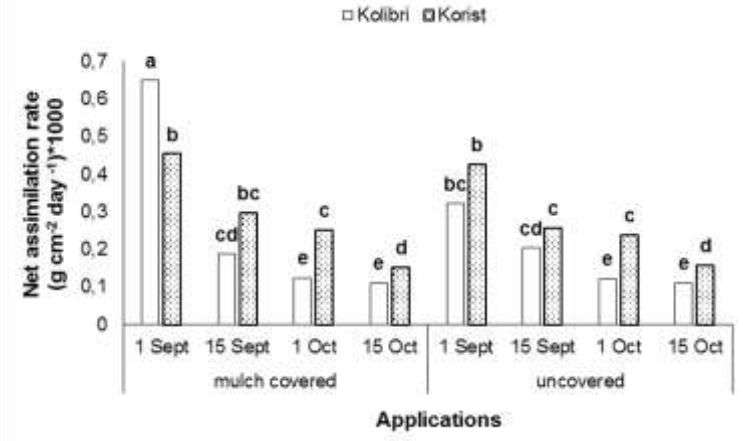

Figure 5. The effects of four different sowing times (I, II, III and IV), two different kohlrabi cultivars (Kolibri F1 and Korist F1) and two mulch applications (mulch covered and uncovered) on net assimilation rate (NAR) (g cm^{-2} day^{-1})*1000 (P<0.05).

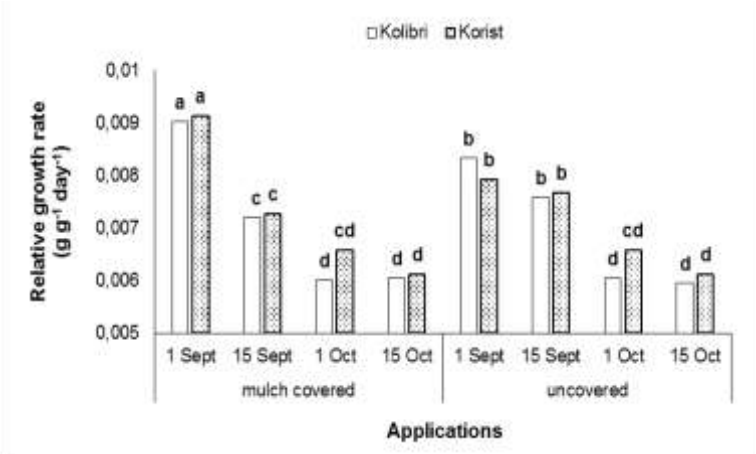

Figure 6. The effects of four different sowing times ((I, II, III and IV), two different kohlrabi cultivars (Kolibri F1 and Korist F1) and two mulch applications (mulch covered and uncovered) on relative growth rate (RGR) (g g^{-2} day^{-1}) (P<0.05).