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EVALUATIVE COMPARISON OF GARLICS PLANTED IN AUTUMN AND IN SPRING

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1. INTRODUCTION AND OBJECTIVES

Garlic is one of the most important plant of the horticultural sector. Its growing dates back for about 5000 years. There are ancient proofs, that garlic was eaten by egyptian slaves during the construction of pyramids.

Garlic has a great importance in human nutrition. Its positive effect on human body is based on thousands years old wisdom, that is confirmed by the modern medical and chemical researches.

The world's garlic production is increasing, while in Hungary there's always less garlic. The Hungarian production has two main growing areas: Makó and its surroundings and Dusnok and its surroundings.

Our aims were:

- Show, that garlic can be grown safely on the area of North-West Hungary, if the rules of growing and pest management are kept.
- Choose from three French ('Arno', 'Thermidrome', 'Sprint') and two Hungarian varieties, which one be produced the highest crop on the above-mentioned area, considering the factors of weather and plant health.

2. MATERIALS AND METHODS

Place of the experiments

This study took place in Hanságliget where the soil type is peat meadow, and in Jánossomorja, where the soil type is alluvial soil with 30-100 cm humus-stratum.

We can group the garlic varieties in two ways: by the time of planting there are winter and spring varieties.

From a morphological view there are softneck varieties (*Allium sativum* convar. *sativum*) the cloves settle down in diffused position. The cloves of

the hardneck garlic (*Allium sativum* convar. *ophioscordon*) settle down in a regular circle around the scape which is often topped with a cluster of small round propagules called bulbils.

In our experiments were involved four winter varieties and a spring variety (1. Table)

1. Table: Properties of examined garlic varieties (MÁRTONFFY ed., 2000), (De GROOT, 2002), (GOMBKÖTŐ & IVÁNCSICS, 2008).

	Makói őszi	**GK Lelexír**	**Sprint**	**Thermidrome**	**Arno**
Type of variety	winter variety	spring variety	winter variety	winter variety	winter/spring variety
Height of foliage (cm)	40-60	30-50	80-90	40-60	50-60
Color of leaves	middle green	light green	light green	middle green	dark green
Clove number of bulbs (piece)	8-10	5-8	6-8	8-10	15-20
Weight of bulbs (g)	50-60	30-50	60-65	50-60	40-50
Color of bulb's skin	grayish white	grayish white	white with purple stripes	white with pink stripes	white
Crop yield (tons/ha)	15-20	10-15	15-20	15-20	15-20
Adventageous properties	good storage, high crop yield, high spicy value	good storage, high spicy value	early ripening, fresh consumption	good storage, high crop yield	excellent storage, lack of plant diseases

The plantings dates were:

Winter varieties:

- 7-10 October, 2006,
- 5-10 October, 2007,
- 29-30 September, 2008,
- 3-5 October, 2009.

'GK Lelexír' ('Makói tavaszi') spring variety:

- 10-12 March, 2007,
- 24-25 February, 2008,
- 12 March, 2009,
- 26 February, 2010.

The planting depth of the winter varieties was 7-8 cm, and the spring varieties 4-6 cm. Line width x stem distance = 30 cm x 8-12 cm.

2. Table. Dates of data recordings (2006-2010)

	2006-2007	**2007-2008**	**2008-2009**	**2009-2010**
Shooting percentage	03-12-2006 22-12-2006 20-01-2007	15-11-2007 18-12-2007 26-01-2008 25-03-2008	27-10-2008 03-12-2008 26-01-2009 15-02-2009 15-03-2009 18-04-2009	
Growing intensity	03-12-2006 22-12-2006 20-01-2007 18-02-2007 27-03-2007 22-04-2007 13-05-2007 03-06-2007	18-12-2007 26-01-2008 20-02-2008 25-03-2008 25-04-2008 22-05-2008	27-10-2008 03-12-2008 12-01-2009 15-02-2009 15-03-2009 18-04-2009 24-05-2009	
Determination of number of leaves	09-04-2007 21-04-2007 13-05-2007 03-06-2007	25-03-2008 25-04-2008 22-05-2008	15-03-2009 18-04-2009 24-05-2009	
Measurement of mass of the bulbs	18-06-2007 18-07-2007	22-06-2008 30-07-2008	20-07-2009	29-06-2010 16-07-2010
Measurement of diameter of the bulbs	18-06-2007 18-07-2007	22-06-2008 30-07-2008	20-07-2009	29-06-2010 16-07-2010
Determination of number of the cloves	18-06-2007 18-07-2007	22-06-2008 30-07-2008	20-07-2009	29-06-2010 16-07-2010

3. Table: Dates of recordings of data of healthy problems on plants

	2007	**2008**	**2009**	**2010**
Stem and bulb nematode (*Ditylenchus dipsaci* Kühn)	05-05-2007	02-05-2008	18-04-2009	12-05-2010
Garlic rots (*Puccinia allii-fragilis* Kleb., *Puccinia allii-populina* Kleb.)	05-05-2007 03-06-2007	02-05-2008 27-05-2008 10-06-2008	18-04-2009 24-05-2009 12-06-2009	12-05-2010 08-06-2010
Garlic carpenterworm (*Dyspessa ulula* Borkhausen)	05-05-2007 15-05-2007	02-05-2008 15-05-2008		
Onion thrips (*Thrips tabaci* Lindemann)	15-05-2007 – 15-07-2007	15-05-2008 – 30-07-2008		
Recording of weeds	02-04-2007 22-05-2007			
Determination of diseases in the storage	15-11-2007 07-12-2007 04-01-2008 31-01-2008 25-02-2008 24-03-2008	22-11-2008 15-12-2008 18-01-2009 05-02-2009 18-03-2009	16-11-2009 16-12-2009 08-01-2010 27-01-2010 12-02-2010 16-03-2010	

Examination of shooting percentage

Every time we counted the number of garlic plants on each signed meter of examined parcels. Returned in other time we counted the plants again, and determined the percentage of shooted plants. The data of three years were ordered in tables, and represented on diagram (2. Table).

Growing intensity of vegetative parts

We measured the foliage of garlic with a ruler or a tape. The measures were done monthly, for three years in four repeats. We counted the growing

intensity by the days between each time of measurement, and the growth of the plants. The data were ordered in tables, and represented on diagram (2. Table)

Number of leaves

We counted the number of leaves of each garlic plant monthly, for three years. The data were ordered in Microsoft Excel tables, and represented on diagram (2. Table).

Examination of healthy problems in garlic

This study used the following methods to determine the degree of damage (3. Table):

- Stem and bulb nematode: individual plant observation in the field
- Garlic rusts: individual plant observation in the field
- Garlic carpenter worm: light trap
- Onion thrips: yellow water bowl, blue water bowl
- Weeds : Balázs – Újvárosi method to estimate the percentage of weed coverage
- Storage diseases: observation of stored garlic bulbs, wet chamber

Measurement of the weight of bulbs

The weight of bulbs were measured after the harvest, after some days of drying. We defined the weight of garlic by a digital scale. Before the measurement the foliage and root of plants were removed. The data were ordered in tables, and represented on diagram.

Measurement of cross diameter of bulbs

After some days of the harvest we measured the cross diameter of garlic bulbs, which is an important measure of value properties. We measured the diameter with a caliper. The data were ordered in tables, and represented on a diagram (2. Table).

Determination of the number of cloves in bulbs

We determined the number of cloves and cross diameter of bulbs at the same time. The data were ordered in tables, and represented on diagram (2. Table).

Examination of nutritive values of garlic varieties

The analisys of garlic's nutritive value were made by an accredited laboratory.

For the analisys of garlic samples a Shimadzu GC-MS + headspace (GC17A + QP 5000 MS + Perkin-Elmer HS-40XL) mass spectrometer was used, adapted the MSZ-21470-92:1998 and MSZ-21470-93:1998 Hungarian standards. The time of the thermostat was 30 minute, and the temperature was 80°C.

Determination the problems during the storage

First we determinated the species of diseases, which damaged the stored garlic. For this process we incubated garlic cloves in wet chamber. Five days later there were sleazy grey mildew-cover of *Botrytis spp*.

The infection of *Botrytis* was determined in percentage. 30 pieces of each varieties were taken each time, and the number of infected bulbs were given in percent.

The data process

Data analysis was completed using a Microsoft Excel spreadsheet. The average values of the gathered results were displayed in a table, and either columns on a bar chart diagram, or in line graphs format. The received values were evaluated by one-way analysis of variance at a $P_{5\%}$ probability level, received values was evaluated by one-way analysis of variance at a $P_{1\%}$ probability level, and multivariate correlation analysis was used (SVÁB, 1973) (SZŰCS ET AL., 2004).

3. RESULTS

Examination of shooting percentage (%)

We got different values in each years. The most fast growing variety is 'Spring'. It has a 95% shooting after the first measurement in the autumn. The 'Makói őszi' variety had a fast shooting in the first two years. This variety reached the 90% of shooted plants. In the first autumn 'Thermidrome' had the less of shooted plants (88%), but in following years it also reached the 100%. 'Arno' starts to grow very slowly, but its shooting percentage reach the 100%.

Determination of growing intensity of vegetative parts

We can experience a fast growing after shooting. In the months of winter was the growing intensity the lowest. The fastest growing intensity was shown in March and April (except the case of 'Arno'). Since the 'GK Lelexír' is a spring variety, it has a short time to grow, so its growing maximum is shown in April too. After made the one-way analysis of variance on level $P_{1\%}$ we can ascertain, that there was significant difference, which can be related to the varieties.

Determination of number of leaves in different times of season

We determined the number of leaves in April, May, and June of each years. The values were similar between the years. The data were represented on diagrams, and a trend line were taken on it. So we can tell, that the multiplication of leaves can be described with a linear function. The spring garlic variety ('GK Lelexír') has the minimum number of leaves at the time of harvest. Between the data of months we got a significant difference by the one-way analysis of variance, which is releated to the varieties.

Infection of stem and bulb nematode

The results suggest that the infection of stem and bulb nematode shows the highest value in the 'Sprint' variety, even though super elite cloves had been

planted. Examination of the data for the following year reveals that in every variety the infection had doubled except in the case of ’Sprint’. For this variety, the infection of stem and bulb nematode was reduced to a minimum. By the case of ’Thermidrome’, ’Makói őszi’ and ’GK Lelexír’ we observed more stem and bulb nematode in later years. The causes are the planting cloves and the weather.

Between the temperature of soil and the number of stem and bulb nematode there was a power connection by the case of ’Makói őszi’, which van be described with a hyperbola.

Infection of garlic rusts

Typical orange coloured uredo spots of *Puccinia allii-fragilis* Kleb., and *Puccinia allii-populina* Kleb were sought on the plants. The following values were noted on different dates. By the varieties ’Makói őszi’ and ’Sprint’ the infection of garlic rusts were the highest in the first summer, and by ’Thermidrome’ in second summer. There wasn’t any infection by ’Arno’. By ’Makói őszi’ we could prove a tight function connection between the infection of rusts and precipitation. There was a significant difference in the infection by one-way analysis of varience on level $P_{5\%}$, which can be related to the years.

Diseases during storage (*Botrytis* spp., *Fusarium* spp., *Penicillium* spp., *Alternaria* spp.)

Results suggest that winter varieties are less suitable for storage than spring varieties. ’Arno’ is an exception as it displayed the specific symptoms at the same time as the ’GK Lelexír’ spring variety. Even in the latest observation, it was found that the healthiest bulbs were from ’Arno’. Unfortunately in the case of the Hungarian ’Makói őszi’ symptoms were presented very early.

Between the data in each months, there is an exponential growth, which fits tight (R^2= 0,9588) in the function.

Weed-composition of the examined plots

The first inspection revealed that in winter garlic varieties only perennial weeds that have the T2 life form were found, of all the weed types, these only covered a relatively small surface of the field. In the second inspection, May 22, 2007 numerous other weeds had also appeared. From this data weed maps were created.

The slow warming of the soil is the cause of late weed infestation, because of the thermal pocket caused by the lowland soil and by the Hanság-mainchannel that flows at the end of plots. For the plots supporting spring varieties; it was the central part that was more exposed to sunshine which had a large cover of weeds, because this optimal enviroment provided perfect conditions for the weed species seeds to germinate.

From the results displayed in it appears that the most significant problem was ragweed (*Ambrosia elatior),* and yellow foxtail *(Setaria glauca)* which appeared in very high number.

Measurement of weight of bulbs

'Sprint' produced the largest bulbs. The Hungarian 'Makói őszi' and the French 'Thermidrome' showed similar values by the first harvest, but later there was a decrease of 'Thermidrome'. The smallest values were measured by the case of 'GK Lelexír', because it's a spring variety, even so this variety showed the minimal standard deviation (σ = 4,0661 – 7,837).

Measurement of diameter of bulbs

We can tell, that there was a little difference between each years' data of diameter. All of garlic varieties examined by us meets the standards. The most homogeneous varieties were 'GK Lelexír' (σ = 2,6931-7,3384), and 'Thermidrome' (σ = 5,4799-7,231).

Number of cloves in the bulbs

There was little differences between the years by each varieties (4. Table), so we can say, that the number of cloves is specific to each varieties, and there isn't any connection with weather, or other environmental factors.

4. Table: Number of cloves in garlic bulbs (pieces)

	Sprint	**Makói őszi**	**Thermidrome**	**Arno**	**GK Lelexír**
2007	8,8	8,3	8,5	15,4	8,4
2008	8,82	8,54	8	14,36	8,18
2009	9	8,7	8,3	15	8,2
2010	8,82	8,4	8,18	15,32	8,3

Concentration of diallyl-sulfone

The concentration of dially-sulfone in the samples of garlic varieties was determined by the data of internal standard, loss on drying, and weight of matherials. The sample with highest concentration of diallyl-sulfone was equaled to 100 unit. The results are the following (Figure 1):

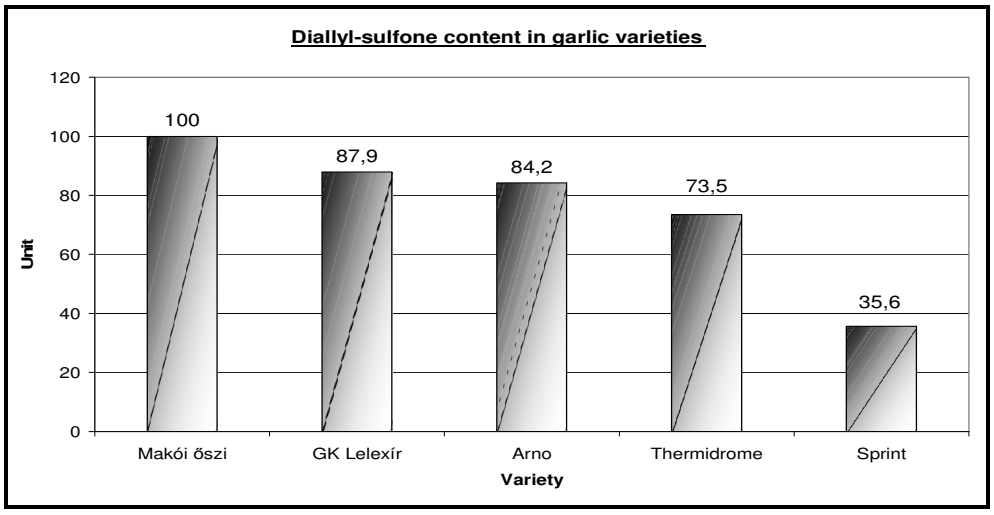

Figure 1: Dially-sulfone content int he examined garlic varieties (unit)

Concentration of microelements and minerals in garlic varieties

We have made the analysis of variance on each mineral and microelements. By all cases (except by the case of natrium) we can relate that after the accomplishment of the analysis of variance the calculated F value was higher than the F critical value, because of these there was a significant difference between the examined varieties at $P_{1\%}$ probability level.

The highest content of zinc was measured by the 'GK Lelexír', but we can appoint, that both Hungarian varieties have very low iron concentration. 'Sprint' has high concentration of zinc, phosphorus, manganese, copper, potassium, and its content of iron has an average value.

There was found a strict positive correlation between boron - calcium, magnesium - potassium, manganese – potassium, manganese – magnesium and zinc – phosphorus. We found a medium positive correlation between phosphorus – copper. At the same time there was a strict negative correlation between copper – iron, and a medium negative correlation was found between copper – calcium and manganese – calcium.

4. CONCLUSIONS AND SUGGESTIONS

All examined garlic varieties shooted safety in Northwest Hungary. Even in the worst case, there was a 88% shooting of plants. After the slow growth in winter we could observe a maximum level of growing intensity in March and April. Only the 'Arno' variety doesn't show this tendency.

In June all varieties reached the maximum number of leaves, than they started to dry. 'GK Lelexír' had the less leaves.

We followed up the problems of plants health. The most important pest is the stem and bulb nematode, by which especially the 'Sprint' variety was

damaged. We could observe garlic rusts too. The highest infection level was by ‘Sprint’ and ‘Makói őszi’ varieties.

By the case of ‘Arno’ we didn’t found any infection of stem and bulb nematode nor rust.

The variety ‘Sprint’ produced the largest bulbs. The smallest bulbs were measured by ‘GK Lelexír’, but also its values meets the standards. The diallyl-sulfone is a very important compound, which has an anticarcinogen effect. The highest level of diallyl-sulfon was in ‘Makói őszi’.

The highest content of zinc was measured by the ’GK Lelexír’, but we can appoint, that both Hungarian varieties have very low iron concentration. ’Sprint’ has high concentration of zinc, phosphorus, manganese, copper, potassium, and its content of iron has an average value.

5. NEW SCIENTIFIC RESULTS

1. We convinced with our examinations, the shooting of garlic in Northwest-Hungary was minimum 88% by all varieties.
2. We determined, that the multiplication of leaves in time follows a linear way.
3. The stem and bulb nematode is one of the most important pest of garlic. We convinced, that there is a significant difference between the damage of stem and bulb nematode in different years. We found, that by the case of ’Makói őszi’ there is a tight power connection between the temperature of soil and infection of nematode (R^2 = 0,9091).
4. The rust diseases appear before the harvest. We observed, that there is a significant difference between the infection in each years, which is related to the precipitation and temperature.

5. The cross diameter of garlic is descripted in standards. All of examined garlic varieties (’GK Lelexír’, ’Makói őszi’, ’Sprint’, ’Arno’,’Thermidrome’) meets with the values of standards.
6. Diallyl-sulfone is an importnant sulfur-containing compounds of garlic. We determined, that the Hungarian ’Makói őszi’ has the highest concentration of this compound.
7. By the examination of mineral content of garlic there was found a strict positive correlation between boron - calcium, magnesium - potassium, manganese – potassium, manganese – magnesium and zinc – phosphorus. We found a medium positive correlation between phosphorus – copper.
8. It’s important to store garlic as long as possible. From the examined garlic varieties ’Arno’ and ’GK lelexír’ van be stored the longest. So it’s convinced, that a variety planted in autumn can show an excellent shelf life.

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