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Research Concerning the Bolting of Chinese Cabbage (*Brassica campestris* var. *pekinensis* (Lour.) Olson) in Early Crops in Polyethylene Tunnels

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Abstract. The research regarding the bolting of Chinese cabbage (*Brassica campestris* var. *pekinensis* (Lour.) Olson) in early cultures was realized from January to May in 2010. The culture took place in the polyethylene tunnel of Vegetable Growing Department from University of Agricultural Sciences and Veterinary Medicine from Cluj - Napoca.

The main purpose of this experiment was to establish the optimum cultivation technology to obtain a high production of best quality.

The results showed that to avoid Chinese cabbage bolting, before head formation, the culture setting up must be done in the first decade of April with 36 days old seedlings.

Keywords: headed Chinese cabbage, planting period, seedling age

1 Introduction

In parallel with the evolution of white headed cabbage in Europe, some cabbage species have developed in China to, which are part of the same family, *Brassicaceae*, together with the well known and used cabbage in the western kitchens [1]. One of this species is the Chinese cabbage (*Brassica campestris* var. *pekinensis* (Lour, Olson), which looks rather like a well developed lettuce, not at all like the typical rounded or flat western cabbage. It forms an elongated head, with very tight, overlapping leaves, sometimes a looser head. Heads vary enormously in shape and size and when well grown can weight from 1.4 kg to 4.5 kg [2].

The importance of this vegetable is the fact that all plant parts are edible, the leaves, the flowering stems and flowers can be all consumed raw or prepared in different ways.

Although, currently, in our country is a least known and used vegetable, Chinese cabbage is very appreciated in Western Europe, where the cultivated surface and the consumption are growing very fast. In this area is being used increasingly as a substitute for the white headed cabbage in recipes like stuffed cabbage, or is prepared using Chinese methods and recipes [2].

2 Materials and methods

In the spring of 2010 it was realized a Chinese cabbage culture in the polyethylene tunnel of Vegetable Growing Department which belongs to the Faculty of Horticulture from University of Agricultural Sciences and Veterinary Medicine from Cluj-Napoca. The experiment took place from January to May.

It was used a single variety, Granat, commercialized by Agrosel Company, which belongs to *pekinensis* variety of *Brassica campestris* species, and has a short vegetation period (70 days). The heads are compact and cylindrical; leaves are not overlapping on the top of the head. Green leaves belonging to this variety have a fine aroma, a taste which recalls the aroma of chicory, turnips and cabbages. They can be eaten raw, in salads or cooked.

Harvesting occurs at 2-3 months after seeding.

This experiment was bifactorial, involving the next factors:

- Factor A: planting period, with 4 graduations:
  - a1: - first decade of March

- a2: - second decade of March
- a3: - third decade of March
- a4: - first decade of April

- Factor B: seedlings age at planting, with 2 graduations:
  - b1: - age I: 48 days
  - b2: - age II: 38 days

By this factors combination were obtained 8 variants, which are presented in table 1.

Table 1: Experimental variants

Variant	Planting period	Seedling age
1.	First decade of March (March I)	Age I
2.	First decade of March (March I)	Age II
3.	Second decade of March (March II)	Age I
4.	Second decade of March (March II)	Age II
5.	Third decade of March (March III)	Age I
6.	Third decade of March (March III)	Age II
7.	First decade of April (April I)	Age I
8.	First decade of April (April I)	Age II

Each variant was placed into three repetitions; the surface of one experimental plot being 3 m^2.

The seeds were individually sown in pots. The plants arisen in 3-4 days and after approximately 15 days they were transplanted in pots of 10 × 10 cm. The sowing started on 18^{th} January, and was done from 10 to 10 days, to obtain seedlings of different ages for the mentioned four planting periods. Last sowing was made in 27^{th} February. The seedlings were planted when they reached 38, respectively 48 days.

The culture was established in the polyethylene tunnel, where was used a plant density of 4.66 plants/m^2, the distance between rows was 75 cm, while between plants was used a distance of 30 cm.

During the vegetation period were made observations regarding plants growth and development (this were made at planting, at one month after planting and at harvest) and regarding the production. In the same time was registered the number of bolted plants, which had a negative role by decreasing the yield.

3 Results and discussions

Flowering marks the transition from vegetative to reproductive stages in seed plants. It is, thus, a crucial event in the life cycle of plants, particularly from the standpoint of seed production.

There is no definite sequence or relationship between head formation and floral bud differentiation, floral buds could differentiate after or before the onset of heading. If floral buds differentiate prior to heading, loose and unmarketable heads are formed [3].

Chinese cabbage varieties differ considerably regarding the predisposition of bolting, especially if they are exposed to low temperatures while seedling is produced.

The causes of bolting are complex and interrelated. To a grater or lesser extent the following factors all play a part:

- Low temperatures in the early stages of growth: this is thought to be the single most important factor. Low temperatures, both when seeds are germinating and in the early stages of growth, lead to the initiation of flowers instead of leaves. Put very simply, the young plants need to "clock up" a certain number of heat units to prevent bolting. Once this has been done they can be subjected to lower temperatures without damage.
- Day length: with many species there is a grater tendency to bolt in long days (more than 12-14 hours of daylight), than in shorter days. In the northern hemisphere the bolting risk is therefore highest in spring and early summer.
- Genetic factors: some types of Brassica are inherently less prone to bolting than others. This makes it possible to select and develop varieties with improved bolting resistance.
- Stress: various kinds of "stress" such as the "shock" of transplanting, lack of water, overwatering or sudden temperature changes can exacerbate the tendency to bolt [2].

To avoid the negative effects of low temperatures, of stress, which is caused by the impropriate soil humidity, and to provide optimum growth and development conditions, measurements regarding: air temperature, soil temperature, relative air humidity and light intensity were made during the seedlings production. These were made three times a week, in morning hours.

Fig. 1 shows the oscillation of air and soil temperature. It can be observed that the air temperature varied between 16-28°C, most temperatures exceeding 20°C. Regarding soil temperature, the lowest temperature recorded was 13.1°C, while the highest 18.2°C.

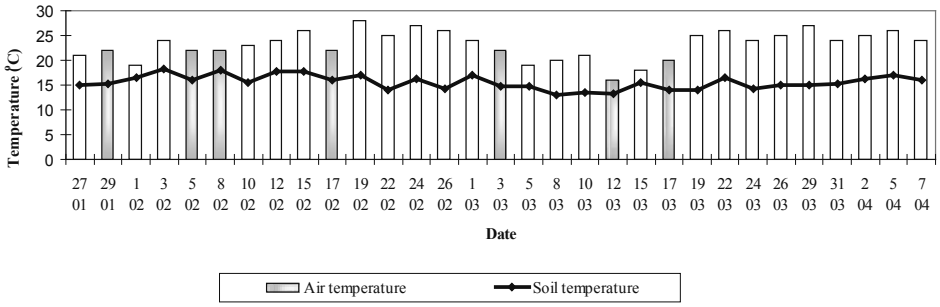

Figure 1: The evolution of air and soil temperatures during seedlings production

Relative air humidity varied between 38 and 69%, this factor was easily controllable by watering when low values were recorded (Fig. 2).

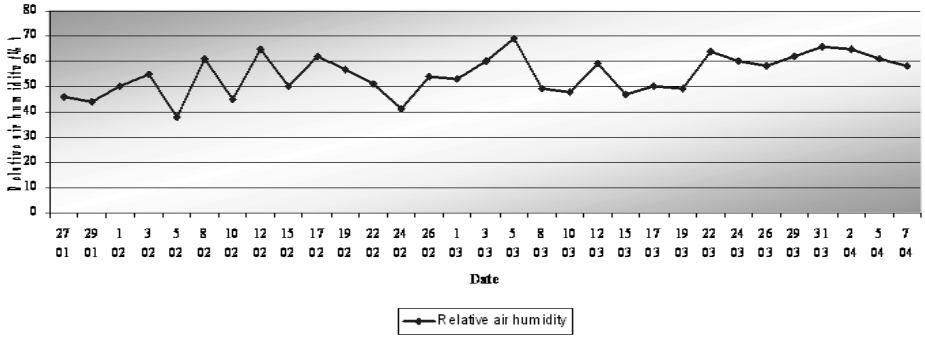

Figure 2: Evolution of relative air humidity during seedling production

For measuring the light intensity, the device was placed always at plants level, so the recorded data could correctly reflect the specific culture conditions.

The lowest light intensity was registered in 15th March (1540 lx), while the highest in 22nd February (23521 lx) (Fig. 3).

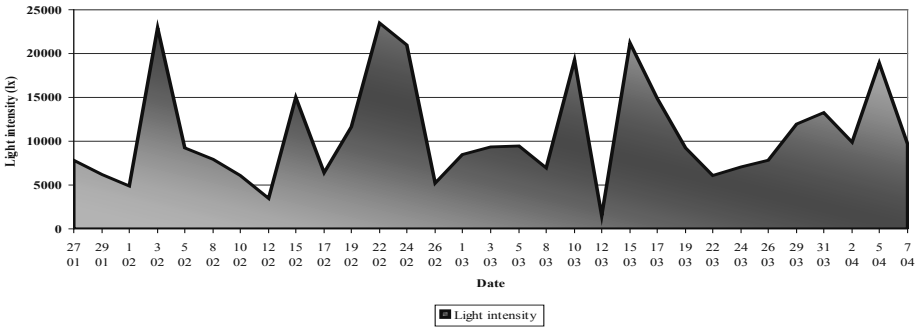

Figure 3: Evolution of light intensity during seedlings production

Observations regarding the number of bolted plants were made at one month after planting, and at harvest.

It was observed that, although at the beginning, bolted plants appeared only sporadically, with the passage of time at more and more plants appeared the flowering stems.

Table 2 presents the number of bolted plants at one month after planting. By analyzing the data from the table, it can be observed that from the 224 plants which were taken in culture, 20 plants emitted flower stems already at one month after planting, which represents 8.93% from the total plants. Most bolted plants (5 plants) were from variant 5, while from variant 8 no plant showed signs of flowering, the bolting percentage being 0.

Table 2: The bolted plants situation at one month after planting

Variant	**Total plants\ variant**	**Number of bolted plants**	**% of bolted plants**
1	28	4	14.29
2	28	4	14.29
3	28	1	3.57
4	28	1	3.57
5	28	5	17.86
6	28	3	10.71
7	28	2	7.14
8	28	0	0.00
Total	224	20	8.93

During harvest a series of observations were made regarding number of

bolted plants, plants which emitted flower stems before head formation. The registered data are presented in table 3. Most bolted plants at harvest were numbered at variant 1, where more than half (53.57%) of the plants have flourished prematurely; from the total of 28 plants of this variant 15 turned to flower too early. The lowest bolting percentage (10.71%) was registered at last variant, where only 3 plants bolted.

Table 3: Bolted plants situation at harvest

Variant	**Total plants\ variant**	**Number of bolted plants**	**% of bolted plants**
1	28	15	53.57
2	28	14	50.00
3	28	11	39.29
4	28	9	32.14
5	28	14	50.00
6	28	8	28.57
7	28	11	39.29
8	28	2	10.71
Total	224	85	37.95

In Fig. 4., which presents the evolution of average bolting percentage, it can be seen that the lowest increasing (10.71%) which regards this character was recorded at variant 8, while the highest increasing (39.28%) at variant 1.

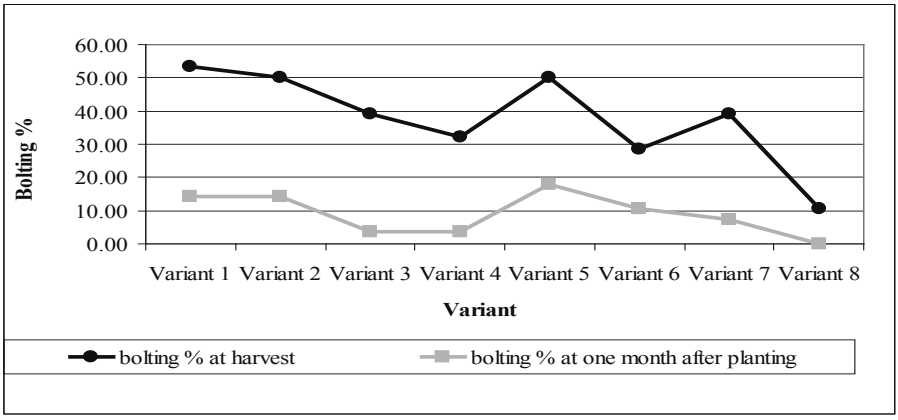

Figure 4: Evolution of average bolting percent

The Chinese cabbage bolting had negative effects regarding the obtained total yield. In Fig. 5. is presented a graphical representation of the achieved production in comparison with the theoretical production, which could be obtained if the plants wouldn't bolted. The theoretical production was calculated with the aid of average weight of the plants.

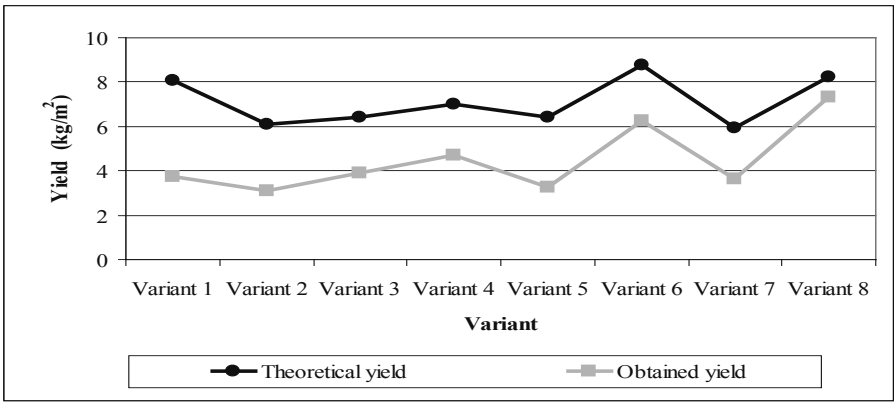

Figure 5: Comparison between obtained and theoretical production

It can be observed that at most variants the obtained production is half of the theoretical one.

Also in this figure can be observed that the highest yield was realized in case of last variant, the obtained production being 7.31 kg/m^2, while the lowest in case of variant 2, with a production of only 3.11 kg/m^2.

4 Conclusions

The lowest percent of bolted plants was registered at the variant which was established in first decade of April, with 38 days old seedlings.

The highest percent of bolted plants was recorded in case of first variant, which was established in the second decade of March, with seedlings of 48 days.

By decreasing the number of bolted plants, the obtained production could increase much, even to a double value.