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PhD THESIS SUMMARY

RESEARCH CONCERNING SOME AGROTECHNOLOGICAL PARTICULARITIES OF CHINESE CABBAGE (BRASSICA CAMPESTRIS SIN. BRASSICA RAPA) IN ORDER TO PROMOTE IT IN CULTURE

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From Chinese cabbage it can be consumed the leaves from the rosette or the cabbage head, depending on the variety, these can be used raw in salads or prepared as different culinary dishes (POȘTA, 2008). In Western Europe, Chinese cabbage is used more and more like the substitute of white headed cabbage in recipes like stuffed cabbage, or it is prepared according to traditional Chinese methods.

Compared to white headed cabbage, Chinese cabbage contains more water, less calories and carbohydrates, but a higher quantity of vitamins and mineral salts, being thus a good source of beta-caroten, glucosinolates, antioxidants and bioavailable calcium. It has been proved, that the consumption of Chinese cabbage can have anticancer effects, contributing in the prevention of lung, pancreas, ovary and kidneys cancer, but in the same time at the improvement of the survival rate after breast cancer (NECHUTA et al., 2012, www.passeportsante.net).

China is considered the country of Chinese cabbage origin, where this vegetable is cultivated for a very long time (KING and JIPING, 1996). In our country it is known from interwar period, and an organized action of introduction in culture took place in 1957-1960, but without a generalization in production (DUMITRESCU și colab., 1998). Currently it is cultivated in some areas from Transylvania, Muntenia and Dobrogea (BUTNARIU și colab., 1992; GIORGOTA și NICOLAE, 2010).

While *B. campestris* subsp. *chinensis* (non-heading Chinese cabbage) was cultivated only in South China, for at least 1600 years, the headed Chinese cabbage (*B. campestris* subsp. *pekinensis*), which then had only a loose head, was recorded for the first time in tenth century, and a clear apparition of those with a well developed head was registered in 1330 (OPEŇA et al., 1988).

By its nature, Chinese cabbage it is a biannual plant. Its short vegetation period allows the obtaining of harvestable part and seeds in the same year, being thus characterized, in this case, as an annual plant (CEAUȘESCU, 1980; STAN și MUNTEAN, 2001, APAHIDEAN și APAHIDEAN, 2005).
Chinese cabbage present a very expanded, fibrous, finely branched root system (OPEŇA et al., 1988), which is less developed than at other cabbages (CEAUŞESCU, 1980; BUTNARIU şi colab., 1992; STAN şi MUNTEAN, 2001). The stem is short and thicker than at the white headed cabbage, from it are growing the leaves (CEAUŞESCU, 1980; BERAR, 1998; GIORGOTA şi NICOLAE, 2010). Leaves are usually sessile, at variety pekinensis and petiolated at variety chinensis, they presents a very well developed main rib (which have 4-6 cm at base), which is flat, has a white color and has a large, soft, green, irregularly toothed foliar limb, which develops at the base of the stem. The outer leaves are usually more or less pubescent (CHOUX and FOURRY, 1994). The inflorescence is simple, elongated, undetermined. Wears dipedicelated flowers, which are disposed in terminal raceme on the main and second order branches. The flowers are perfect hermaphrodite. The fruit of Chinese cabbage is a smooth silique, often called pod (OPEŇA et al., 1988).

This species grows well at relatively low temperatures, needs an average temperature of 22°C for seedlings production and leaves formation in rosette, 16-20°C for head formation (OPEŇA et al., 1988), while in the last phases of vegetation they need 10-13°C (BURT et al., 2006; SHATTUCK and SHelp, 2004).

Most of the species from Brassicaceae family are considered long day plants. If the day length is longer, the plants will bolt more amply and earlier. The minimum period for photoinduction at Chinese cabbage is only nine days.

The need for water grows with the growing stages of the species, being highest during head formation. The drought from this period doesn’t allow the head formation, while the excessive humidity and poor soil aeration are in the detriment of the head growing and formation, plants perish if water stagnation last more than three days (OPEŇA et al., 1988).

Chinese cabbage thrives best in fertile soils, which are clay loam, because it needs a considerable amount of nutrients which will sustain a rapid growth in a relatively short period.

The cultivation of this species is limited in multiple areas from the World because of its easy bolting property. The causes of this are complex and interrelated. To a greater or lesser extent the following factors all play a part: low temperatures in early stages of growth, in the first few weeks after seeding, day length, genetic factors and stress factors.
such as the shock of transplanting, lack of water, overwatering or sudden temperature changes can exacerbate the tendency to bolt. Main measures to avoid bolting are: raising plants in protected environment, sowing seeds in some form of module, to enable a good root system to develop and minimize the shock when the plants are transplanted into their permanent position, germinate seeds at high temperatures, of at least 18-20°C or at ideally temperatures of 22°C, if unexpectedly low temperatures are forecast, the cultures must be given extra protection, choosing bolting resistant varieties, delaying the seeding if low temperatures persist, choosing varieties which are low temperature resistant for spring cultures and high temperature resistant varieties for summer crops, watering frequently to avoid soil drying and providing a constant growth for the plants (LARKCOM, 2008).

The main purpose of the researches for this PhD thesis is the detailed study of some agrotechnological particularities of Chinese cabbage culture (Brassica campestris var. pekinensis and Brassica campestris var. chinensis) in order to promote it in culture. Besides improving the culture technology of this vegetable was aimed the obtaining of a high quality and quantity yield at a wide rage of varieties and hybrids.

The objectives which helped the achievement of the proposed purpose are:

- The study of the two varieties of Chinese cabbage: var. pekinensis, respectively var. chinensis, from agro-technologically and agro-biologically point of view;
- Determination of optimal seedling age and ideally planting period of the crops, in order to obtain high quality and quantity yields;
- Establishment of an appropriate planting density with positive effects upon the yield increasing per unit area;
- Establishment of an optimal culture technology suitable for Transylvanian Tableland specific conditions;
- The introduction in culture of some new Chinese cabbage varieties and hybrids, as well as following their evolution throughout the vegetative period;
- Establishment of optimal culture cycles for this species in order to could be cultivated all year round and to produce superior yields, both in protected areas and in open fields;
- The promotion of this vegetable species both among consumers and producers, well being known the close relationship between supply and demand;
• The study of the pedoclimatic and microclimatic conditions, which are achieved in the protected areas, to provide optimal grooving and development conditions for the plants.

To achieve the attended purpose and objectives, during the three experimental years, respectively in the period 2010-2012, several experiences took place, all of them being performed in vigorous experimental technique conditions, all being carried out in three repetitions. At variety *pekinesis* were used five cultivars: variety Granat, and hybrids Nepa, Michihli, Kingdom 80 and Vitimo, of which the first three form cylindrical and elongated heads, while the last two, more compact heads which have barrel shape. At variety *chinensis* were studied five hybrids All season, Canton long, Dwarf choy sum, Dwarf green petiole şi Colour&Crunch. Because in our country there can not be found seeds of Chinese cabbage, in special seeds from *chinensis* variety, beside the seeds from Granat variety and hybrids Nepa and Vitimo, seeds were bought from abroad.

During the vegetative period were made observations and determinations: thereby at planting were registered data regarding plants height, rosette diameter, number of leaves and seedlings weight, at one month after planting at variety *pekinesis*, respectively at three weeks after planting at variety *chinensis*, were effectuated observations regarding plants height, rosette diameter and number of leaves, while at harvest was measured the plants height, rosette diameter, number of leaves and their weight, and at variety *pekinesis* were recorded data about the cabbage heads (height, diameter, weight and number of leaves).

Besides these data, at one month, respectively at three weeks after planting, but also at harvest, was registered the number of bolted plants, whit which was determined the bolting percentage.

The yield was established by weighting, on experimental plots, by variants and repetitions, the harvest being done when the majority of the cabbage heads or rosettes have had reached the typical size of the cultivar. The yield obtained on the experimental plots, was calculated as yield on hectares by reporting the two surfaces. Data obtained were registered and statistically interpreted by method of the analysis of variance, and with method of multiple comparison (the Duncan test), as well as by establishment of correlations between different analyzed characteristics.
The influence of planting period and seedlings age upon the growth, development and yield of Chinese cabbage (year 2010)

Bifactorial experiences were established (the factors being the planting period (planting being done from ten to ten days) and seedlings age (the difference between the two categories being ten days)) both in polyethylene tunnels and open field, in spring and in autumn to.

- at the extra-early culture from the polyethylene tunnel, the planting started in the first decade of March, and ended in the first decade of April, when seedling had 48, respectively 38 days;
- in the late culture from polyethylene tunnel the three planting periods corresponded with the three decades of October, seedlings having 34, respectively 24 days;
- at the early culture from open field planting started in the second decade of April and continued still the second decade of May, the seedlings having an age of 46, respectively 36 days;
- at the late culture from open field the first variants were established in the second decade of September, the last ones in the first decade of October, with seedling of 33 and 23 days old.

- In the extra-early culture from the polyethylene tunnel, the highest yield of 65.80 t/ha, was obtained by using younger seedlings, of 38 days, compared to those of 48 days, planting being done in the third decade of April.
- In autumn culture from polyethylene tunnel, the yields have decreased significantly, the earlier establishment (at the beginning of October or even earlier) and the utilization of 34 days old seedlings, compared to the 24 days old ones, bringing higher productions.
- Due to unfavorably climatic conditions from the open field, in the early culture, the average bolting percentage had a value of 76.88%, the highest yield (43.32 t/ha) being obtained at the variant which was established in the third decade of April with younger seedlings of 34 days.
- Like in case of the autumn culture effectuated in polyethylene tunnel, higher yields in open field were registered at the variants which were established earlier
(in the middle of September) with older seedlings (which had more than 30 days), without any bolted plants.

- Highest yield, taking into consideration the influence of the interaction seedlings age and planting period, was registered in the extra-early culture from polyethylene tunnel, when younger seedlings were used.
- In spring, higher yields were recorded in the polyethylene tunnel, while in autumn those from open field were superior.

*The influence of the cultivar and planting density upon the growth, development and yield of Chinese cabbage (year 2011)*

To determinate the optimal cultivar and planting density, bifactorial experiences were established in the same places and times like in the first year of research. The factors, in this case, were represented by cultivar (variety Granat and hybrid Vitimo) and planting density (66,667 plants/ha, 80,000 plants/ha and 100,000 plants/ha).

- In the extra-early culture from polyethylene tunnel, higher yields were registered at variety Granat compared to hybrid Vitimo, and at a density of 100 thousand plants/ha compared to the other used densities, yields growing with the increasing of plants number from the unit area.
- Unlike the early culture from polyethylene tunnel, in the late one, higher yields were registered at the lowest planting density, 66.67 thousand plants/ha at the same Granat variety.
- In the early cultures from open field, significantly higher yields were reported at hybrid Vitimo, the lowest density (66.67 thousand plants/ha) having a positive influence upon this factor.
- In open field culture from autumn, the highest yield (72.00 t/ha) was registered at hybrid Vitimo, at the density of 66.67 thousand plants/ha. Overall, however, planting Granat variety at a low density has brought increases in yields.
- The highest yield (86.42 t/ha) was observed at Granat variety, which was cultivated in spring in polyethylene tunnel, being followed by Vitimo hybrid (77.76 t/ha) in the same crop.
Like in first year of research, higher yields were obtained in the protected areas in spring, while in autumn in open field.

From the point of view of bolting, hybrid Vitimo had a better behavior compared to Granat variety.

The study of some cultivars of Chinese cabbage (year 2011)

The collection of varieties and hybrids at variety pekinensis was organized as a monofactorial experience, the factor being represented by the cultivar, in total five cultivars being used. The crops were established in the same periods and places like the previous ones, with the specification that in the spring, in the open field, were carried out two cultures, at a distance of 10 days between them.

The highest yield from the extra-early culture from polyethylene tunnel was registered at hybrid Kingdom 80 (110.4 t/ha) followed by Granat variety (88.13 t/ha), while in the autumn culture Granat variety obtained a significantly higher yield compared to the other cultivars.

In both open field spring cultures maximal yields (63.15 t/ha, respectively 87.47 t/ha) were reported at hybrid Vitimo, while in autumn hybrid Nepa have revealed (with an average yield of 67.21 t/ha).

Overall, higher yields were registered in protected crops in spring, while in autumn in open field. From the hybrid point of view, Vitimo stands out with the higher average yield (65.62 t/ha), and also with the lowest bolting percentage.

At chinensis variety, where the culture was established in the same way like at the other variety, the experimental factor was represented by the five hybrids presented above.

Hybrid All season had the highest yield in the extra-early crop from polyethylene tunnel (29.14 t/ha), while hybrid Canton long, with a production of 35.35 t/ha came out in the autumn culture from the same place.

In the first culture and the autumn culture from open field, hybrid Colour&Crunch registered high yields compared to the other hybrids (with 21.06 t/ha, respectively 16.82 t/ha), in the second culture effectuated in spring the maximum yield of 26.76 t/ha being observed at hybrid Canton long.
Taking into consideration the influence of cultivar and the place and time of the culture, as well as the interaction of these factors, the highest yield was registered at hybrid Canton long, the highest production from the point of view of the culture place and time, being reported in autumn in the polyethylene tunnel culture. The highest yield overall was registered at Canton long hybrid, in autumn in polyethylene tunnel.

Unlike the other variety, higher yields were observed in protected area in autumn, while in open field in spring.

From bolting point of view, best behavior was noted at All season hybrid, which presented the lowest number of bolted plants, on the opposite side being situated Colour&Crunch hybrid.

The influence of cultivar, planting period and planting density upon the growth, development and yield of Chinese cabbage (year 2012)

In the last year of research were established polifactorial experiences, both the factors and its graduations were founded by taking into consideration the results of the first two experimental years. Thereby the three factors were: the cultivar (Granat variety and hybrid Vitimo), the planting density (100,000 plants/ha and 80,000 plants/ha) and the planting density (third decade of March and first decade of April for extra-early culture from polyethylene tunnel and the second and third decade of April, for the early culture from open field).

Yield increasing, in the extra-early culture from polyethylene tunnel, were obtained by use of Granat variety compared to Vitimo hybrid, the density of 100 thousand plants/ha compared to the density of 80 thousand plants/ha, with planting in the third decade of March, against of planting in the first decade of the next month.

In the early crop from open field all the plants from Granat variety bolted, while regarding Vitimo hybrid, higher yields were obtained at a density of 100 thousand plants/ha compared to the density of 80 thousand plants/ha, when planting was effectuated in the third decade of April compared to the second decade of the same month.

Overall, significant differences were registered not only between the two cultivars, but also between the two culture places.
During the experiments some *determinations* were effectuated regarding the dry matter content, acidity and vitamin C content.

- The average *dry matter* content had a value of 4.40% at variety *pekinensis* and 4.46% at variety *chinensis*, higher values being registered at variety Granat and hybrid Canton long.

- The average *acidity* was 0.118% at both varieties, maximum values being recorded at hybrids Vitimo, respectively Colour&Crunch.

- Regarding the content of this vegetable in *vitamin C*, this had an average value of 44.00% at variety *pekinensis* and of 62.67% at variety *chinensis*, the higher contents being registered at hybrids: Vitimo and Colour&Crunch.

After analyzing the obtained results several *recommendations* were formulated, which are presented as follows:

- The optimal moment of extra-early culture establishment in polyethylene tunnels, with Granat variety, is the third decade of April, while for obtaining high yields, the autumn cultures have to be established as early as possible (at the beginning of October, or even earlier).

- Granat variety is not recommended for open field cultures, especially in spring, because it is prone to bolt, but it can be cultivated in autumn, both in open field and in protected area.

- Hybrid Vitimo presents a high resistance against bolting, which recommends it for cultures in Transylvanian Tableland areas.

- In polyethylene tunnel, in spring, it is recommended the use of higher planting densities (100 thousand plants/ha), while in autumn lower densities (80 thousand plants/ha).

- In open field, the lower planting densities can assure yield increases, both in spring and in autumn.

- Hybrid Vitimo is recommended for cultures in protected areas and in open field to, this cultivar being preferred by consumers because of its compact head.
- The cultivars from *pekinensis* variety which are recommended for protected area are hybrid Kingdom 80, respectively Granat variety, and for open field cultures hybrids Vitimo (for early crops) and Nepa (for autumn cultures).
- At variety *chinensis* are recommended hybrids All season, Canton long and Colour&Crunch, the last one being perfect for open field cultures.
- Hybrid Vitimo (from *pekinensis* variety), respectively hybrid Colour&Crunch (from *chinensis* variety) presented the highest values from nutritional point of view, being recommended for cultures.
- Although sometimes the yields are higher when this species is cultivated in open field, it is recommended its cultivation in protected areas for a better quality of the plants.
- It is strongly recommended the cultivation of Chinese cabbage, not only by the amateur gardeners, but also by the leading producers, not only because of the multiple qualities of this species, but also because with the increasing of the Chinese population from our country the demand for this vegetable will increase to.