Research Paper Agriculture

Studies Regarding Non-Heading Chinese Cabbage (*Brassica Campestris* Var. Chinensis (L.) Hanelt.) Cultivation in Transylvanian Tableland Specific Conditions

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ABSTRACT

In Romania non-heading Chinese cabbage it's almost unknown, and it is cultivated only by amateur gardeners. The main purpose of the research was the study of this species behaviour in Transylvania, so that an appropriate culture technology could be concluded. Because of the high price of this vegetable, it can be considered a profitable culture.
The research took place in the experimental field of the Vegetable Growing Department from the UASVM Cluj-Napoca. To achieve the objectives of this research, a polyfactorial experiment was organized, which involved the following factors: the hybrid, the harvesting date and the place and time of the culture. Besides the observations and measurements concerning the growth, development and yield, some laboratory analysis regarding its nutritional value were made.
The main conclusion of this research is that non-heading Chinese cabbage can be easily cultivated in our region, not only in open field, but in polyethylene tunnels too, and it is recommended to be introduced as a new vegetable in culture, mostly because of the high request for this kind of vegetable.

Keywords : non-heading Chinese cabbage, open filed culture, polyethylene tunnel culture, vitamin C content

Introduction

Pak choy, sometimes also called non-heading Chinese cabbage, is known to have been cultivated in China since the fifth century AD and is older than Chinese cabbage. Originally a South Chinese vegetable, it has now spread throughout Asia, to Europe and America and, with recently developed varieties, to tropical countries such as Nigeria and Brazil (Larcom, 2008).

The typical pak choy has smooth, shiny rounded leaves, pale or dark green in colour (Larcom, 2003). It is a quick maturing plant which can be harvested 30 to 45 days after planting (Palada & Crossman, 1999; Dixon, 2007). At pak choy the harvest could occur at three weeks after sowing, but highest yields are obtained at 30-45 days after planting (Toxopeus & Baas, 2004). Both, the dark green leaves and the white ribs can be eaten, it can be stir fried or steamed, or added to soups or other dishes (Myers, Fu & Valenzuela, 1998).

Unfortunately in our country it is almost unknown, and it is cultivated only by amateur gardeners, so in this area doesn't exists an appropriate culture technology for this species. This research has as main purpose the study of this vegetable behaviour in Transylvanian area, so that this culture technology could be concluded. Beside this, the qualitative and quantitative yield, and also the influence of the experimental factors upon the production were measured and studied. Within the research a comparison was made between protected and open field cultures, knowing the fact that pedoclimatic conditions in Transylvania are less favourable to obtain early productions for vegetables than in the South and West of Romania, where vegetable growers obtain earlier productions with 2-3 weeks (Apahidean, Apahidean, Maniutiu, Ganea, Paven & Ficior, 2004).

Even if, in this moment, in Romania, the demand for pak choy is not very high, after some authors this demand, could increase with the increasing of Asian population percentage and the increasing of leafy vegetable consumption, which is the way to a healthier nutrition (Ciofu, Stan, Popescu, Chilom, Apahidean, Horgos, Berar, Lauer & Atanasiu, 2007).

Materials and methods

The experiment took place in the spring of 2011, in the experimental field which belongs to the Vegetable Growing Department from the UASVM Cluj-Napoca. To analyze the influence of the cultivation place and the harvesting date upon the yield of the used pak choy hybrids, a polyfactorial experiment was organized, which involved the following factors and their graduations:

- Factor A: the hybrid, with five graduations: All season, Canton long, Dwarf green petiole, Dwarf choy sum, Colour&Crunch hybrids;
- Factor B: harvesting date, with three graduations: three harvest times, with one week between each of them;
- Factor C: place and period of culture, with three graduations: polyethylene tunnel, early and late open field culture.

By these factors combination were obtained 45 experimental variants, each of them being placed into three repetitions, the surface of an experimental plot being 5 m^2.

Sowing was made in 25th of February for the polyethylene tunnel culture and the early culture from the open field and in 22nd of March for the late culture from the open field, while the establishment of protected culture was effectuated in 30th of March, in open field the seedlings were planted in 4th and 15th of April. Planting was made at a density of 142857 plants/

ha, the distances between rows being 0.3 m, between plants on rows 0.20 m.

No fertilizations or phytosanitary treatments were made during the vegetation period. The harvest was realized three times, between two harvests being one week difference. In the polyethylene tunnel the harvest started in 19th of April, while in the open field in 10th of May for the earlier culture and in 12th May for the late culture. During growing season observations were made regarding plants growth, development and yield. The results were analysed using correlations between different factors and the analysis of variance (Ardelean, 1986).

Results and discussions

Between the plants weight and their height, diameter and number of leaves there exists a very significant positive correlation. The values of correlation coefficient are 0.81, 0.71 and 0.74, all being higher than the values of P(1%)=0.36 (fig. 1). In his studies, Feltrim, Rezende & Cecílio Filho (2004) also found a significant interaction between plants height and the number of leaves. An other very significant positive correlation was found between plants weight and the obtained yield (fig. 2), where, the correlation coefficient ha a value of 0.99.

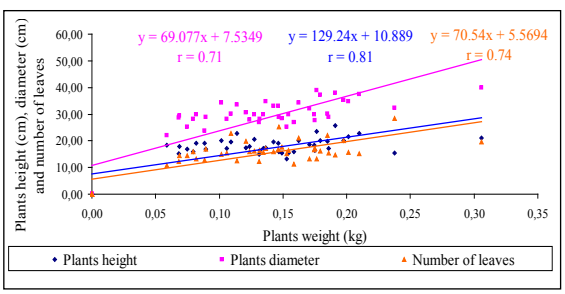

Fig. 1. Correlation between plants weight and their height, diameter and the number of leaves (P5%=0.28, P1%=0.36)

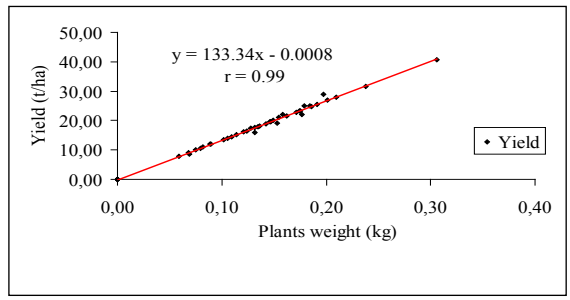

Fig. 2. Correlation between plants weight and the yield (P5%=0.28, P1%=0.36)

The yield of this vegetable varies very much according to the hybrid, cultivation system, place of culture etc. According to Elzebroek and Wind (2008), the average yield ranges between 10-30 t/ha, after Roecklein and Leung (1987) between 23-45 t/ha. Siomos (1999) observed in his experiment, that the yields varied between 4.02 and 12.66 kg/m^2, best cultivation period being March-May.

High yields were obtained when the sowing was made in November (Islam & Choudhury, 2002) or in January (Tanongsak, Sanghai & Khunsupa, 1994). Studies made by Leonardi (2001) showed that high yields were obtained either after a shorter vegetative period and lower density or after a longer vegetative period, but a high density, although at longer growing periods the risk of bolting is increasing constantly (Zutic, Borošić, Toth, Novak & Dobričević, 2007). By delay sowing from January to February, Yu, Chen, Xu and Yu (2001) obtained an increased yield, while by delaying it from February to March, the yield has decreased.

The highest yield, 22.96 t/ha, was reached by All season hybrid. This was higher with almost 35% than the average yield, the difference being very significant positive. At Colour&Crunch hybrid was observed also a very significant positive difference, the yield being higher than the average one with 2.11 t/ha. On the other side, with the lowest yield, only 10.71 t/ha, and a very significant negative difference stands out Dwarf choy sum hybrid. The second harvest date brings the highest yield (19.51 t/ha) which is higher with almost 15% than the control variant, the difference being very significant positive.

Table 1. The unilateral influence of hybrid upon the yield

Variant Hybrid	Yield (t/ha)	Yield (%)	Diff. (t/ha)	Signif.
All season	22.96	134.8	5.93	***
Canton long	15.94	93.6	-1.09	o
Dwarf green petiole	16.41	96.3	-0.63	-
Dwarf choy sum	10.71	62.9	-6.32	ooo
Colour&Crunch	19.14	112.4	2.11	***
Average	17.03	100.0	0.00	Ct.

LSD (p 5%)=0.76, LSD (p1%)=1.10, LSD (p 0.1%)=1.65;

Table 2. The unilateral influence of harvest date upon the yield

Variant Harvest date	Yield (t/ha)	Yield (%)	Diff. (t/ha)	Signif.
First harvest	14.84	87.2	-2.19	ooo
Second harvest	19.51	114.5	2.47	***
Third harvest	16.75	98.3	-0.29	-
Average	17.03	100.0	0,00	Ct.

LSD (p 5%)=0.70, LSD (p1%)=0.96, LSD (p 0.1%)=1.30;

The analyse of the unilateral influence of the place and period of culture (Tab. 3) reveals the fact that pak choy can be cultivated with good results in open field, but in a late culture. A total yield of 19.98 t/ha was obtained in this experiment, which was higher with 17.3% than the average production, the difference being very significant positive. Due to the earli-

er plantation and unfavourable conditions, the earlier culture gave a much lower yield.

In the polyethylene tunnel the yields varied between 9.07 and 22.80 t/ha. The highest yields were recorded at All season (22.80 t/ha) and Dwarf choy sum hybrids (21.11 t/ha), the differences of 7.33 and 5.64 t/ha being very significant positives from the control variant.

Table 3. The unilateral influence of place and period of culture upon the yield

Variant Place and period of culture	Yield (t/ha)	Yield (%)	Diff. (t/ha)	Signif.
Polyethylene culture	17.46	102.5	0.43	-
Early open field	13.66	80.2	-3.38	ooo
Late open field	19.98	117.3	2.95	***
Average	17.03	100.0	0,00	Ct.

LSD (p 5%)=0.81, LSD (p1%)=1.08, LSD (p 0.1%)=1.41;

Table 4. The combined influence of the three factors upon the yield

Hybrid	Harvesting date[1]	Cultivation place[2]	Yield (t/ha)	Yield (%)	Diff. (t/ha)	Signif.	Harvesting date[1]	Cultivation place[2]	Yield (t/ha)	Yield (%)	Diff. (t/ha)	Signif.	Harvesting date[1]	Cultivation place[2]	Yield (t/ha)	Yield (%)	Diff. (t/ha)	Signif.
All season	H1	PR	22.80	147.4	7.33	***	H2	PR	23.87	118.1	3.66	*	H3	PR	40.76	244.0	24.05	***
Canton long	H1	PR	15.20	98.2	-0.27	-	H2	PR	23.53	116.4	3.32	*	H3	PR	0.00			
Dwarf green petiole	H1	PR	9.07	58.6	-6.40	ooo	H2	PR	17.96	88.9	-2.25	-	H3	PR	23.24	139.1	6.54	***
Dwarf choy sum	H1	PR	21.11	136.4	5.64	***	H2	PR	17.51	86.7	-2.70	-	H3	PR	0.00			
Colour&Crunch	H1	PR	9.18	59.3	-6.29	ooo	H2	PR	18.18	89.9	-2.03	-	H3	PR	19.51	116.8	2.81	-
Average			15.47	100.0	0,00	Ct.	-	-	20.21	100.0	0.00	Ct.	-	-	16.70	100.0	0,00	Ct.
All season	H1	EOF	10.62	103.6	0.37	-	H2	EOF	21.67	131.0	5.12	**	H3	EOF	24.62	173.8	10.45	***
Canton long	H1	EOF	10.91	106.4	0.65	-	H2	EOF	13.56	81.9	-2.99	o	H3	EOF	0.00			
Dwarf green petiole	H1	EOF	10.00	97.5	-0.26	-	H2	EOF	16.11	97.4	-0.43	-	H3	EOF	14.54	102.6	0.37	-
Dwarf choy sum	H1	EOF	7.82	76.3	-2.43	-	H2	EOF	11.82	71.4	-4.72	oo	H3	EOF	0.00			
Colour&Crunch	H1	EOF	11.93	116.3	1.68	-	H2	EOF	19.56	118.2	3.02	*	H3	EOF	31.69	223.6	17.52	***
Average			10.26	100.0	0,00	Ct.	-	-	16.54	100.0	0,00	Ct.	-	-	14.17	100.0	0,00	Ct.
All season	H1	LOF	17.02	90.5	-1.78	-	H2	LOF	18.98	87.2	-2.79	-	H3	LOF	26.33	136.0	6.96	***
Canton long	H1	LOF	25.47	135.4	6.66	***	H2	LOF	27.98	128.5	6.21	***	H3	LOF	26.84	138.6	7.47	***
Dwarf green petiole	H1	LOF	19.87	105.6	1.06	-	H2	LOF	16.51	75.9	-5.25	oo	H3	LOF	20.36	105.1	0.99	-
Dwarf choy sum	H1	LOF	17.56	93.4	-1.25	-	H2	LOF	20.58	94.5	-1.19	-	H3	LOF	0.00			
Colour&Crunch	H1	LOF	14.11	75.0	-4.69	oo	H2	LOF	24.78	113.9	3.02	*	H3	LOF	23.31	120.3	3.94	*
Average			18.81	100.0	0,00	Ct.	-	-	21.76	100.0	0,00	Ct.	-	-	19.37	100.0	0,00	Ct.

LSD (p 5%)=2.97, LSD (p1%)=3.99, LSD (p 0.1%)=5.28;

[1] - harvesting date: H1 – first harvest, H2 – second harvest, H3 – third harvest

[2] - cultivation place: PR – protected culture, EOF – early open field culture, LOF – late open field culture

The highest yield in the late open field, and in the same time from the first harvest, was 25.47 t/ha, obtained at Canton long hybrid, higher with 35.4% than the average yield for this culture (18.81 t/ha). The second harvest was made at one week after the first one. Until this period the pak choy plants had time to develop more leaves and to gain more weight so the yields should have been higher than in the first harvest period. The results showed that the yield varied between 11.82 t/ha (at Dwarf choy sum hybrid in early open field) and 27.98 t/ha (at Canton long hybrid, in the late culture). The average yields showed that the lowest yield (16.54 t/ha) was realised in the open field, in early culture, while the highest one also in open field, but in the later culture (27.98 t/ha).

In the early open field culture the highest production (21.67 t/ha) was observed at All season hybrid, this being higher with 18.1% than the average yield, the difference of 5.12 t/ha being distinct significant positive. The results reveals that in the later culture the highest yield (27.98 t/ha) was obtained at Canton long hybrid, followed by Colour&Crunch, with 24.78 t/ha.

Until the third harvesting period all remaining plants bolted or couldn't be harvested from different reasons, at the Canton long and Dwarf choy sum hybrids in the protected and early open field culture, while in the later culture the harvest was impossible only at the variants planted with Dwarf choy sum. There were some hybrids which in this period had developed more and more, so the yield has reached a value of 40.76 t/ha, at All season hybrid, in protected culture. In open filed this hybrid had also high yields: in the early crop 24.62 t/ha, while in the late one 26.33 t/ha. All these yields compared to the average yield had differences which are very significant positives.

This harvesting period reveals Dwarf green petiole hybrid, so in protected culture the yield was 23.24 t/ha, while in late open filed crop it was 20.36 t/ha. It can be concluded that this hybrid needs a longer period to develop, and it is more bolting resistant than the other hybrids.

In early open filed culture high yield was obtain at Colour&Crunch hybrid, 31.69 t/ha which was the highest one recorded at this hybrid.

The obtained yields are situated between the limits specified

by Toxopeus and Baas (2004). They said that the production ranges between 10-30 t/ha, while the marketable production decreases with a few percent.

According to some experiments effectuated by Artemyeva and Solovyova (2003), pak choy contains between 3.56 and 145.2 mg/100 g fm vitamin C, while in the Specialty and minor crops handbook (1998) appears an average content of 45 mg/100 fm. The USDA National Nutrient Database (2013) gives a quantity of 45 mg/100 g fresh Chinese cabbage and 26 mg/100 g cooked pak choy.

The vitamin C content was measured in two different points: in petiole and in leaf blade. As expected higher content of this vitamin was observed in the leaf blade: from 38.78 mg/100 g f.m. (Dwarf choy sum hybrid) to 84.48 mg/100 g f.m. (Colour&Crunch hybrid), while in the petiole from 10.56 mg/100 g f.m. (Canton long) to 24.64 mg/100 g f.m. (Colour&Crunch hybrid). The average ascorbic acid content was 41.72 mg/100 g f.m.

There are some ways to obtain higher ascorbic acid content in Pak choy. Experiments showed that intercropping Chinese cabbage with noncrucifer plants increased the plants nutrient content (Cai, You, Ryall, Li & Wang, 2011).

Conclusions

Pak choy, or non-heading Chinese cabbage can be easily cultivated, with good results, in Romania taking into consideration the present results. Even if the protected culture gives an earliest production, in this experience the open filed culture gave the highest yield, the hybrid with best results being All season. The combined influence of the three factors showed that the highest yield (more than 40 t/ha) was obtained at the last harvest of All season hybrid, cultivated in polyethylene tunnel.

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