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# FORECROP GREEN MANURES AND THE SIZE AND QUALITY OF WHITE CABBAGE YIELD

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## ABSTRACT

The studies examined the effect of forecrop green manures in the form of oats and field pea on the yielding and selected elements of the nutritious value of white cabbage, 'Amager' cultivar. The cabbage was cultivated directly after organic fertilization. The plants meant for green manure were sown in early spring, and they were ploughed in on the first days of June. The whole biomass or only the aftercrop residue was introduced into the soil. The effect of the forecrop green manure was compared to the effect of farmyard manure in the dose of 25 $t \cdot ha^{-1}$. The greatest yields of cabbage were obtained after farmyard manure. Field pea was characterized by a very similar yield-forming effect to that of farmyard manure. The greatest amount of dry matter was found in the cabbage cultivated after oats, while the greatest quantity of sugars and vitamin C – after field pea. The amount of the organic matter introduced into the soil had no significant effect on the yielding or the content of dry matter, reduction sugars, sugars totally or vitamin C in white cabbage.

**Key words:** organic fertilization, green manure, forecrop, white cabbage, yield, quality

## INTRODUCTION

White cabbage occupies a foremost place among the vegetables produced in Poland. Its economic importance results from the considerable nutritious value, high yields from a unit of area and the possibilities of differentiated utilization throughout the year [13]. It is perfect for storing, processing and pickling. This is

associated with the quantity of dry matter and sugars in it. The content of these elements is conditioned by the differences among the cultivars but also by the proper agricultural practices.

Mineral fertilization, especially of nitrogen, affects the chemical composition of vegetables. Some authors [1, 14, 17] argue that increasing pre-sowing and top-dressing doses of nitrogen fertilizers cause a decrease of the dry matter, sugars and vitamin C in cabbage. Besides, inadequate application of organic fertilizers is frequently the cause of decreased yields and their quantity. Organic fertilization is the basic agricultural practice that makes it possible to obtain high and good quality yields of vegetables as well as to keep up the proper culture of the soil. Organic fertilizers are a factor that compensates both the deficit and the excess of nutritious elements in the soil, which can take place with too high mineral fertilization.

Most vegetables, including white cabbage, have very high soil requirements. They mainly concern the physical properties of the soil, which to a large extent are conditioned by the quantity of humus in it. The processes of mineralization cause constant decrease of its quantity in the soil. In order to prevent it and keep the soil in the proper culture it is necessary to introduce the organic matter into it [2]. Green manures are an easily accessible source of the organic matter [3, 7, 8]. Their effect is to a large extent related to the mass of the ploughed in plants, rate of their mineralization as well as the climatic conditions – mainly to the amount and distribution of atmospheric falls [4, 5]. The advantages of using green manures include considerable reduction of production costs [11] and saturation of the rotations with catch crops, which is so important in ecological agriculture [16]. Forecrops are one of the less studied forms of green manure.

## METHODS

A field experiment was performed at the Experimental Station of Podlasie University in Zawady near Siedlce in the years 1999-2000. The studies were conducted on brown soil proper formed from light clayey sands, with the content of humus 1.7% and pH in $H_2O$ of 5.6. The experiment was set in a scheme of random blocks in three repetitions. The area of one plot with organic fertilization was 35 $m^2$.

The factors studied in the experiments included the following:

1. The form of ploughing in the forecrops:
- ploughed in all biomass of forecrop plants,
- ploughed in crop residue of forecrops (the roots along with a 5-cm-deep layers of stubble).
2. The form of organic fertilization:
- control without organic fertilization,
- farmyard manure in the dose 25 t ha-1,
- oats – the sowing norm of 240 kg ha-1,
- field pea – the sowing norm of 160 kg ha-1.

The seeds meant for ploughing in were sown between 2 and 6 April, and the ploughing in took place between 30 May and 4 June. Immediately before ploughing in oats and field pea, the overground parts were mowed and collected, leaving a 5-cm-high stubble. Besides, samples of forecrop plants were collected from the area of 1$m^2$ in order to establish the mass of the overground part of plants and the crop residue as well as the quantity of nitrogen introduced into the soil. At the same time, farmyard manure fertilization was applied on proper plots.

Late cabbage of 'Amager' cv. was cultivated from seedlings produced on a nursery bed. Then it was planted onto a permanent place about 10 June at the spacing of 60 cm × 60 cm. Mineral fertilization was applied under cabbage in the quantity of 600 kg NPK $ha^{-1}$ in the proportion of 2:2:3. The cabbage was picked up between 15 and 20 October. During the harvest, the total yield and the commercial yield were determined according to the binding norms. Samples of the plant material were also taken in order to establish the content of dry matter in the leaves by means of a dryer-weight method, the content of reduction sugars and total sugars by means of Luff-Schoorl's method, and the content of vitamin C by means of Pijanowski's method. The results were statistically analyzed using variance analysis. The significance of differences between the mean values was evaluated by means of Tukey's test.

**Table 1. Monthly air temperatures and sums of rainfall (1999-2001) in relation to long-term averages**

| Month | Temperature (°C) | | | | Sums of rainfall, mm | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean for months | | | Many years' averages | Monthly | | | Many years' means |
| | 1999 | 2000 | 2001 | | 1999 | 2000 | 2001 | |
| April | 9.9 | 12.9 | 8.7 | 7.1 | 87.3 | 47.5 | 69.8 | 33.0 |
| May | 12.9 | 16.4 | 15.5 | 12.6 | 26.4 | 24.6 | 28.8 | 50.0 |
| June | 20.5 | 19.5 | 17.1 | 16.6 | 121.7 | 17.0 | 36.0 | 75.0 |
| July | 21.8 | 19.0 | 23.8 | 17.7 | 21.9 | 155.9 | 55.4 | 80.1 |
| August | 18.7 | 19.1 | 20.6 | 18.9 | 77.4 | 43.6 | 24.0 | 67.9 |
| September | 16.1 | 11.8 | 12.1 | 2.7 | 27.8 | 61.1 | 108.0 | 47.3 |
| October | 8.0 | 11.7 | 10.6 | 7.6 | 11.6 | 3.2 | 28.0 | 40.0 |
| | | | | Σ | 374.1 | 352.9 | 350.0 | 393.3 |

Table 1 presents the course of atmospheric conditions during the vegetation of white cabbage. The highest rainfalls fell on the year 1999, and the lowest on 2001. It could have influenced the yields of cabbage obtained in particular years of the experiment.

## RESULTS AND DISCUSSION

The amount of the ploughed in biomass of forecrops and nitrogen introduced into the soil with it is presented in table 2. Oats introduced 40.8 t ha$^{-1}$ organic matter into the soil, while field pea introduced 16.0 t ha$^{-1}$. Oats ploughed in as the whole and in the form of crop residue introduced by 35.8 t ha$^{-1}$ and 9.2 t ha$^{-1}$ more nitrogen, respectively than field pea. Farmyard manure in the dose of 25 t ha$^{-1}$ introduced 113.3 kg N per 1 hectare.

**Table 2. The quantity of the ploughed biomass and nitrogen introduced with it – mean figures from 1999-2001**

| Kind of forecrop | Fresh matter t·ha$^{-1}$ | | Dry matter t·ha$^{-1}$ | | N kg·ha$^{-1}$ | |
|---|---|---|---|---|---|---|
| | All biomass | Crop residue | All biomass | Crop residue | All biomass | Crop residue |
| Oat | 40.80 | 16.34 | 6.23 | 2.82 | 95.06 | 21.77 |
| Field pea | 16.02 | 3.96 | 2.03 | 0.56 | 59.23 | 12.54 |
| Manure | | | | | | |
| Manure | 25.0 | | - | | 113.3 | |

Analyzing the yields of white cabbage obtained in particular studied years it was found out that in 2001 they were significantly lower than in 1999 (tab. 3). It could have been connected with worse climatic conditions in 2001 (tab. 1).

**Table 3. Yielding of white cabbage cv. 'Amager' grown in the first year after organic fertilization (t ha$^{-1}$)**

| Kind of fertilization | Total yield | | | | Commercial yield | | | |
|---|---|---|---|---|---|---|---|---|
| | 1999 | 2000 | 2001 | Mean | 1999 | 2000 | 2001 | Mean |
| Control | 63.69 | 51.90 | 50.84 | 55.48 | 61.48 | 50.47 | 48.42 | 53.46 |
| Farmyard manure | 70.71 | 71.35 | 63.80 | 68.62 | 69.60 | 69.51 | 61.03 | 66.72 |
| Oat | 57.47 | 57.77 | 54.41 | 56.55 | 49.02 | 55.70 | 53.60 | 52.77 |
| Field pea | 66.41 | 70.82 | 58.34 | 65.19 | 60.71 | 69.26 | 57.26 | 62.41 |
| Mean | 64.57 | 62.96 | 56.85 | 61.46 | 60.20 | 61.24 | 55.08 | 58.84 |
| LSD ($p$ = 0.05) for the kind of fertilization | | | | 9.22 | | | | 10.17 |
| for years | 7.24 | | | | ns. | | | |

The highest yields (total and commercial) of cabbage were obtained in the cultivation after farmyard manure (68.62 t ha$^{-1}$ and 66.72 t ha$^{-1}$, respectively). They were considerably higher than the yields of cabbage grown after ploughing in oats and on the control without organic fertilization. Field pea was characterized by a similar yield-forming effect as farmyard manure in the dose of 25 t ha$^{-1}$. Cabbage yields (total – 65.19 t ha$^{-1}$ and commercial – 62.41 t ha$^{-1}$) were only slightly lower than those obtained on farmyard manure. Definitely lower yields of cabbage were obtained in the cultivation after oats. The results confirm the thesis about a more positive

effect of green manure from papilionaceous plants, which are a valuable source of nitrogen, than from non-papilionaceous plants on the yielding of vegetables [3, 9]. Despite a greater quantity of nitrogen introduced into the soil with oats as compared with field pea, cabbage yields were distinctly higher on the objects fertilized with field pea. In order to form an almost two-fold yield of biomass, oats required more water and nutritious elements. It dried out the soil more and this could have brought about considerably lower cabbage yields. Similar results were obtained Borna in his experiments [3, 4]. He claims that the decrease of the yield of vegetables grown on the ploughed in green manure is directly proportional to the amount of fresh and dry matter formed by the plants meant for ploughing in.

**Table 4. Influence of ploughed down biomass amount on the yielding of white cabbage cv. 'Amager' (t ha$^{-1}$)**

| Form of plough down | Total yield | | | | Commercial yield | | | |
|---|---|---|---|---|---|---|---|---|
| | 1999 | 2000 | 2001 | Mean | 1999 | 2000 | 2001 | Mean |
| Whole plant biomass | 57.15 | 70.53 | 55.97 | 61.22 | 52.17 | 69.63 | 54.22 | 58.67 |
| Post-harvest residue | 71.98 | 55.39 | 57.73 | 61.70 | 68.23 | 52.84 | 55.94 | 59.00 |
| LSD ($p$ = 0.05) for ploughing | | | | ns. | | | | ns. |

**Table 5. Influence of fertilizations with forecrops and with farmyard manure on the content of dry matter, of monosaccharides, of saccharides in total and vitamin C in white cabbage cv. 'Amager' (average from 1999-2001)**

| Ways of fertilization | Dry biomass (%) | Monosaccharides (%) | Total sugars (%) | Vitamin C (mg %) |
|---|---|---|---|---|
| Control | 8.34 | 3.13 | 7.05 | 17.15 |
| Farmyard manure | 8.17 | 3.19 | 7.00 | 17.34 |
| Oat | 8.66 | 3.11 | 7.24 | 16.56 |
| Field pea | 8.34 | 3.22 | 7.44 | 17.36 |
| Mean | 8.38 | 3.16 | 7.18 | 17.10 |
| LSD ($p$ = 0.05) | ns. | ns. | ns. | ns. |

**Table 6. Influence of form of ploughing down of forecrop on the content of dry matter, of monosaccharides, of saccharides in total and vitamin C in white cabbage cv. 'Amager' (average from 1999-2001)**

| Form of plough down | Dry biomass (%) | Monosaccharides (%) | Total sugars (%) | Vitamin C (mg %) |
|---|---|---|---|---|
| All biomass | 8.22 | 3.12 | 7.19 | 17.06 |
| Crop residue | 8.54 | 3.21 | 7.17 | 17.15 |
| LSD ($p$ = 0.05) | ns. | ns. | ns. | ns. |

No significant differences were observed analyzing the effect of the quantity of biomass introduced into the soil on the yielding of cabbage (tab. 4). A slightly increasing tendency was only observed of the yield of cabbage grown on crop residue. It points to high productive effects of crop residue. Borna [3] states that forecrops ploughed in as the whole form an isolation layer, which makes capillary ascension from the deeper layers of the soil more difficult. The results of variance analysis did not find any significant differences in the content of the studied parameters of the nutritious value of white cabbage under the influence of various forms of organic fertilization (tab. 5). The greatest amount of dry matter was, however, observed in the cabbage cultivated on the plots where oats was ploughed in (8.66%), while the smallest in the cabbage cultivated on farmyard manure (8.17%). Cabbage grown after ploughing in the green manure of field pea was the richest in reduction sugars and sugars totally (3.22% and 7.44%, respectively). Cultivation after field pea had a positive effect on the accumulation of vitamin C in cabbage leaves (17.36%). Its quantity was similar to the cabbage grown after farmyard manure. Ploughed in oats caused a slight decrease of the content of L-ascorbic acid in the edible parts of cabbage. Romanov [15] draws attention to the positive effect of green manure on the content of dry matter, sugars and vitamin C in vegetables. Earlier studies by Jabłońska-Ceglarek et al. [12] also confirm the positive effect of organic fertilizers, especially green manure, on the nutritious value of vegetables. The amount of the

ploughed in plant mass had no greater effect on the content of dry matter, sugars or vitamins C in cabbage (tab. 6). However, a tendency was observed of increasing dry matter, reduction sugars and vitamin C in the leaves of cabbage cultivated after ploughing in only the crop residue. A higher content of dry matter in white cabbage cultivated after ploughing in the whole biomass of green manure was obtained by Franczuk et al. [10]. On the other hand, in a potato experiment Byczkowski and Seidler [6] obtained the fruit of higher nutritious value in the cultivation on the ploughed in crop residue.

## CONCLUSIONS

1. The highest total and commercial yields of white cabbage were obtained in the cultivation on manure and after ploughing in field pea.
2. The quantity of biomass introduced into the soil had no significant effect on the yielding on cabbage grown in the first year after organic fertilization.
3. Field pea, as green manure, was characterized by a better yield-forming effect than oats.
4. The highest content of dry matter was observed in the cabbage cultivated after ploughing in oats.
5. The highest quantity of reduction sugars, sugars totally as well as vitamin C was accumulated by cabbage grown after ploughing in field pea.
6. The quantity of the ploughed in organic matter had no significant effect on the nutritious value of white cabbage.

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