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PRODUCTION EFFECTS OF GREEN FERTILIZERS IN THE FORM OF FORECROPS IN VEGETABLE CULTIVATION

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ABSTRACT

The studies examined production effects of green fertilizers (oats, field pea, spring vetch, and mixtures of these plants) ploughed over in spring in the cultivation of white cabbage, onion and red beet. In the first year after ploughing in, the forecrops of field pea and a mixture of field pea with vetch and a mixture of oat with field pea and with vetch were more productive green fertilizers in cabbage cultivation. On the other hand, in the cultivation of onion the forecrops of field pea and its mixtures with oat and vetch were the most productive fertilizers in the second year after ploughing in. In the third year after ploughing in, all green fertilizers were characterized by better consecutive yield-forming effect as compared to manure in the dose of 25 t·ha^{-1}.

Key words: green fertilizers, manure, organic fertilization, cabbage, onion, red beet, yields

INTRODUCTION

Fertilization is the basic factor affecting the size and quality of the yield. If used in the mineral form, they frequently cause its decrease and worse biological value. Pro-ecological tendencies in horticulture gave rise to a greater importance of organic fertilizers, which introduce biologically active substances into the soil and thus stimulate the plant growth [15, 17]. Organic fertilizers also have phytosanitary effect, affecting the intensity of pesticide biodegradation and reducing the heavy metals taken from the soil by plants [13, 17].

In pro-ecological cultivation of vegetables, traditionally applied manure is often replaced by green fertilizers. The majority of papers discuss the use of green fertilizers in the form of summer or winter forecrops [8, 10-12], while less attention is devoted to the forecrops that are sown and ploughed over in spring. The effect of green fertilizers is related to the quantity of biomass that was ploughed in, the rate of its mineralization [5], the content of nutrients and the demand of the cultivated vegetables for those elements.

METHODS

The studies examined the production effects of green fertilizers that were sown and ploughed over in spring in a three-year-crop rotation of vegetables: cabbage, onion, red beet. The following plants were grown for the green fertilizer:

– oat (the norm of the sown seeds 240 kg·ha^{-1}),
– field pea (160 kg·ha^{-1}),
– spring vetch (140 kg·ha^{-1}),
– oat (100 kg·ha^{-1}),
– spring vetch (100 kg·ha^{-1}) + oat (80 kg·ha^{-1}),
– spring vetch (50 kg·ha^{-1}) + field pea (70 kg·ha^{-1}),
– spring vetch (50 kg·ha^{-1}) + field pea (70 kg·ha^{-1}) + oat (100 kg·ha^{-1}).

Two forms of forecrops utilization as green fertlizers were applied – the whole biomass of plants and the crop residues. The effect of green fertilizers was compared to manure fertilization in the dose of 25 t·ha^{-1} and the control object without organic fertilization. The studies were conducted on brown soil in central-eastern Poland in the years 1997-2001.

The mean content of humus in the soil was 1.74%, pH in H_2O was 5.65. The field experiment was set in a split-block scheme in 3 repetitions, on a site after cereals. The area of one plot was 36 m^2. The seeds of forecrop plants meant for green fertilizers were sown during the first ten days of April. Before they were sown, mineral fertilization was applied in the quantity of 30 kg N·ha^{-1} for field pea and spring vetch in pure sowing, 90 kg·ha^{-1} for oat in pure sowing, 60 kg·ha^{-1} for the mixtures of oat with field pea and spring vetch with oat, 40 kg·ha^{-1} for the mixture of spring vetch with field pea and oat. Phosphorus and potassium fertilization on all the objects was 80 kg P_2O_5·ha^{-1} and 160 kg K_2O·ha^{-1}.

The forecrops were ploughed in during the third ten days' period of May. In the same period manure fertilization was applied on the corresponding objects. Just before the plants for green fertilizers were ploughed in, samples were taken from an area of 1 m^2 with the aim of determining the weight of the aboveground part of plants and the weight of the crop residues, which were the roots together with a 5 cm-deep layer of stubble. White cabbage of Amager cultivar was cultivated just before mineral fertilizers were ploughed in.

Onion of Błońska cv. was grown in the second year after organic fertilization, and red beet of Opolski cv. was grown in the third year. The cultivation of vegetables was performed

according to the principles of agricultural practices. In the cultivation of cabbage and onion, mineral fertilization was applied in the quantity of 600 kg NPK·ha^{-1} in the proportion 2:2:3, while in the cultivation of beet the quantity was 400 kg NPK·ha^{-1} in the proportion 2:2:3.The seedlings of cabbage were planted during the first ten days of June, and the harvest was performed during the second ten days' period of October. Onion was sown during the second ten days' period of April, the plants were picked in the middle of September, while red beets sown during the first ten days of April were picked in the second half of September. During the harvest the studies determined the total and commercial yields according to the binding rules. The results were statistically analysed by means of variance analysis. The significance of differences was estimated using Tukey's test.

RESULTS

The quantity of the ploughed in biomass of forecrops and nitrogen introduced into the soil with it is presented in table 1. The greatest amount of organic matter was introduced into the soil ploughing in oat and a mixture of oat with field pea. In the same period oat and its mixture with field pea created about three times as much biomass as field pea and its mixture with vetch, and twice as much as vetch. The greatest quantity of crop residue was left by oat, and the smallest was left by field pea and a mixture of field pea with vetch. The most nitrogen was introduced into the soil with oat (72.68 kg·ha^{-1}) and vetch 72.68 kg·ha^{-1}), and a mixture of oat with field pea (63.46 kg·ha^{-1}). Manure in the dose of 25 t·ha^{-1} introduced 116.83 kg N into the soil per 1 ha.

Table 1. The quantity of the ploughed biomass and nitrogen introduced with it – mean figures from 1997-1999

Kind of forecrop	Fresh mass (t·ha^{-1})	Dry mass (t·ha^{-1})	N (kg·ha^{-1})
All biomass			
Oat	25.45	4.47	72.68
Field pea	8.71	1.24	44.66
Spring vetch	11.54	2.09	72.68
Oat + field pea	20.11	3.05	71.72
Oat + vetch	16.13	2.82	63.46
Field pea + vetch	8.02	1.37	50.48
Oat + field pea + vetch	15.96	2.78	60.26
Crop residue			
Oat	8.91	1.81	14.73
Field pea	2.36	0.37	10.66
Spring vetch	3.31	0.57	15.65
Oat + field pea	7.24	1.14	16.87
Oat + vetch	6.11	1.12	16.80
Field pea + vetch	2.27	0.41	11.17
Oat + field pea + vetch	6.62	1.38	21.13
Manure			
Manure	25.00	-	116.83

The yields of cabbage cultivated immediately after green fertilizers were ploughed in did not significantly differ from the yields achieved after manure was used in the dose of 25 t·ha^{-1} (table 2). In the first year after ploughing in, the forecrops of field pea and a mixture of field pea with vetch and mixtures of oat with field pea and with vetch were more productive green fertilizsers than oat, vetch or a mixture of oat with field pea and oat with vetch (table 3). A mixture of oat with field pea and with vetch was the most productive green fertilizer in the cultivation of cabbage. The commercial yield of cabbage cultivated after it was ploughed in was higher by 12.72 t·ha^{-1} on average, in comparison to the control object without organic fertilization. The production effect of forecrop of field pea and vetch, measured in the increase of the commercial yield of cabbage as compared with the cultivation without organic fertilization, was 4.68 t·ha^{-1}, and that of field pea in pure sowing was 2.22 t·ha^{-1}. The yields of cabbage cultivated after a mixture of oat with field pea and vetch were significantly higher than those that were obtained in the cultivation after vetch and after a mixture of oat with field pea. The manner of utilizing the forecrop as a green fertilizer (the whole biomass of plants or crop residue) did not have a significant effect on the cabbage yield.

Table 2. Total yields of vegetables (t·ha^{-1}) depending on the kind and form of forecrop utilization – mean figures from 1997-2001

Kind of fertilization	Cabbage			Onion			Red beet		
	form of forecrop utilization								
	all biomass	crop residue	mean	all biomass	crop residue	mean	all biomass	crop residue	mean
Control	70.41	76.57	73.49	28.67	29.74	29.21	35.56	33.28	34.43
Manure	78.31	80.57	79.44	41.15	39.91	40.53	39.23	38.48	38.86
Oat	70.68	65.77	68.22	37.87	34.04	35.96	48.57	43.08	45.83
Field pea	72.29	75.33	73.81	44.43	39.82	42.12	45.38	40.56	42.97
Vetch	60.60	69.89	65.24	34.31	34.81	34.56	40.59	36.83	38.71
Oat + field pea	68.40	63.27	65.83	45.82	31.97	38.90	44.89	36.29	40.59
Oat + vetch	72.55	70.37	71.46	34.90	34.15	34.53	44.82	44.92	44.87
Field pea + vetch	80.06	76.71	78.38	37.67	39.21	38.44	46.39	44.49	45.44
Oat + field pea + vetch	86.19	83.89	85.04	35.43	29.73	32.58	47.06	40.93	43.99
Mean	73.27	73.60	73.44	37.81	34.82	36.31	43.61	39.87	41.74
NIR (p = 0.05) for the kind of fertilization	-	-	17.99	-	-	11.14	-	-	7.31
for the form of forecrop utilization	ni.		-	1.35		-	2.71		-

Table 3. Production effects of the ploughed green fertilizers in the form of forecrops (t·ha^{-1}) – mean figures from 1997-2001

Kind of fertilization	Cabbage			Onion			Red beet		
	increase(+) or decrease (-) of commercial yield after ploughing in the forecrop								
	form of forecrop utilization		mean	form of forecrop utilization		mean	form of forecrop utilization		mean
	all biomass	crop residue		all biomass	crop residue		all biomass	crop residue	
Control	67.66	69.09	68.37	27.69	27.79	27.75	31.15	30.47	30.81
Manure	+3.97	+10.30	+7.13	+12.68	+10.42	+11.55	+4.06	+4.44	+4.25
Oat	-1.46	-8.37	-4.91	+8.40	+5.17	+6.78	+10.83	+9.76	+10.29
Field pea	+0.47	+3.98	+2.22	+15.48	+10.63	+13.05	+10.50	+7.11	+8.81
Vetch	-13.95	-5.38	-9.66	+4.87	+5.36	+5.11	+6.89	+3.22	+5.06
Oat + field pea	-3.84	-10.94	-7.39	+16.72	+2.58	+9.64	+10.34	+2.89	+6.62
Oat + vetch	+1.19	-4.43	-1.61	+5.87	+4.86	+5.36	+10.30	+10.71	+10.51
Field pea + vetch	+5.72	+3.03	+4.68	+8.64	+9.46	+9.05	+11.90	+10.69	+11.30
Oat + field pea + vetch	+13.78	+11.65	+12.72	+6.78	+0.74	+3.76	+12.69	+7.61	+10.15
Mean commercial yield	67.87	69.52	68.69	36.52	33.27	34.87	39.76	36.74	38.25
NIR (p = 0.05) for the kind of fertilization	-	-	19.64	-	-	10.90	-	-	6.55
for the form of forecrop utilization	ni.		-	1.46		-	2.23		-

In the second year after ploughing in field pea was the most productive green fertilizer. The mixtures of oat with field pea and field pea with vetch were also characterized by a high production effect. The consecutive effect of green fertilizers of oat, vetch and a mixture of oat with vetch in the cultivation of onion was on average three times as small as manure fertilization. Introducing the whole organic mass of forecrops into the soil contributed to a higher yield of onion than ploughing in only the crop residue.

The fertilizing effect of forecrop plants in the third year of beet cultivation after ploughing in exceeded the effect of manure in the dose of 25 t·ha^{-1}. The total and commercial yields of red beet in the cultivation after a mixture of field pea with vetch were greater than the yields achieved after manure fertilization by 6.58 t·ha^{-1} and 7.05 t·ha^{-1}, respectively. The production results of the consecutive effect of oat and field pea in pure sowing and mixtures of oat with vetch and oat with field pea and with vetch were twice as high as those of manure. The yields of beets cultivated after ploughing in the whole biomass of forecrops were significantly higher than after ploughing in crop residue.

The best yield-forming effect in three-years' rotation of vegetables was shown by mixtures of oat with vetch and with field pea and field pea with vetch as well as by field pea in pure sowing.

DISCUSSION

The studies showed a positive effect of green fertilizers in the form of forecrops on the yielding of plants. Their consecutive effect is especially positive in the second and third years after ploughing in.

The fertilizing effect was related to the kind and quantity of the plant mass of the ploughed forecrops and to the utilization of nutrients contained in them. The mixture of oat with vetch and field pea was the most productive green fertilizer in the first year after ploughing in. Smaller yields of cabbage in the first year after ploughing in some of the examined forecrops could have been caused by greater drying up of the soil. Oat, the mixture of oat with field pea and the mixture of oat with vetch needed more water and nutrients for the production of two to three times as high plant mass than the other forecrops. Additionally, a great quantity of ploughed biomass limited the upward water movement from the deeper layers of the soil. The effect of smaller moistening of the soil was also a difficulty in the distribution of the ploughed green mass. Similar results in the experiments with forecrop green fertilizers in vegetable cultivation were obtained by Borna [3, 4].

In the second year after ploughing in, the most productive green fertilizers whose effect was close to that of manure were mixtures of oat with vetch and oat with field pea. After field pea and manure were ploughed in, significantly higher yields of onion were achieved than in the cultivation without organic fertilization. Borna [2] achieved a significant increase of onion yields in the second year after the mixture of vetch with field pea was ploughed in. High efficiency of green fertilizers in the second year after their introduction into the soil is also confirmed by other authors [9, 14, 16]. In the discussed studies the best yield-forming effect of the forecrop green fertilizers was shown in the third year after application. The ploughed mass underwent decomposition, owing to which the cultivated vegetables could fully utilize the nutrients introduced into the soil. According to some authors [6], the ploughed in green fertilizers have a shorter effect than manure ploughed in at the same time. The results presented here do not confirm this opinion. The yields of red beet cultivated in the third year after ploughing in the green fertilizers were higher than after manure fertilization.

The yields of vegetables cultivated in the second and third years after the whole plant biomass was ploughed in were higher as compared to the yields obtained after only crop residue was ploughed in. This confirms the thesis by Batalin [1], according to whom increasing the ploughed mass of green fertilizers causes an equivalent increase of the yield of the consecutive plant.

CONCLUSIONS

1. The most productive green fertilizer in the cultivation of cabbage in the first year after organic fertilization was a forecrop of a mixture of oat with vetch and with field pea.
2. More productive green fertilizers in the cultivation of onion in the second year after ploughing in were forecrops of field pea, a mixture of oat with field pea and field pea with vetch as compared to oat, vetch and mixtures of oat with vetch and oat with vetch and field pea.

3. In the third year after ploughing in all kinds of green fertilization had a more positive effect on the yielding of red beet than manure in the dose of 25 $t \cdot ha^{-1}$. The highest beet yields were obtained after the mixtures of field pea with vetch, oat with vetch, and after oat in pure sowing.
4. Significantly higher yields of onion and red beet were achieved after ploughing in the whole biomass of forecrops than after ploughing in only the crop residue.
5. The best yield-forming effect in three years' crop rotation of vegetables was shown by the mixtures of oat with vetch and with field pea as well as field pea with vetch and field pea in pure sowing.

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