THE IMPACT OF VERMICOMPOST APPLICATION ON YIELD PARAMETERS OF MAIZE

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ABSTRACT

The impact of vermicompost application on yield parameters of maize was assessed in a pot experiment carried out in vegetation cage located in area of SUA in Nitra.

The experiment had 5 treatments. The first treatment was controlled, i.e., without the appliance of vermicompost. In treatment 2, vermicompost was applied in autumn and introduced a dose of 170 kg ha^{-1} N into the soil. In treatment 3 to 5, vermicompost was applied at twice dose in comparison to treatment 2 (340 kg ha^{-1} N). In treatment 3, the whole dose of vermicompost (340 kg ha^{-1} N) was applied at once, in autumn. In treatments 4 and 5, half of vermicompost (170 kg ha^{-1} N) was applied in autumn and half (170 kg ha^{-1} N) in spring, month before maize sowing. Not only was vermicompost applied in treatment 5, but also nitrogen fertilizer in form of LAD (ammonium nitrate with dolomite) at 60 kg ha^{-1} N dose.

The obtained results suggest that impact of vermicompost application on thickness of stalk and plant height of maize depended on the vermicompost application dose and on time of application. A bigger dose had a more positive impact than a smaller dose. From aspect of thickness of stalk and plant height is more appropriate when a bigger dose of vermicompost is applied once in autumn than a dose divided into autumn and spring applications. From the aspect of yield, no difference has been observed between a single autumn application and an application divided into autumn-spring dates. Pre-sowing addition of industrial nitrogen into the soil fertilized with vermicompost in autumn and spring dates resulted in creation of thickest stalks of maize plants, highest plants, highest total chlorophyll content in leaves, longest spadix of maize, highest thousand kernel weight and in highest grain yield of maize.

Key words: vermicompost, maize, growth parameters, yield, chlorophyll

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INTRODUCTION

The current agricultural production is trying to create sustainable management when it comes to maintaining a balance between the intake and the output of nutrients in the soil. Although the use of industrial fertilizers provides a sufficient content of nutrients into the soil and the influence on yield is evident, on the other hand, it only has a one-time effect. With the current price developments of industrial fertilizers and the decline in production of organic fertilizer due to the reduction of livestock numbers, it is necessary to pay attention to other appropriate alternatives to improve this negative situation.

Re-evaluation of waste i.e. composting has an important position in this context. A large scale of reusable materials that are suitable for composting only increases the value of this technology, having due regard to the protection of the environment. Compost, as a result of composting waste materials, can be regarded as a suitable alternative to organic fertilizers.

The production of vermicompost is realized by the re-using of waste products through the technologies of the earthworm *Eisenia foetida*, which mixes the digested organic matter with minerals in its digestive tract, i.e. with the soil, creating relatively water-resistant aggregates i.e. cats, which have a positive impact on the physical, chemical and biological soil parameters (Kováčik P. 2005).

The aim of this article is to present the experiment of testing different application doses and terms of vermicompost and its effect on some of the yield parameters of maize.

MATERIAL AND METHODS

The pot experiment was carried out in the vegetation cage at the Slovak University of Agriculture in Nitra (48°18´ S, 18°06´ V). The experiment was started in November 2012. In the given months, 22 kg of soil were put into the pots of 0.38 m height and of 0.38 m diameter. The soil was taken from the growing areas of Agrokomplex Nitra from upper 0,25 m of the humus horizon Haplic Fluvisol. Basic agrochemical parameters of vermicompost and soil are presented in Table 1. The experiment treatments are shown in Table 2.

Tab.1 Agrochemical characteristics of soil and vermicompost

Material	pH_{KCl}	N_{an}	P	K	Ca	Mg	N_t	C_{ox}	Org. s.
		[mg.kg^{-1}]							
Soil	6,52	17,6	26,25	300,5	4670	1096	3234	2,295	9,59
VC (100% drymass)	7,36	477,14	5642,86	14285,71	8535,71	4893,57	29 400	20,51	48,53

VC – vermicompost, Org. s. – organic substances

Tab. 2 Treatments of experiment

Treatment		Dose of N		Dose of vermicompost		Dose of LAD		Term of application	
no.	labeling	VC	LAD	t.ha^{-1}	g.pot^{-1}	kg.ha^{-1}	g.pot^{-1}	VC	LAD
		kg.ha^{-1}							
1	Control	0	0	0	0	0	0	-	-
2	VC_1	170	-	8,26	202	-	-	autumn	-
3	VC_2	340	-	16,52	404	-	-	autumn	-
4	$VC_1 + VC_1$	170 + 170	-	8,26 + 8,26	202 + 202	-	-	autumn + spring	-
5	$VC_1 + VC_1 + N_1$	170 + 170	60	8,26 + 8,26	202 + 202	218,18	5,30	autumn + spring	spring

VC – vermicompost, N – nitrogen, LAD – ammonium nitrate with dolomite, no. – number

The tested vermicompost was produced from cow dung (about 50%), sheep manure (about 25%), straw (about 10%), green grass (about 10%) and leaf litter (about 5%). 2 months after the

fermentation, earthworms were introduced into the compost produced from these materials. Earthworms were left in the compost for four months and were fed through an amount of 400 kg per ton of compost fodder per month. The fodder was mainly fruit and vegetables, and the fodder was mashed before the application.

The sowing of the Pionner type maize was carried out in the second decade of April. It was seeded in a rate of 10 seeds per pot. The sowing depth was 0.03 m. During the whole period of vegetation, the experiment was regularly checked and monitored for the overall health of plants. By the beginning of July, the number of plants kept in the pot was 3 individuals per pot, which remained until the end of the growing season.

The maize harvest was carried out on the 13/09/2013. After harvesting the maize, the yield and the thousand kernel weight (TKW) were determined by weighing, growth dynamics (growth parameters) and the length of spadix was measured with a measuring tape. The content of assimilation pigments (chlorophyll *a*, chlorophyll *b*, chlorophyll *a* + *b*) was determined by the Šesták and Čatský method (1966) in the growing stage BBCH 18 (16/07/2013). The last developed leaf was used to determine the assimilation pigments.

The acquired results were processed by mathematical and statistical methods, by analysis of the variance and linear regression analysis using Statgraphics PC program, version 4.0.

RESULT AND DISCUSSION

Except for the first measurement, in the last three measurements, there were differences between the control treatment and the treatments fertilized with vermicompost that were statistically significant, from which it is evident that the application of vermicompost significantly influences the growth dynamics of the thickness of maize the stalk (Table 3).

Tab.3 The impact of experiment treatments on the dynamics of increase of maize stalks thickness

Treatments		Date / growing stage			
		21. 5./BBCH 12	29. 5./BBCH 12	6. 6./BBCH 14	13. 6./BBCH 14
no.	labelling	[cm]			
1	Control	1,85 a	1,96 a	2,11 a	2,81 a
2	VC_1	2,01 a	2,37 b	2,47 b	3,11 b
3	VC_2	2,61 b	2,76 c	2,91 c	3,23 bc
4	$VC_1 + VC_1$	2,40 b	2,63 cd	2,66 d	3,16 bd
5	$VC_1 + VC_1 + N_1$	3,48 c	3,75 e	3,98 e	4,43 e
$LSD_{0,05}$		0,370	0,245	0,133	0,116
$LSD_{0,01}$		0,496	0,328	0,178	0,155

$LSD_{0.05}$ – least significant difference test at 0.05 significance level α 0.05, VC – vermicompost, N – nitrogen, no. - number

In each measurement, which was taken at weekly intervals, the smallest thickness of stalk was present in the plants grown on the unfertilized control treatment 1. The statistically significant thickest stalks were grown in the treatment 5, where in addition to autumn and spring applications of vermicompost (total 340 kg ha^{-1} N), industrial fertilizer LAD (60 $kg.ha^{-1}$ N) was applied in spring. The cause of this find is the fact that in this treatment, not only the largest amount nitrogen was applied, but also the fact that only in this treatment, nitrogen was added in the form of an easily soluble inorganic salt just before sowing of the plants. This find confirmed the well-known finding that the largest effect on the growth parameters of plants is achieved by the combined application of organic and industrial fertilizers (Zhao J., Zhou L. 2011; Akanbi W.B. *et al.* 2002), where fertilizers are an instantaneous source of nutrients and they also accelerate the mineralization of organic compounds (Kováčik P. 2009).

The second thickest stalks were produced on the plants fertilized with vermicompost once in autumn at a dose of 340 kg ha^{-1} N (tr. 3). The third thickest stalks were created in the treatment 4,

where vermicompost was applied at dose of 340 kg ha^{-1} N, just like in treatment 3, but half of the dose was applied in autumn and half in spring. Our find points to the fact that from the aspect of stalk thickness, it is preferable to carry out a single vermicompost fertilization in autumn, rather than to divide the fertilization into autumn and spring applications. Jančich (2012) came to similar conclusions, indicating that the efficiency of the dividing dose of pig manure into spring and autumn application, may under favorable climatic conditions achieve the efficiency of a single autumn application.

From all the vermicompost fertilized treatments, the thinnest stalks were created under treatment 2, in which the smallest dose of nitrogen (170 kg ha^{-1} N) was applied.

The application of vermicompost significantly influenced the increase the dynamics of maize plant height (Table 4). In the treatment with a double application dose of only vermicompost, without the introduction of N in the form of an industrial fertilizer (tr. 3 and 4), is the increase of the height of maize plants significantly higher compared to the control, unfertilized treatment, but also in comparison to the treatment in which half-dose (170 kg ha^{-1} N) of vermicompost was applied (tr. 2). The significantly highest increase in plant height was recorded in the treatment in which the industrial fertilizer LAD was applied in spring (tr. 5). In comparison with our results Thu Thuy Doan et al. (2013) in their experiment with maize and tomatoes did not find significant differences in the impact of the application of industrial fertilizers, vermicompost and classical compost on the growth parameters, but a trend of higher growth parameters was observed with the use of vermicompost and industrial fertilizer in comparison to classical compost.

From the foregoing, it is obvious that the treatments of the experiment influenced height of the plants and the thickness of the stalks identically. This is confirmed by the correlation coefficients between the thickness of the stalk and plant heights measured in individual samplings (Table 5). This finding does not correspond with the knowledge of Kováčik et al. (2010), who found that sunflower plants due to inadequate nutrition were higher than well-fertilized plants and their stalks were thinner than the stalks of the plants sufficiently fertilized.

Tab. 4 The impact of experiment treatments on dynamics increase of maize plants height

Treatments		Date / growing stage			
		21. 5./BBCH 12	29. 5./BBCH 12	6. 6./BBCH 14	13. 6./BBCH 14
no.	labelling	[cm]			
1	Control	7,22 a	10,22 a	12,72 a	15,72 a
2	VC_1	8,33 b	12,88 b	14,44 b	19,88 b
3	VC_2	9,33 c	14,16 c	18,55 c	22,33 c
4	$VC_1 + VC_1$	9,22 cd	13,00 bd	17,00 d	19,94 bd
5	$VC_1 + VC_1 + N_1$	13,55 e	20,16 e	24,66 e	31,61 e
$LSD_{0,05}$		0,507	0,437	0,593	0,832
$LSD_{0,01}$		0,678	0,585	0,793	1,114

$LSD_{0.05}$ – least significant difference test at 0.05 significance level α 0.05, VC – vermicompost, N – nitrogen, no. – number

Tab. 5 The significance of the relationship between plant height and thickness of maize stalks expressed as a correlation coefficient (r)

Parameter		Date / growing stage			
Dependent	Independent	21. 5./BBCH 12	29. 5./BBCH 12	6. 6./BBCH 14	13. 6./BBCH 14
		r			
Plant height	Thickness of stalks	0,7973^{++}	0,9057^{++}	0,9653^{++}	0,9491^{++}

The application of vermicompost significantly influenced the grain yield of maize (Table 6).

Tab.6 The impact of experiment treatment on yield parameters of maize

Treatment		Grain yield (86 % drymass)		TKW (86 % drymass)		Length of spadix	
no.	labelling	[g.pot^{-1}]	rel. %	[g]	rel. %	[cm]	rel. %
1	Control	32,42 a	100,00	234,84 a	100,00	6,53 a	100,00
2	VC_1	50,06 b	154,41	251,44 a	107,07	7,07 ab	108,27
3	VC_2	49,93 b	154,01	245,38 a	104,49	6,90 ab	105,67
4	$VC_1 + VC_1$	51,57 b	159,07	255,15 a	108,65	7,30 ab	111,79
5	$VC_1 + VC_1 + N_1$	62,82 c	193,77	263,55 a	112,23	7,77 b	118,99
$LSD_{0,05}$		10,829		35,172		0,981	
$LSD_{0,01}$		14,771		50,028		1,302	

$LSD_{0.05}$ – least significant difference test at 0.05 significance level α 0.05, no. – number, TKW – thousand kernel weight

Throughout the experiment the significantly lowest grain yield, the smallest spadix and the lowest thousand kernels weight was recorded in the control, unfertilized treatment. The highest grain yield was achieved in treatment 5, i.e. the same treatment, in which in the growing stage BBCH 14, the highest plant with thickest stalk was grown.

Similarly Kováčik et al. (2011) found a relationship between the thickness of stalks and maize grain yield indicating that the thickness of maize stalks in the growing stage BBCH 14 significantly predetermined the amount of maize yield. The differences in the yield between treatment 5, in which, besides vermicompost, also nitrogen in the form of an industrial fertilizer was applied, and treatment 2, 3 and 4, in which only vermicompost was applied, were significant. This find enhances the rationality of the use of organic fertilizers together with industrial fertilizers.

The differences between treatments 2, 3 and 4 were not significant, which was surprising, since differences in the stalk thickness of plants were significant. The surprise was the fact that in the vermicompost fertilized treatments was the lowest yield in treatment 3, i.e. in the treatment in which in the growing phase BBCH 14, plants reached the second largest height and thickness of stalks. A similarly surprising finding was that despite an absolute difference in the total nitrogen application dose, differences in grain yield between treatments 2 and 3, respectively 2 and 4 were not significant. This find does not correspond with the well-known relationship between the nitrogen application dose and the yield of cultivated plants (Marschner H. 2005; Kováčik P. *et al.* 2008) and the earlier suggestion of a relationship between the thickness of maize stalks and maize grain yield. The cause of this finding is that in this treatment, within the vermicompost fertilized treatments, the smallest spadixs were created and the maize had the lowest TKW (Table 6). The fact that a double dose of nitrogen in the form of vermicompost (340 kg ha^{-1} N) had the same effect on grain yield as a half-dose (170 kg ha^{-1} N), cannot be justified with depressant effects of excessive doses of N for plant production, because in 5th treatment, in which an even bigger dose of N was applied, the yield has increased. Similarly, the differences in the total chlorophyll contents between treatment 2, 3 and 4 do not indicate an increased supply of nitrogen to maize plants (Table 7). It can even be specified, that in the growing stage BBCH 18 the total chlorophyll content in leaves of maize did not show differences the between autumn application of vermicompost at a doses of 170 to 340 kg.ha^{-1} N (tr. 1 versus 2 and 3), or a combination of autumn and spring vermicompost application into soil in total dose of 340 kg.ha^{-1} N (tr. 1 versus tr. 4). A statistically

significant and positive change in chlorophyll content was observed only in the treatment, where, in addition to vermicompost, industrial nitrogen was applied (tr. 1 versus tr. 5). The effect of industrial N justifies the popularity of nitrogenous fertilizers among agronomists (Kováčik P. 2009).

Tab. 7 The impact of experiment treatments on content of assimilation pigments in maize leaves in the growing stage BBCH 18

Treatment / no.	labelling	Assimilation pigments in mg.l^{-1}		
		Chl *a*	Chl *b*	Chl *a* + *b*
1	Control	2,585 a	0,978 a	3,563 a
2	VC_1	2,601 a	1,059 a	3,661 a
3	VC_2	2,606 a	0,962 a	3,568 a
4	VC_1 + VC_1	2,604 a	1,038 ab	3,642 a
5	VC_1 + VC_1 + N_1	3,340 b	1,233 b	4,573 b
$LSD_{0,05}$		0,329	0,186	0,463
$LSD_{0,01}$		0,468	0,265	0,658

$LSD_{0.05}$ – least significant difference test at 0.05 significance level α 0.05, Chl – chlorophyll, no. – number

CONCLUSIONS

The obtained results suggest that the impact of vermicompost application on the thickness of stalk and plant height of maize depended on the vermicompost application dose and on the date of application. A bigger dose had a more positive impact than a smaller dose. From the aspect of the thickness of stalk and plant height, it is more appropriate when a bigger dose of vermicompost is applied at a single time in autumn, than a dose divided into an autumn and a spring application. From the aspect of yield, no difference between a single autumn application and an application divided into autumn-spring dates was observed. A single, pre-sowing addition of industrial nitrogen into the soil fertilized with vermicompost in autumn and spring dates resulted in the creation of the thickest stalks of maize plants, highest plants, highest total chlorophyll content in leaves, longest spadix of maize, highest thousand kernel weight and in the highest grain yield of maize. The rationality of common organic-mineral fertilization of plants was confirmed.

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