The effect of Zn fertilization on the dry matter production of ryegrass

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Summary

*The effect of Zn fertilization was studied in a greenhouse experiment. 17 soil samples were collected from two Hungarian counties, that are Hajdú- Bihar and Szabolcs Szatmár Bereg. The samples originated from agricultural areas. The samples were sand, sandy loam and loam by texture, and their nutrient supply was various. The experimental plant was ryegrass (Lolium perenne L.) The applied Zn rates were 0, 2,5 and 5 mg/kg Zn as $ZnSO_4$*$7H_2O$. Beside it each pot received a uniform NPK application. We analysed the dry matter weights of the first and second harvest. The average dry matter production increased for the added Zn significantly for both cuts. Not only the 2,5 mg/kg Zn application increased the yield but the 5 mg/kg Zn dose increased it further.*

We concluded the followings:

- Zn fertilization is of importance on the investigated regions.

- Under greenhouse circumstances above 1,4 mg/kg Zn doses (MÉM-NAK critical value) have also yield increasing effect, therefore we suggest the revision of the critical value.

INTRODUCTION

Zinc is one of the essential microelements for plants. Zn is an essential catalytic component of over 300 enzymes (Mengel,1976). Through the activation of peptidase it is very closely involved in protein synthesis and by stimulating the auxine production – interaction with manganese- it regulates the plant growth (Loch és Nosticzius, 2004).

According to FAO investigations on a global scale more than 30% of agricultural soils are deficient in Zn (Sillanpaa 1982). In Hungary 27% of the agricultural soils are qualified as Zn deficient soil (Elek and Patócs). The critical Zn value suggested by MÉM NAK is 1.4 mg/kg Zn extracted by KCl+EDTA solution, which is independent from soil texture (Kádár 2005). The different plant cultures has various Zn requirements, thus the former value is of only approaching nature.

In this study our aim was to investigate the Zn supply of 17 agricultural soil samples from two Hungarian counties, that are Hajdú- Bihar and Szabolcs Szatmár Bereg. Using ryegrass as test plant we investigate, whether critical Zn value suggested by MÉM- NAK can also consider critical value under our greenhouse experimental circumstances or not.

MATERIALS AND METHODS

A pot experiment was conducted using 17 agronomical soils with various soil type and texture. 14 soil samples were taken from points assigned from Soil Information and Monitoring System (SIMS). The most important soil properties are summarised in *Table 1*. The data are originated partly from the SIMS database (Hu%, K_A, pH), the Zn content of the soils were determined using KCl- EDTA extractant (MSZ 20135 1999). The Zn content of the extracted solutions was measured by VARIAN Spectr. AA-20 Atom adsorbtion spectrophotometer. Pots were filled with 2700g air-dry soil in case of sandy soils and 2250g in case of loamy soils. The treatments included NPK , NPK + 2,5 mg/kg Zn and NPK +5mg/kg Zn levels with three replicates. Each pot received uniform application of 100 mg N/kg soil as NH_4NO_3, 80 mg P_2O_5/kg soil as KH_2PO_4 and 120 mg K_2O/kg soil as KH_2PO_4 and KCl. The zinc was added as $ZnSO_4$*$7H_2O$ in aqueous form. Soils were kept at constant moisture by daily irrigation, which was 75% of maximum water capacity of the soils. To avoid wilting on hot days plants were also irrigated in the afternoon.

The experimental plant was ryegrass (Lolium perenne L.) 1,7 g seeds were sown in the soils per pots. After 33 and 53 days the plants were cut 2cm above ground level and dried at 40 ^{0}C until constant weight was reached. After the first harvest 100 mg N/kg soil as NH_4NO_3 solution was added to the pots.

Table 1.

Main soil characteristics of the investigated soils.

Nr.	Soil Type	Soil site	*K_A	pH_{H2O}	pH_{KCl}	Hu%	$Zn_{KCl\text{-}EDTA}$
1	Shifting sand	Nyírség	24	4,97	4,51	0,37	0,3
2	Humous sand	Nyírség	24	5,18	4,01	0,62	1,2
3	Brown forest soil with thin clay layers	Nyírség	24	5,02	4,00	0,31	0,5
4	Shifting sand	Hajdúság	24	5,6	4,14	0,37	0,4
5	Shifting sand	Nyírség	24	5,24	3,87	0,50	0,3
6	Sand with humus	Hajdúság	26	5,7	3,90	0,78	0,7
7	Leached chernozem	Hajdúság	43	6,7	5,54	2,73	1,7
8	Sand with humus	Nyírség	31	7,0	6,18	1,14	2,2
9	Meadow chernozem	Hajdúság	45	8,05	7,21	3,16	0,8
10	Meadow chernozem	Hajdúság	42	7,9	7,35	2,66	0,9
11	Meadow chernozem	Hajdúság	46	7,8	7,30	2,69	0,9
12	Meadow chernozem	Hajdúság	42	7,8	7,47	2,09	0,9
13	Calcareous chernozem	Hajdúság	42	6,9	7,18	2,83	1,8
14	Meadow chernozem	Hajdúság	43	8,0	7,14	3,05	2,9
15	Humous sand	Nyírség	26	4,5	4,2	0,6	0,5
16	Humous sand	Hajdúság	26	4,9	3,8	0,55	0,4
17	Calcareous chernozem	Hajdúság	43	7,2	6,4	3,02	1,9

* K_A is the water amount taken up by soil to plasticity capacity (cm^3/100g soil)

RESULTS AND DISCUSSION

The average dry production of the first cut is summarized in *Table 2*. The dry matter production of the different soil samples varied greatly. The greatest yield was experienced at 15. soil sample (7,2zg/pot), and the smallest at 16. soil sample (0,93g/pot). The 15. soil probably had an extraordinary good nutrient supply. These data shows that although every pots got optimal NPK, the other factors is also of great importance. The data were evaluated with two variable variance analysis. Accordingly significant positive relationship was found at between Zn application and the dry matter production. Between the soils and dry production there was also significant relationship

If we consider the soils distinctly only six samples show significant increment for 2,5 mg/kg Zn application and 12 samples for 5 mg/kg Zn related to the control.

The dry matter productions of 2nd cut (*Table 3.*) were smaller than that of the 1st one. It can be attributed to the decrease of available nutrients' amount. Sample 16. is an exception from this rule. Regarding to the average of all soils positive effect of zinc application can be revealed, too, which is proven statistically.

The sum of the 1st and 2nd cut is shown in *Table 4*. Similarly to our former results, there is significant positive relationship between the yields and the Zn aplication. For distinct soils ten samples show significant increment for 2,5 mg/kg Zn application and 12 samples for 5 mg/kg Zn related to the control.

To demonstrate the influence of added Zn to the yields, we calculated the relative dry production in percentage. We considered the control production as 100% by each soil sample. The results are shown in Figure 1. In most of the cases the added Zn increased the yield, and in some cases the yield increment was more than 150%. These soils were Zn deficient soils according to the MÉM NAK recommendations (except sample 8.). Due to it, it can be stated that Zn fertilization increases the yield , and the increment can be 150 – 200 % . It is also appearent that not only 2,5 mg/kg Zn application has an effect relating to control , but applying 5mg/kg Zn increases the dry matter production further, significantly.

Table 2.

Mean dry weight of ryegrass of the 1st cut

Soil number	Mean dry weight (g pot^{-1}) Zn doses (mg kg^{-1} soil)			mean	Difference between treatments in dry weight	
	0	2,5	5		2,5-0	5-0
1	1,70	2,77	3,80	2,76	1,07	2,10
2	2,90	3,50	4,80	3,73	0,60	1,90
3	1,43	2,00	3,40	2,28	0,57	1,97
4	2,13	3,10	3,60	2,94	0,97	1,47
5	3,33	4,07	4,10	3,83	0,73	0,77
6	2,57	3,77	4,33	3,56	1,20	1,77
7	3,70	4,00	4,73	4,14	0,30	1,03
8	2,87	3,80	4,60	3,76	0,93	1,73
9	4,00	4,40	5,03	4,48	0,40	1,03
10	3,03	3,97	4,33	3,78	0,93	1,30
11	3,33	4,10	4,17	3,87	0,77	0,83
12	5,43	6,07	5,87	5,79	0,63	0,43
13	2,83	2,50	3,33	2,89	-0,33	0,50
14	4,60	5,10	5,40	5,03	0,50	0,80
15	7,23	7,10	7,47	7,27	-0,13	0,23
16	0,90	0,83	1,07	0,93	-0,07	0,17
17	4,80	5,07	4,73	4,87	0,27	-0,07
mean	3,34	3,89	4,40	3,88	1,07	2,10

$SD_{5\%}$ between Zn treatments = 0,18
$SD_{5\%}$ between soils = 0,44
$SD_{5\%}$ between any two combinations = 0,76

Table 3.

Mean dry weight of ryegrass of the 2nd cut

Soil number	Mean dry weight (g pot^{-1}) Zn doses (mg kg^{-1} soil)			mean	Difference between treatments in dry weight	
	0	2,5	5		2,5-0	5-0
1	0,68	0,88	1,37	0,98	0,20	0,69
2	1,44	1,64	2,05	1,71	0,20	0,61
3	0,30	1,11	1,58	1,00	0,81	1,28
4	0,46	0,95	1,43	0,95	0,49	0,97
5	1,61	2,11	2,61	2,11	0,50	1,00
6	1,32	1,45	1,89	1,55	0,13	0,56
7	1,22	1,31	1,76	1,43	0,09	0,54
8	1,15	1,66	2,39	1,73	0,51	1,24
9	1,59	1,41	1,85	1,62	-0,18	0,26
10	0,94	1,64	1,98	1,52	0,69	1,04
11	1,20	1,55	1,99	1,58	0,35	0,79
12	5,58	5,69	6,51	5,93	0,12	0,93
13	1,36	2,03	2,65	2,01	0,67	1,29
14	1,63	2,03	2,30	1,99	0,39	0,66
15	6,37	6,87	6,65	6,63	0,50	0,29
16	2,74	2,79	2,81	2,78	0,05	0,06
17	3,35	3,40	4,43	3,73	0,05	1,08
mean	1,94	2,27	2,72	2,31	0,33	0,78

$SD_{5\%}$ between Zn treatments = 0,15
$SD_{5\%}$ between soils = 0,36
$SD_{5\%}$ between any two combinations = 0,63

Table 4.

Mean dry weight of ryegrass of 1st + 2nd cu

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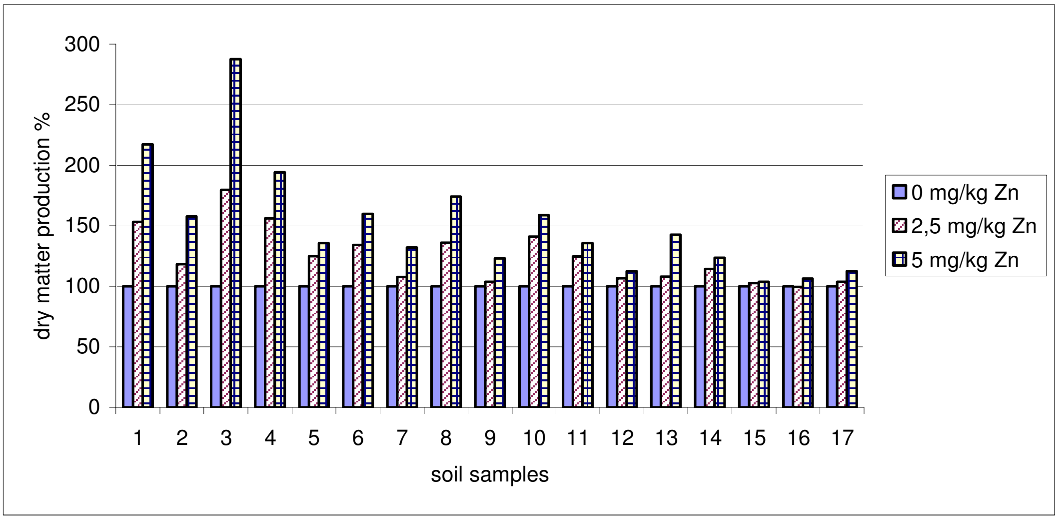
Soil number	Mean dry weight (g pot^{-1})			mean	Difference between treatments in dry weight	
	Zn doses (mg kg^{-1} soil)					
	0	2,5	5		2,5-0	5-0
1	2,38	3,64	5,17	3,73	1,26	2,79
2	4,34	5,14	6,85	5,44	0,80	2,51
3	1,73	3,11	4,98	3,28	1,38	3,25
4	2,59	4,05	5,03	3,89	1,45	2,44
5	4,94	6,18	6,71	5,94	1,23	1,76
6	3,89	5,22	6,22	5,11	1,33	2,33
7	4,92	5,31	6,49	5,57	0,39	1,57
8	4,01	5,46	6,99	5,49	1,44	2,97
9	5,59	5,81	6,88	6,10	0,22	1,29
10	3,98	5,60	6,31	5,30	1,63	2,34
11	4,54	5,65	6,16	5,45	1,11	1,62
12	11,01	11,76	12,37	11,71	0,75	1,36
13	4,19	4,53	5,98	4,90	0,34	1,79
14	6,23	7,13	7,70	7,02	0,89	1,46
15	13,59	13,97	14,12	13,89	0,38	0,53
16	3,64	3,63	3,87	3,71	-0,02	0,23
17	8,15	8,47	9,16	8,59	0,32	1,01
mean	2,38	3,64	5,17	3,73	1,26	2,79

$SD_{5\%}$ between Zn treatments = 0,20
$SD_{5\%}$ between soils = 0,48
$SD_{5\%}$ between any two combinations = 0,84

Figure 1: The effect of Zn treatments on dry matter production of 1st + 2nd cut



CONCLUSIONS

Our results prove, that above the MÉM NAK critical Zn value (1,4 mg Zn/kg soil) the yield increasing effect of zinc can prevail under greenhouse experiment circumstances. Therefore we suggest the revision of the actual critical value (1,4 mg Zn/kg soil).

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