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APPLICATION OF COMPLEX FERTILIZERS IN OATS

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ABSTRACT

In the paper effects of two complex blended fertilizers on yield and content, as well as accumulation of macronutrients by oats are presented. From the results of three-years lasting field trial it can be concluded that application of complex blended fertilizers (under commercial names Amofosmag 4 and Amofosmag 3) did not affect oats grain and straw yields in comparison to control (straight NPK fertilizers). Content of studied macronutrients in grain appeared to be unaffected by fertilization treatments. However, significant differences of chemical composition of oats tissues were noted between seasons of studies what indicated impact of weather conditions. The highest total uptake of nitrogen and potassium by oats yield was found in Amofosmag 3 treatment whereas total uptake of phosphorus was the highest in control treatment.

Key words: oats, yield, macronutrients, complex fertilizers

INTRODUCTION

Nowadays in Polish market high variety of fertilizers of different prices and quality are available. Often it happens that they have similar commercial names what makes proper choice of the best fertilizer for given crops rather difficult. Complex fertilizers can supply crops in several nutrients in appropriate amounts and proportions and their rates are related to soil abundance in available essential nutrients: phosphorus, potassium and magnesium. Gradual but continuous increment of the market share of complex fertilizers in total consumption of fertilizers should be treated as a positive phenomenon under conditoions of Polish agriculture.

The key factor is effectiveness of application of complex fertilizers which is high only when their composition matches not only crop demands but also soil abundance in nutrients what has to be taken into account during planning of fertilizers' application. Reasons of undertaking worldwide production and practical application of complex fertilizers which can have desired chemical composition are as follows: soil acidification, magnesium shortage and reduction of sulphur emission into atmosphere what finally led to not covering crops requirements for essential nutrients [1, 2]. Economical advantages of complex over straight fertilizers was pointed out by Glabisz et. al [3]. Because of the fact that reports concerning application of complex fertilizers in oats production are scarce the studies were undertaken to estimate the effects of application to two blended complex fertilizers Amofosmag 4 and

Amofosmag 3 on oats yield, chemical composition of its above-ground biomass and accumulation macronutrients in this crop.

MATERIALS AND METHODS

A three-years lasting field experiment (2005–2007) was carried out in a randomized block design at the Research and Experimental Station in Tomaszkowo, owned by the University of Warmia and Mazury in Olsztyn. The experiment, which comprised of three fertilization treatments in four replications: control treatment (simple fertilizers), Amofosmag 3 and Amofosmag 4, was established on proper brown soil developed from sandy loam, of quality class III b and very good rye complex of agricultural suitability. The physicochemical properties of soil in each year of the study are presented in Table 1. The tested crop was oats (*Avena sativa* L.) cv. Kasztan. The forecrops were winter triticale in the first year, and winter rapeseed in the following two years. Single plot area was 10 m².

Table 1. Selected chemical properties of soil used in the experiment, mg · kg^{-1}

Year	pH (1 M KCl)	Available forms		
		P	K	Mg
2005	6.15	56.70	112.0	31.0
2006	7.20	112.9	145.3	25.0
2007	5.60	116.0	224.0	87.0

Based on the average levels of available phosphorus in the soil, 300 kg · ha^{-1} Amofosmag 3 (NPKMg 3:14:20:2+22% CaO + 9% SO_3; 9 kg N, 18 kg P and 50 kg K on pure ingredient basis) and Amofosmag 4 (NPKMg 4:15:15:3+25% CaO + 13% SO_3; 12 kg N, 20 P and 37 kg K on pure ingredient basis) were applied pre-sowing. In the control treatment, the following fertilizers were applied pre-sowing: 12 kg N in the form of urea, 45 kg P_2O_5 (20 kg P) in the form of triple superphosphate and 45 kg K_2O (37 kg K) per ha in the form of potash salt. The nitrogen rate of 90 kg ha^{-1} was supplemented with two doses of ammonium nitrate applied by top-dressing BBCH (22-23) and BBCH (32-33), as follows: control treatment and Amofosmag 4 treatment - 50 and 28 kg N, Amofosmag 3 treatment - 50 and 31 kg N ·ha^{-1}.

Samples of oats were collected at the stage of full maturity. The grain and straw harvested in each plot was weighed individually. Wet mineralized samples were assayed for the content of: total nitrogen – by the hypochlorite method, phosphorus – by the vanadium-molybdenum method, calcium and potassium – by atomic emission spectrometry (ESA), and magnesium – by atomic absorption spectrometry (AAS). The obtained results of oats yield and from chemical analyses were verified statistically by a two-factorial analysis of variance for a randomized block design. The experimental factors were as follows: a – fertilization, b – duration of the experiment. The significance of differences between means was estimated by Duncan's test at p=0.05.

RESULTS AND DISCUSSION

The distribution of air temperatures in 2005 differed insignificantly from the appropriate values from reference period 1970–2000 (Table 2). Total precipitation in April was substantially lower comparing to reference period, what could have contributed to uneven emergence, whereas July was too wet. In 2006, mean monthly temperatures were similar to the average from the reference period. The highest temperature was noted in July. Precipitation levels differed considerably from the average values in July and August. Precipitation total in July in August was over 2.5-fold lower and nearly 2.5-fold higher, respectively, than in the reference period average, which made harvest difficult. In 2007, air temperatures during the growing season were above the reference period average. Relatively dry period in April and too wet period in July were not favorable for crop's growth and maturation then harvesting was performed under very wet condition (with precipitation sum higher by factor 2.4 comparing to reference period) what caused plants' lodging. Weather conditions could have affected the yield of oats.

Table 2. Weather conditions in 2005-2007 data provided by the Meteorological Station in Tomaszkowo

Month	Mean daily temperature (˚C)				Total precipitation (mm)			
	2005	2006	2007	1970-2000	2005	2006	2007	1970-2000
April	8.2	7.3	7.5	6.9	22	25.6	24.7	36.1
May	11.6	12.5	13.8	12.7	68.2	89.2	93.5	51.9
June	14.2	16	17.7	15.9	35.4	79.2	88.1	79.3
July	19.7	20.9	17.7	17.7	83.9	29.3	173.7	73.8
August	16.9	17.2	18.3	17.2	39.6	165	68	67.1
Mean	14.1	14.8	15	14.1	Σ 249.1	388.4	448	308.2

Application of complex fertilizers Amofosmag 4 and Amofosmag 3 did not significantly affect straw and grain yield of tested plant comparing to the control treatment (Table 3). Grain yield ranged (in relation to applied fertilizer) from 5.73 to 5.90 t ha^{-1}. The significant difference was found between seasons of the experiment. The highest mean grain and straw yield (7.48 and 7.18 t ha^{-1}, respectively) was noted in the second season of studies. Significantly lower grain yield was obtained in the third season of studies and this yield reduction amounted to 29 and 44% in relation to the first and the second season, respectively. The main reason could be less favourable for oats weather pattern in the last season of studies. When spring wheat was a test plant the significant increase of its straw and grain yield was found in the result of Amofosmag 4 application [9]. Reports of other authors' have confirmed yield increase of many crops under effects of complex fertilizers application [8, 10, 12]. However, Krzywy et al. [7] reported that effects of complex fertilizers on winter triticale and spring barley yields were insignificant.

Table 3. Oats yield, Mg · ha^{-1}

Treatment	Grain				Straw			
	2005	2006	2007	mean for a	2005	2006	2007	mean for a
NPK	6.12	7.64	3.88	5.88	4.88	6.82	4.86	5.52
Amofosmag 4	5.78	7.14	4.27	5.73	4.36	7.20	4.44	5.33
Amofosmag 3	5.69	7.65	4.36	5.90	4.10	7.53	4.67	5.43
Mean for b	5.86	7.48	4.17	–	4.45	7.18	4.66	–
$LSD_{p=0.05}$ for: a	ns				ns			
b	0.56				0.87			
a × b	ns				ns			

Legend: a – fertilization, b – duration of the experiment, a × b – interaction, ns – not significant difference

Presented in the Table 4 results of chemical analyses show that content of studied macronutrients in oats grain and straw harvested from fertilizers' treatments was only slightly differentiated and generally was within range of typical content given by standards [4]. Comparing to the control application Amofosmag 3 resulted in significant increase of potassium content in straw. Content of phosphorus and potassium in grain and straw was not significantly modified by application of studied fertilizers. Higher variability was found among seasons of the studies. Oats grain obtained in the first season contained significantly less nitrogen than grain from other seasons of studies. In the second year of studies kernels were more abundant in nitrogen comparing to the first season of studies. In the first and third season of studies oats grain contained significantly lower amounts of phosphorus and potassium. The highest mean nitrogen concentration (21.9 g N kg^{-1} in dry matter) was found in grain obtained in the last season of the studies. Comparing to the first and the second season of the studies considerable increase of nitrogen content in grain was found which amounted to 52 and 19%, respectively. The highest content of nitrogen in oats straw was found in the first season of the experiment, potassium and phosphorus in the third season of the

studies. In many reports the insignificant effects of complex fertilizers' application on nutrients content in some crops were found [1, 6-9].

Table 4. Macronutrients content in oats aboveground organs, g · kg^{-1} d.m.

Treatment	Grain				Straw			
	2005	2006	2007	mean for a	2005	2006	2007	mean for a
Nitrogen								
NPK	14.2	17.9	22.2	18.1	6.5	4.8	4.9	5.4
Amofosmag 4	14.5	19.3	22,0	18.6	7.0	5.1	4.2	5.4
Amofosmag3	14.6	17.9	21.5	18.0	6.1	5.5	4.9	5.5
Mean for b	14.4	18.4	21.9	–	6.5	5.1	4.7	–
LSD $_{p=0.05}$ for: a	ns				ns			
b	1.37				0.72			
a × b	ns				ns			
Phosphorus								
NPK	3.4	3.6	2.1	3.0	0.68	1.71	2.30	1.56
Amofosmag4	3.1	3.6	2.2	3.0	0.28	1.70	2.20	1.39
Amofosmag3	3.2	3.7	2.2	3.0	0.33	1.90	2.21	1.48
Mean for b	3.2	3.6	2.2	–	0.43	1.77	2.24	–
LSD $_{p=0.05}$ for: a	ns				ns			
b	0.13				0.25			
a × b	ns				ns			
Potassium								
NPK	4.1	4.1	3.4	3.9	24.7	22.6	23.7	23.7
Amofosmag4	3.7	4.2	3.2	3.7	23.8	24.1	25.1	24.3
Amofosmag3	4.0	4.3	3.4	3.9	26.1	25,0	26.2	25.8
Mean for b	3.9	4.2	4.2	–	24.9	23.9	25,0	–
LSD $_{p=0.05}$ for: a	ns				1.61			
b	0.22				ns			
a × b	ns				ns			

Legend as in the Table 3

Basing on yield of above-ground oats biomass and macronutrients contents the total accumulation was calculated for each studied nutrient (Table 5). The highest accumulation of nitrogen in aboveground oats' biomass was found in the second year of studies in Amofosmag 3 treatment (178.3 kg N · ha^{-1}) what was an effect of the highest straw and grain yield. Uptake of phosphorus and potassium by oats yield was not related to fertilizer treatments and the highest values were found in the second season of studies because of high content of mentioned nutrients in oats straw as well in grain. Weather pattern determined accumulation of nitrogen in oats' biomass at the great extend what was confirmed by results of Szmigiel's [11] studies. Herein, the highest total accumulation of nitrogen and potassium in oats abovegroud biomass was found in Amofosmag 3 treatment whereas the highest value for phosphorus was found in the control. It can indicate that availability of nutrients is similar from straight fertilizers and from Amofosmag 3 for oats was on the same level and that that nutrients from Amofosmag 4 were less available for studied crop. It was found that higher amounts of nutrients were uptaken by maize and spring wheat from multicomponent fertilizers comparing to straight ones according to Kruczek and Sulewska [5] and Nogalska et al. [9]. Stępień and Mercik [10]

reported that uptake and utilization of P and K from complex fertilizers by potatoes, barley, triticale and wheat were comparable to respective parameters of straight fertilizers.

Table 5. Nutrient uptake by oats grain and straw, kg · ha^{-1}

Treatment	Nitrogen	Phosphorus	Potassium
2005			
NPK	118.6	24.1	145.6
Amofosmag4	114.3	19.1	125.2
Amofosmag3	108.1	19.5	129.8
2006			
NPK	169.4	39.2	185.4
Amofosmag4	174.5	37.9	203.5
Amofosmag3	178.3	42.6	221.1
2007			
NPK	109.9	19.3	128.4
Amofosmag4	112.5	23.5	125.1
Amofosmag3	116.6	19.9	137.1
Total of three-years			
NKP	397.9	82.6	459.4
Amofosmag4	401.3	80.5	453.8
Amofosmag3	403.0	82.0	488.0

CONCLUSIONS

1. From the results of three-years lasting field experiments can be concluded that applied complex fertilizers Amofosmag 3 and Amofosmag 4 did not significantly affect grain and straw yield comparing to the control treatment (straight fertilizers).
2. Content of studied macronutrients in oats grain was not variable in relation to fertilizers' treatments. In the oats' straw significantly higher potassium content in Amofosmag 3 treatment comparing to the control was noted. Significant differences of chemical composition of oats above-ground biomass were found among seasons of studies what was a result of different weather pattern.
3. The highest total nitrogen uptake by oats yield was found in Amofosmag 3 treatment while phosphorus uptake was the highest in control.

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