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YIELDING EFFECT OF NITROGEN AND SULFUR AT POT EXPERIMENT CONDITIONS WITH WINTER WHEAT (*Triticum aestivum* L.)

PLONOTWÓRCZE DZIAŁANIE AZOTU I SIARKI W WARUNKACH DOŚWIADCZENIA WAZONOWEGO Z PSZENICĄ OZIMĄ (*Triticum aestivum* L.)

Abstract: The aim of the present research was to proof the yielding role of nitrogen and sulfur in the process of growth and development of winter wheat. The experiment was conducted at a greenhouse, in Mitscherlich pots and soil had a low concentration of sulfur. Three increasing doses of N were applied in this experiment. The N sources were ammonium nitrate (without sulfur) and tetra urea calcium sulfate (with sulfur). No other sulfur fertilizer was used in this experiment. It was found that higher yields of wheat were obtained at objects with use of sulfur containing fertilizer. These plants gave higher yield of grain on all N-S levels in comparison to objects not fertilized with S. Plant supply with N and S produced a larger number of lateral fertile shoots as well as a significantly larger number of grains per ear of main and lateral shoots. Mineral sulfur also caused better plumpness of grain in comparison to parallel objects without sulfur, because in these objects a larger mass of thousand grains was found.

Keywords: pot experiment, winter wheat, nitrogen, sulfur, yield structure

Cereals belong to plants with relatively little requirement for sulfur, however it is known that they uptake up to 20 kg S · ha^{-1} [1, 2]. It is observed in agriculture the considerable sulfur exhaustion from the soil resources by enlarging cereal participation in cropping system and cultivation of cruciferous plants which have the biggest requirement for this nutrient. As an effect of this process as well as permanent decrease of sulfur compounds emitted to the atmosphere, sulfur becomes a deficit nutrient in some regions of Poland. There is an anxiety that in this nutrient shortage conditions, widespread use of NPK fertilization can appear less effective. Balanced fertilization, which is recommended in recent years, is based on the foundation that plants require all

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nutrients, in adequate amounts, for proper development and production of high and good quality yields.

The aim of the present research was to prove the important role of sulfur in the process of growth, development as well as yield formation of winter wheat.

Material and methods

The experiment was conducted at a greenhouse, in Mitscherlich pots filled with 6,5 kg soil with granulometric composition of heavy loamy sand, which was characterized by following parameters (mg · kg^{-1} soil): 13.6 – P_2O_5, 11.6 K_2O, 3.5 Mg, < 1 mg S-SO_4 and pH_{KCl} 5,6. In each pots were cultivated 12 plants of winter wheat, cv. Mobela. The first experimental factor was the type of nitrogen fertilizer: ammonium nitrate (without sulfur) and tetra urea calcium sulfate – CMSW (with sulfur) [3], and the second factor – N dose (g · pot^{-1}): 0.8, 1.6 and 2.4. At objects fertilized with tetra urea calcium sulfate were applied also the following doses of sulfur (g · pot^{-1}): 0.25, 0.50 and 0.75 for succeeding N doses, respectively. During the establishing of the experiment also 0.8 g P, 1.6 g K and 5.4 g $CaCO_3$ were applied to every pot. Plants were watered with distilled water and soil moisture was kept on the level of 40–60 % of field water capacity in dependence on the developmental stage of wheat. Three plant harvests, at phases evaluated according to the BBCH scale, were performed in the vegetation period: 33 – shooting, 65 – flowering and 92 – full maturity. During all harvests, plants from 3 pots, from each fertilizer object were harvested. The presented data are the mean from the objects and two years of research. The obtained results were calculated statistically with the use of Statgraphics Program v. 5.1.

Results and discussion

From the phase of the second node there were observed some differences in the growth and development of wheat, in dependence on N dose and supply with sulfur. Plants fertilized with ammonium nitrate, and particularly at low doses of this fertilizer, had light yellow pigmentation of leaves as opposed to dark green leaves of wheat fertilized with tetra urea calcium sulfate, which was also observed by Haneklaus et al [4]. Moreover, in the shooting phase retarding the increase of aboveground part dry mass of plants with sulfur deficit was found in spite of nitrogen supply. In this result the lowest dose of N applied with S gave greater yielding effect than the highest dose of nitrogen alone (Fig. 1). This tendency was maintained up to the end of vegetation. Sulfur shortage in the soil influenced change of wheat growth and development because in plants occurs mutual regulation of the NO_3^- and SO_4^{2-} assimilatory pathways [5], as a result of which the deficit of one nutrient decreases assimilation of the other. Karmoker et al [6] found that barley deprivation of sulfate ions led to decrease of nitrogen transport in plant and lower stomatal conductance, transpiration and photosynthesis. Growth reduction as a consequence of a lack of balance between fertilization with N and S was caused probably by protein synthesis inhibition and lower nitrate reductase activity as well as accumulation of low molecular protein compounds in these

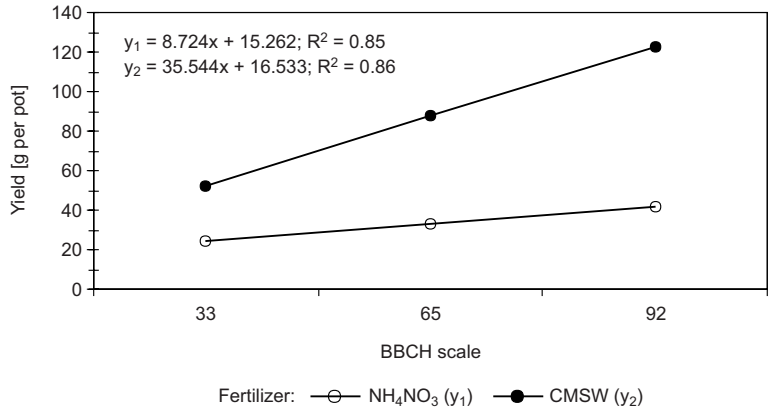

Fig. 1. Aboveground part yield of wheat in dependence on stage of growth and fertilizer

plant vegetative organs [7]. At full maturity it was found, that the used fertilizers and their doses had a significant effect on grain yield, which at objects without sulfur was lower in comparison to the yield found on each N-S level (Fig. 2). Sulfur deficit found at the objects where fertilizers without sulfur were used, caused (mean for N): 75 and 60 % yield reduction of grain and straw, respectively. At a pot experiment conducted by Haneklaus et al [4] and Brodowska [2] wheat from sulfur deficit object gave only 10 and 6 % of seed yield, respectively, in comparison to control. However, Rasmussen et al [8] found in a field experiment a 15 and 20 % seed and straw yield decrease of wheat cultivated in sulfur deficit conditions. It the present author's own research there was observed a significant effect of sulfur and nitrogen on the increase of fertile shoot number, number of grain per ear and number of seeds per plant (Table 1). The obtained results indicated an important role of sulfur in lateral fertile shoot formation as well as their participation in total seeds yield (Fig. 2, Table 1), which was also found in research led by Rasmussen et al [8].

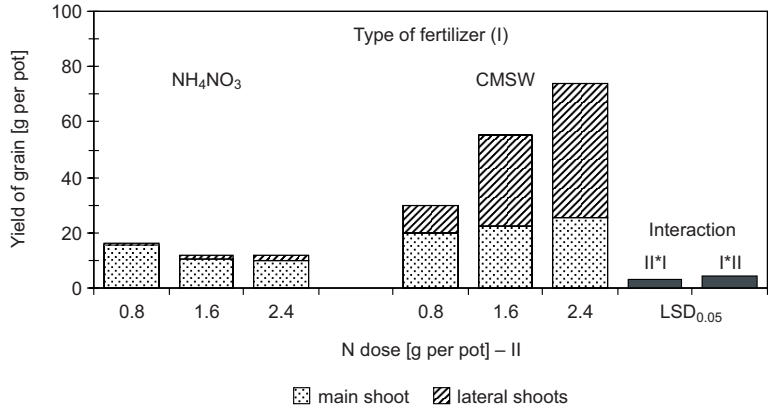

Fig. 2. Yield of wheat grain in dependence on fertilization

Table 1

Yield structure of winter wheat

Fertilizer	N dose [g per pot]	Number of shoots per plant		Number of grain per ear		Number of grain per plant	1000 grain weight [g]
		fertile	sterile	main shoot	lateral shoots		
NH_4NO_3	0.8	0.08	1.5	33.6	1.86	35.2	38.7
	1.6	0.19	1.3	28.8	2.60	31.3	31.2
	2.4	0.39	1.5	28.4	5.10	33.4	29.3
CMSW	0.8	1.00	2.7	35.1	23.8	58.8	42.7
	1.6	2.19	1.7	45.1	70.3	115.3	39.9
	2.4	3.00	1.7	48.7	93.9	142.5	43.3
$LSD_{0.05}$		0.161	0.089	0.470	0.428	0.399	0.631

Haneklaus et al [4] supposes however, that in deficit conditions an intra-plant competition for sulfur takes place and in its effect lateral shoots are kept alive at the cost of ear growth and number of seeds per ear. In the experimental wheat plants fertilized with sulfur also a higher mass of a thousand seeds was noted (Table 1), although it is not confirmed by Karmoker et al [6]. According to Castle and Randall [9], sulfur shortage causes abridgement of time necessary to kernel cell division and acceleration of storage protein synthesis phase, as a result of which the number of cells and possibility of their filling decrease. Moreover, incorporation of nitrogen to seed protein still requires sulfur supply after the end of flowering [10], which probably affected better seed filling in the present experiment.

Conclusions

1. The use of a fertilizer with sulfur caused positive changes in the growth and development of wheat and as a consequence these plants gave significant higher yield in comparison to plants cultivated without sulfur.

2. Efficiency of nitrogen and its usefulness for the yielding potential of wheat was very low in conditions of sulfur deficit.

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Abstrakt: Doświadczenie prowadzono w wazonach Mitscherlicha, na glebie o niskiej zawartości siarki. W doświadczeniu zastosowano trzy wzrastające dawki N z użyciem nawozu bezsiarkowego (saletra amonowa) oraz czteromocznikanu siarczanu wapnia jako źródła azotu i siarki. Stwierdzono, że od początku wzrostu i rozwoju pszenicy wyższe plony suchej masy uzyskano na obiektach, w których stosowano dodatkowo nawożenie siarką. Rośliny dojrzałe, które nawożono siarką, dały wyższy plon ziarna na wszystkich poziomach nawożenia w porównaniu do obiektów nawożonych tylko azotem. Uzyskany wzrost plonu wynikał przede wszystkim ze wzrostu liczby pędów bocznych kłosowych oraz liczby ziaren w kłosie pędu głównego i kłosach pędów bocznych. Po zastosowaniu każdej z dawek siarki stwierdzono również wzrost MTZ w porównaniu do równoległych obiektów N bez siarki.

Słowa kluczowe: doświadczenie wazonowe, pszenica ozima, azot, siarka, struktura plonu