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IMPACT OF THE VARIABLE LEVEL OF POTASSIUM FERTILIZATION ON FRAGILITY OF A RACHIS OF THE SELECTED SPELT VARIETIES

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ABSTRACT

The objective of the research was to determine and compare values of forces necessary to separate a rachis of four selected varieties of spelt at the use of two levels of potassium fertilization. The tests were carried out with a testing machine MTS Insight 2. Measurements were carried out separately for upper, central and bottom zone of a rachis. Based on the obtained results, it was stated that the researched varieties of spelt show a considerable variability on account of rachis strength in particular rachis zones. In the upper zone, the level of the applied potassium fertilization did not influence the rachis strength. It was related to all the researched varieties and the force values, at which separation of the rachis segment occurred, were within 1.09 to 1.67 N in relation to the variety. In the lower zone of rachis, its strength in all varieties was the biggest regardless the applied potassium dose.

Introduction

Spelt (*Triticum aestivum ssp. spelta*) is a subspecies of common wheat, which on the territory of Europe has been known and cultivated from approx. 3000 years. This grain has become popular in cool climate regions: in Scandinavia, in mountainous regions of Germany, Switzerland and in Poland. As early as in the beginning of the 20th century, in some regions of Germany and Switzerland, acreage of its cultivation was bigger than other bread wheat. Later, spelt has been finally driven out from cultivation by introduction of new wheat varieties, which characterize with better crop and simpler threshing (Sulewska et al., 2008; Tyburski and Babalski, 2006). Only in the end of the 20th century, another increase of spelt popularity, related to organic food production has taken place. Investigation on the chemical composition of seeds of this wheat showed its precious nutritional values. Literature data prove that within this subspecies of wheat, there are forms, characterizing with more advantageous biochemical composition of seeds in comparison to the cultivation forms of common wheat (Piergiovanni et al., 1996; Ranhortra et al., 1996; Campbell, 1997; Danutė Jablonskytė-Raščė et al., 2013). This wheat has also a particular meaning in or-

ganic agriculture and for cultivation on areas with higher organic requirements. It distinguishes with low requirements concerning environmental and agrotechnical conditions, natural resistance to diseases and pests (Wiwart et al., 2004; Kordan et al., 2007) and thus with good adjustment to extensive cultivation system (Eusterschulte and Kahnt, 1995). However, the spelt cultivation is related to a serious problem, which has been insolvable so far, concerning separation of seeds from ears. Caryopses are strictly surrounded by chaffs and glumes and a fragile rachis which breaks down during threshing, makes this variety non-threshable. During the grain combine harvesting, whole non-threshed ears get to a tank and further treatment is necessary in order to separate seeds (Tyburski and Babalski, 2006). The undertaken tests were to prove, whether the phenomenon of spelt rachis fragility may be limited through the change of the level of potassium fertilization of this plant. A stronger rachis would allow prolonging the time of impact of a batten of a threshing machine drum on ears and make the seeds separation process more efficient. Differentiation of the potassium dose is justified with nutrient requirements of spelt. According to Tyburski and Babalski (2006) spelt requires very good supply in potassium because of long stalks, for formation of which, greater amount of this element is required. After a good forecrop, which very often consists of papilionaceous plants, especially perennial, an increased potassium dose may also prevent the lodging phenomenon.

The objective of the research, which was carried out was to determine and compare forces values, necessary to separate the segment of the spelt rachis, cultivated in conditions of variable level of potassium fertilization.

Material and research methodology

Ears of four winter spelt varieties constituted the research material, which according to the literature data (Konvalina et al., 2013) belong to the group of the most frequently cultivated in Poland. These were: Franckenkorn, Oberkulmer Rotkorn, Schwabekorn and Ostro. Material came from the field experiment, placed on the good rye complex soil. Spelt was fertilized with minerals with the use of the following doses of a clean component: N – 70 kg·ha⁻¹, P₂O₅ – 60 kg·ha⁻¹, whereas the potassium dose was verified with the use of 75 and 150 kg·ha⁻¹ K₂O. Ears were manually collected in the stage of full maturity of plants, separately for each variety and the level of potassium fertilization. Humidity of ears determined with the balance desiccators method was at the level of 8%. In order to determine the value of force required for separation of the rachis segment with an ear, tests of rachis segment separation of the testing machine MTS Insight 2 were carried out. Ears were divided into three equal parts marking their borderlines and thus separating 3 zones. Ears along with the rachis segments were separated individually from the lower part of an ear and the record of the ear zone, where measurement was carried out, was conducted. 100 ears for each variant of fertilization within each variety were analysed. 3 small spikelets from each zone were separated from each ear. The measurement ending of the testing machine was combined with an ear with the use of a plastic jaw chuck with high friction coefficient, which allowed reduction of its pressure on the investigated material. Manner of mounting an ear in the testing machine was presented in figure 1 below. In order to enable recording of the moment of stripping the rachis segment a tensometric head for the force measurement with

the scope up to 120 N was applied. Measurements of force values were carried out with precision up to 0.01 N.



Figure 1. Measurement head of the testing machine MTS Insight 2 with a mounted ear

In the process of rachis separation, two stages may be distinguished. The first stage (A) is related to fighting flex stresses in a rachis and deviation of its segment from the ear axis. During the second stage (B) stretching of rachis takes place, which finally leads to separation of its segment – point "z" in figure 2.

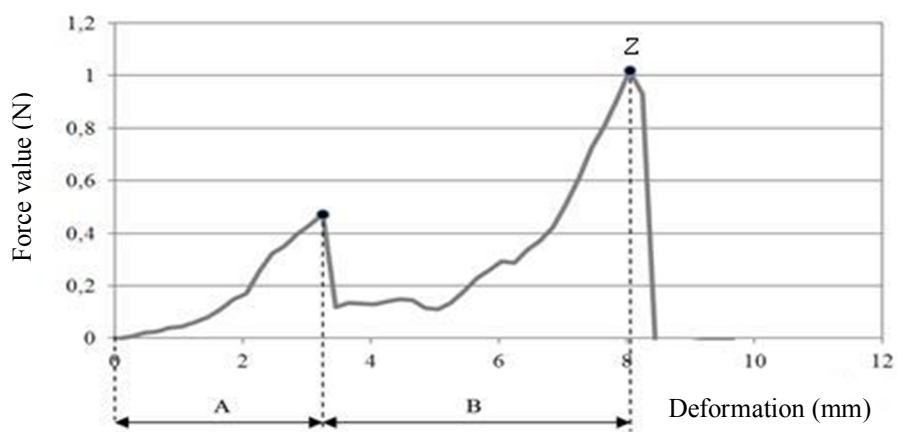


Figure 2. An exemplary course of force values changes during separation of the rachis segment

Research results and discussion

One of the factors, which are significant in the process of cereals threshing, is a binding force of a seed with an ear. According to the literature data, its values for spring wheat are within 0.96 to 1.79 N for winter wheat from 1.02 to 2.09 whereas for rye are within 0.81 to 1.31 N (Rezniček, 1971). In case of wheat spelt, a fragile rachis hinders determination of the binding force of a grain with an ear. Its division into segments takes place at the values of forces lower than those, which are necessary to separate a caryopsis from a spikelet. Rachis fragility is a genetic property, typical for tetraploid and diploid wheat species. Origin of wheat spelt (*Triticum spelta* L.) has not been entirely explained yet. Based on the genetic tests of the material, it was established that it was created, most probably, by cross-breeding of hexaploid and tetraploid common wheat, from which, they probably inherited this property (Gašiorowski, 2004; Tyburski i Babalski, 2006).

The investigated varieties of wheat spelt were varied on account of rachis strength, expressed with the value of force necessary to separate its segment with a spikelet. Reaction of varieties on the variable level of potassium fertilization was analysed separately for each from the distinguished three zones of an ear, because the flowering and ripening process of caryopses in each of them takes place in a slightly different time, which may cause the variability of mechanical properties of the rachis fragment, which is within them.

Statistical analysis of the obtained results proved that in the upper zone of an ear, a variable level of potassium fertilization did not influence the rachis strength and it concerns all investigated varieties (table 2). In case of varieties: Oberkulmer Rotkorn, Ostro, Schwabenkorn, the rachis of the upper zone of an ear characterized with strength and the average value of the force which causes separation of its segment was 1.58 N (table 1). In the discussed ear zone, Franckenkorn variety differed significantly from the remaining ones. Its rachis was divided into segments at the force of 1.17 N (table 2).

Table 1
Average values of forces required for separation of the rachis segment with a spikelet in particular ear zones for the investigated varieties of wheat spelt

Variety	Ear zone	Uniform groups						The force of stripping the rachis segment (N)	SD (N)
		a	b	c	d	e	f		
Franckenkorn	upper						x	1.17	0.62
Franckenkorn	central					x		1.59	0.51
Franckenkorn	lower		x					2.60	1.26
Oberkulmer Rotkorn	upper					x		1.57	0.77
Oberkulmer Rotkorn	central				x			2.13	0.95
Oberkulmer Rotkorn	lower	x						3.29	1.67
Ostro	upper					x		1.62	0.54
Ostro	central			x	x			2.25	0.59
Ostro	lower	x						3.50	1.90
Schwabenkorn	upper					x		1.56	0.72
Schwabenkorn	central					x		1.60	0.55
Schwabenkorn	lower		x	x				2.42	1.37

SD – standard deviation

a,b,c,d,e,f – uniform groups acc. to Duncan test

Table 2

Average values of forces required for separation of the rachis segment with a spikelet in the upper ear zone for the investigated varieties of wheat spelt

Spelt variety	Dose of K ₂ O (kg·ha ⁻¹)	Uniform groups			The force of stripping the rachis segment (N)	SD (N)
		a	b	c		
Franckenkorn	75			x	1.09	0.58
Franckenkorn	150			x	1.25	0.66
Oberkulmer Rotkorn	75		x		1.49	0.73
Oberkulmer Rotkorn	150	x	x		1.65	0.80
Ostro	75	x	x		1.56	0.54
Ostro	150	x	x		1.67	0.53
Schwabenkorn	75	x	x		1.53	0.62
Schwabenkorn	150	x	x		1.59	0.81

SD – standard deviation

a, b, c – uniform groups acc. to Duncan test

In the central zone, rachis of the following varieties: Franckenkorn, Oberkulmer Rotkorn and Ostro was the strongest in comparison to the upper zone. It was reflected in the values of the registered forces, which regardless the level of the applied potassium fertilization had higher values (table 1). In the analysed zone, the highest value of the force, leading to the rachis division into segments, was registered in case of Ostro variety at both fertilization variants and Oberkulmer Rotkorn variety which was fertilized with potassium in the doze of 150 kg·ha⁻¹. Average value of this force was 2.27 N (table 3). The lowest rachis strength was reported in Franckenkorn variety with the potassium dose of 75 kg·ha⁻¹.

Table 3

Average values of forces required for separation of the rachis segment with a spikelet in the central ear zone for the investigated varieties of wheat spelt

Variety	Dose of K ₂ O (kg·ha ⁻¹)	Uniform groups					The force of stripping the rachis segment (N)	(SD) (N)
		a	b	c	d	e		
Franckenkorn	75					x	1.49	0.54
Franckenkorn	150					x	1.69	0.47
Oberkulmer Rotkorn	75					x	1.93	0.52
Oberkulmer Rotkorn	150	x	x				2.32	1.21
Ostro	75	x	x				2.29	0.59
Ostro	150		x				2.20	0.59
Schwabenkorn	75				x	x	1.59	0.60
Schwabenkorn	150				x	x	1.59	0.50

SD – standard deviation

a, b, c, d, e – uniform groups acc. to Duncan test

The central zone showed also significant differences concerning rachis strength in relation to the potassium dose. They concerned two varieties: Franckenkorn and Oberkulmer Rotkorn. At a higher level of potassium fertilization which was $150 \text{ kg}\cdot\text{ha}^{-1}$, forces, at which a rachis segment with an ear was separated in case of the mentioned varieties, were respectively 13.4 and 20.2% (table 3). However, due to considerably high variability of this property and small differences in its values in relation to the level of potassium fertilization, one may not clearly determine that the rachis strength increase was caused only by a varied potassium fertilization.

The lower ear zone registered the highest values of forces, at which a rachis was divided into particular segments. It relates to each investigated varieties (table 1). The biggest rachis strength in the lower zone with an average force value of 3.46 N was reported in case of Ostro variety at both levels of potassium fertilization and Oberkulmer Rotkorn variety at the higher potassium dose (table 4). The lowest rachis strength in the discussed zone was determined in case of Schwabenkorn variety at both potassium fertilization levels and it was at the average of 2.42 N (table 4). In the lower zone, also significant differences in the rachis anti- breaking strength were determined in relation to the potassium dose, but only in case of Oberkulmer Rotkorn variety. The increase of the potassium fertilization level resulted, in case of this variety, the increase of the force value necessary to separate the rachis segments. This value at the increase of the potassium dose from 75 to $150 \text{ kg}\cdot\text{ha}^{-1}$ increased from 3.19 to 3.38 N i.e. by 5.9% (table 4). This small increase in the rachis strength at quite high variability of this property in the discussed variety, particularly in the lower zone, does not allow explicit statement whether it was only caused by a variable level of potassium fertilization. It requires confirmation during further research.

Table 4

Average values of forces required for separation of the rachis segment with a spikelet in the lower ear zone for the investigated varieties of wheat spelt

Variety	Dose of K_2O ($\text{kg}\cdot\text{ha}^{-1}$)	Uniform groups				The force of stripping the rachis segment (N)	SD (N)
		a	b	c	d		
Franckenkorn	75			x		2.62	1.30
Franckenkorn	150			x		2.58	1.21
Oberkulmer Rotkorn	75		x			3.19	1.60
Oberkulmer Rotkorn	150	x				3.38	1.73
Ostro	75	x				3.51	2.17
Ostro	150	x				3.48	1.54
Schwabenkorn	75			x	x	2.45	1.43
Schwabenkorn	150				x	2.40	1.32

SD – standard deviation

a, b, c, d – uniform groups acc. to Duncan test

Conclusions

1. The wheat spelt varieties, which were investigated, showed a considerable variability on account of rachis strength in particular ear zones.
2. A varied level of potassium fertilization did not significantly influenced the rachis strength in the upper zone, it concerns all investigated varieties. Values of forces, at which rachis segment was separated in this zone, were formed in relation to the variety within 1.09 to 1.67 N.
3. In the lower zone of an ear, regardless the potassium dose, rachis in case of all varieties was the highest and it was from 2.40 to 3.51 N.

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WPLYW ZMIENNEGO POZIOMU NAWOŻENIA POTASOWEGO NA ŁAMLIWOŚĆ OSADKI KŁOSA WYBRANYCH ODMIAN ORKISZU PSZENNEGO

Streszczenie. Celem podjętych badań było określenie i porównanie wartości sił potrzebnych do oddzielenia segmentu osadki kłosa czterech wybranych odmian orkisz pszennego, przy zastosowanych dwóch poziomach nawożenia potasowego. Badania wykonano za pomocą maszyny wytrzymałościowej MTS Insight 2. Pomiary wykonywano oddzielnie dla górnej, środkowej i dolnej strefy kłosa. Na podstawie otrzymanych wyników stwierdzono że badane odmiany orkisz wykazują znaczną zmienność pod względem wytrzymałości osadki w poszczególnych strefach kłosa. W strefie górnej poziom zastosowanego nawożenia potasowego nie miał wpływu na wytrzymałość osadki. Dotyczyło to wszystkich badanych odmian a wartości sił przy których następowało oddzielenie segmentu osadki kształtowały się w zależności od odmiany w zakresie od 1,09 do 1,67 N. W dolnej strefie kłosa wytrzymałość osadki wszystkich odmian była największa niezależnie od zastosowanej dawki potasu.

Słowa kluczowe: orkisz pszenny, dawka potasu, wytrzymałość osadki kłosa.