Influence of cereal seed size on shoot and root length

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Einfluß der Saatgutgröße auf die Sproß- und Wurzellänge

1. Introduction

It has been noticed by several researches that large cereal seed, i.e. seed with larger endosperm and a bigger quantity of nutrients, germinates faster and very intensively in comparison with small seed. PETERSON et al. (1989) reported that seed reserves are essential for germination of cereals including wheat. The size of the embryo was the most important factor in seed germination (LOPEZCASTANEDA et al., 1996). Some authors claim to have got quite opposite results, i.e. NEDEL et al. (1996) concluded that the large seed positively affected coleoptile length, root dry weight and seedling dry weight at early stages of plant development, but had no effect on emergence rate index and plant and root dry weights at 40 days after emergence. CHASTAIN et al. (1995 a, b) presented similar results whereas the large seed of winter barley had more rapidly germination and plants grown from large seeds were somewhat larger in spring, but seed size had no other effect on growth or yield. Researches have been conducted on these three species of cereals which are of considerable importance for Croatia.

2. Material and methods

During 1996 and 1997, the researches were carried out on the variety ZITARKA (winter wheat variety), JARAN (spring barley variety) and VESNA (spring oat variety). Three seed fractions (2.8 mm, 2.5 mm and 2.2 mm in diameter) were calibrated by a calibration machine according to EBC, and unsieved seed being used as a control. In the first research year tested seed of all cereals and varieties was harvested in 1995. Also, in the second tested year the tested seed fractions were separated from grain yield har-

Zusammenfassung

Anfangs 1996 und 1997 wurden Untersuchungen im Labor der Landwirtschaftlichen Fakultät Osijek durchgeführt mit dem Ziel, den Einfluß der Saatgutgröße (Winterweizen, Sommergerste und Sommerhafer) auf die Sproß- und Wurzellänge festzustellen. Diese auf vier Kalibrierungen durchgeführten Untersuchungen (drei verschiedene Korngrößendurchschnitte: 2,8 mm, 2,5 mm und 2,2 mm und der ungesiebte Samen als Kontrolle) haben gezeigt, daß für alle drei Getreidearten charakteristisch ist, daß die kleinsten Samen die kürzesten Sprosse ergeben, und umgekehrt. Aufgrund des zweijährigen Durchschnitts wurde festgestellt, daß von allen Getreiden die besten Resultate bezüglich der Sproßlänge für die Samenfraktion von 2,8 mm kennzeichnend waren: Winterweizen 71,4 mm, Sommergerste 92,1 mm und Sommerhafer 82,9 mm. Anderseits gab es bei den Kleinsamen aller Getreidearten (Korngrößendurchschnitt 2,2 mm) niedrige Resultate: Winterweizen 48,3 mm, Sommergerste 48,1 mm und Sommerhafer 64,0 mm. Statistisch betrachtet waren die festgestellten Unterschiede zwischen den Sproßlängen bei allen Getreidearten hoch signifikant ($P < 0,01$).

Ähnliche Ergebnisse gab es, als man den Einfluß der Saatgutgröße auf die Wurzellänge untersuchte. Es wurde für alle drei Getreidearten festgestellt, daß Kleinsamen kürzere Wurzeln haben, und umgekehrt. Aufgrund des zweijährigen Durchschnitts stellte man fest, daß von allen Getreiden die besten Resultate bezüglich der Wurzellänge für die Samenfraktion von 2,8mm kennzeichnend waren: Winterweizen 131,9 mm, Sommergerste 182,2 mm und Sommerhafer 97,4 mm. Anderseits gab es bei den Kleinsamen aller Getreidearten (Korngrößendurchschnitt 2,2 mm) niedrige Resultate: Winterweizen 102,6 mm, Sommergerste 120,7 mm und Sommerhafer 79,4 mm. Statistisch betrachtet waren die festgestellten Unterschiede zwischen den Sproßlängen bei allen Getreidearten hoch signifikant ($P < 0,01$).

Schlagworte: Winterweizen, Sommergerste, Sommerhafer, Samenfraktion, Sproßlänge, Wurzellänge.

Summary

During the years 1996 and 1997, researches on the influence of winter wheat, spring barley and spring oats seed size on shoot and root length were carried out in the laboratory of the Faculty of Agriculture in Osijek (Croatia). During the research on four calibrations (three seed fractions as follows: 2.8; 2.5 and 2.2 mm of diameter and unsieved seed being used as a control), it was found that large seeds had the longest shoot, whereas small seeds resulted in the shortest shoot. According two years average, the seed fractions of 2.8 mm have the highest values of shoot length by all cereals as follows: winter wheat 71.4 mm, spring barley 92.1 mm and spring oat 82.9 mm. Also, the lowest values of shoot length were attained with small seed (seed fractions of 2.2 mm) by all tested cereals: winter wheat 48.3 mm, spring barley 48.1 mm and spring oat 64.0 mm. The differences found in shoot length between seed fractions with all cereals are statistically highly significant ($P < 0.01$).

Similar results were also achieved with the seed size influence on root length. The largest seeds had the highest values of root length, also the smallest one had the shortest root, with all tested cereals. According to two year average, the seed fractions of 2.8 mm have the highest values of root length as follows: winter wheat 131.9 mm, spring barley 182.2 mm and spring oat 97.4 mm. Also, the lowest values of root length were attained with small seed (seed fractions of 2.2 mm): winter wheat 102.6 mm, spring barley 120.7 mm and spring oat 79.4 mm. The differences found in root length between seed fractions by all cereals are statistically highly significant ($P < 0.01$).

Key words: winter wheat, spring barley, spring oats, seed size, seed fraction, shoot length, root length.

vested in 1996. The seed was placed on the blotting paper to germinate by the means of the standard method in laboratory conditions (ISTA, 1985). It was a four time repeated experiment; there were 500 seeds used in each replicate (2000 seeds for each seed fraction). Shoot and root length was measured by millimetre callipers and the results are expressed as millimetres. The obtained results were tested by analysis of variation (two factorial trials) and existing differences were tested by LSD-test.

3. Results and discussion

The shoot and root length measurement was preceded by weight measurement of 1000 seeds according to seed fractions, and the results are presented in Table 1. 1000 kernels of large seeds of the above mentioned cereals weighted more than 1000 kernels of small seeds, in both tested years. Similar results were obtained by MATOTAN (1992), MARTINČIĆ and GUBERAC (1994) and GUBERAC et al. (1998), who found that larger seeds have a larger endosperm and higher 1000-kernel weight.

The best results in shoot and root length (Table 2 and Table 3) were obtained by large cereal seed (2.8 mm in diameter) and the poor ones by small cereal seed (2.2 mm in diameter). According to two year average, the longest shoot lengths were 71.4 mm by large wheat seed, 92.1 mm by large barley seed and 82.9 mm by large oat seed. Also, the shortest lengths were attained with small cereal seed as follows: 48.3 mm by small wheat seed, 48.1 mm by small barley seed and 79.4 mm by small oat seed. The longest root lengths were 1319 mm by large wheat seed, 182.2 mm by

Table 1: 1000 kernel weight (g) of cereal seed fractions, during two investigation years
Tabelle 1: Tausendkorngewicht (g) der Samengetreidefraktion während der zweijährigen Untersuchung

Seed diameter		Seed of 2,8 mm in diameter	Seed of 2,5 mm in diameter	Seed of 2,2 mm in diameter	Unsieved seed
First tested year	Winter wheat	47.31	37.82	27.40	36.61
	Spring barley	48.13	40.23	30.02	43.11
	Spring oats	34.60	30.98	24.87	29.90
Second tested year	Winter wheat	46.35	35.89	27.05	36.12
	Spring barley	47.88	39.96	30.13	42.15
	Spring oats	34.12	31.01	23.45	28.96

large barley seed and 97.4 mm by large oat seed. According to research results, the shortest root lengths were attained with small cereal seed, as follows: 102.6 mm by small wheat seed, 120.7 mm by small barley seed and 79.4 mm by small oat seed. The shoot and root length is defined by a correlation coefficient, i.e. r = 0.960** by wheat, r = 0.972** by barley and 0.849** by oat. These results are proved by research carried out by SARIC (1981), KASTORI (1984), KOLAK (1994), RAGASITS et al. (1992), MATOTAN (1992), MARTINČIĆ and GUBERAC (1994) and GAN et al. (1996a). They stress that large wheat seed has more developed and longer shoot and root than small seed. NAYLOR (1993), DOUGLAS et al. (1994), MIAN and NAFZIGER (1994), GAN and STOBBE (1995), GAN et al. (1996b), and BOCKUS et al. (1996) presented similar results whereas concluded that large seeds have some advantages during germination and emergence, in comparison with small seed. These results are proved by research conducted by KASTORI (1984) and GUBERAC (1992). Similar results are obtained by KASTORI (1984). He found out that larger oats seed germinates with longer roots in comparison with smaller seed. Seed quality of spring oats is of crucial importance for germination and emergence and plant growing (MARSHAL and SORRELLS, 1992). Some authors state that shoot and root growth can to be inhibited by the presence of ethanol in seed as well as by air deficiency in soil (PARKER and PROUDLOVE, 1995 and VANOVA et al., 1995). The tested years (factor B) have statistically not significant (ns) influences on shoot and root lengths, by all tested cereals (Table 2 and Table 3).

4. Conclusion

On the basis of research results the following may be concluded; winter wheat, spring malting barley, and spring oats larger seed have the advantage in the process of germination and sprouting in comparison with smaller seed. Larger seed of the above mentioned cereals will develop both a longer shoot and a longer root, owing to a larger endosperm and a bigger quantity of nutrients. This is the

Table 2: Shoot length (mm) of cereal seed fractions, during two tested years
Tabelle 2: Sproßlänge (mm) der Samengetreidefraktion während der zweijährigen Untersuchung

Seed diameter (Factor A)		Seed of 2.8 mm in diameter	Seed of 2.5 mm in diameter	Seed of 2.2 mm in diameter	Unsieved seed
Two years average 1996 and 1997 (Factor B)	Winter wheat	71.4	68.2	48.3	63.5
	Spring barley	92.1	70.9	48.1	69.6
	Spring oat	82.9	72.3	64.0	67.6
		F-test	LSD-test		
Winter wheat (A)		365.473^{**}	$LSD_{0,05}=1.712$ $LSD_{0,01}=2.460$		
(B)		2.055^{ns}			
Spring barley (A)		453.397^{**}	$LSD_{0,05}=2.692$ $LSD_{0,01}=3.868$		
(B)		0.915^{ns}			
Spring oat (A)		93.029^{**}	$LSD_{0,05}=2.715$ $LSD_{0,01}=3.901$		
(B)		0.222^{ns}			

^{ns}-not significant

Table 3: Root length (mm) of cereal seed fractions, during two tested years
Tabelle 3: Wurzellänge (mm) der Samengetreidefraktion während der zweijährigen Untersuchung

Seed diameter (Factor A)		Seed of 2.8 mm in diameter	Seed of 2.5 mm in diameter	Seed of 2.2 mm in diameter	Unsieved seed
Two years average (1996 and 1997) Factor B	Winter wheat	131.9	119.9	102.6	116.1
	Spring barley	182.2	169.4	120.7	154.8
	Spring oat	97.4	86.0	79.4	90.2
		F-test	LSD-test		
Winter wheat (A)		71.681^{**}	$LSD_{0,05}=4.571$ $LSD_{0,01}=6.568$		
(B)		0.137^{ns}			
Spring barley (A)		246.992^{**}	$LSD_{0,05}=5,401$ $LSD_{0,01}=7,760$		
(B)		0.027^{ns}			
Spring oat (A)		$96,840^{**}$	$LSD_{0,05}=2.451$ $LSD_{0,01}=3.522$		
(B)		0.415^{ns}			

^{ns}-not significant

reason why one should use larger seed fraction, whenever it is possible, for the sowing of these cereals. The following researches should be indicated by the influence of larger cereal seed fractions on the further growth and development of young seedlings.

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