Influence of seed size on germinability, germ length, rootlet length and grain yield in spring oat

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Einfluß der Samengröße auf die Keimfähigkeit, Keimlings- und Wurzellänge und auf den Ertrag von Sommerhafer

1. Introduction

Seed quality of spring oats is of crucial importance for first phenophases and their growing, whereas the large seeds have had higher germinability, BOCKUS et al. (1996), LOPEZCASTANEDA et al. (1996), NAYLOR (1993), NEDEL et al. (1996) and positive effects on grain yield than small seeds, MARSHALL and SORRELLS (1992), GAN and STOBBE (1995, 1996). Large seeds of winter wheat have had higher laboratory germination and larger values of germ length and rootlet length, than small seeds.

MARTINČIĆ et al. (1990, 1991, 1994) reported that seed size has had the influence on the intensity and the rate of first phenophases in the development of spring barley. KOLAK (1994) has had similar results whereas large seeds of winter wheat and spring barley have had longer germ and rootlet than small seeds.

GUBERAC (1992) reported that depend of spring barley seed size, the largest values of germ length and rootlet length were attained with the seed fraction of 2,8 mm, and the lowest values with seed fraction of 2,2 mm.

PIETRZAK and FULCHER (1995) growing ten Canadian oat cultivars in 1984 and 1985 at five and four locations, have concluded that the environment has little effect on the polymorphism of seed shape. CHASTAIN et al. (1995) have concluded that large seeds have had more rapidly germination and have emerged more rapidly field emergence. Seedlings produced from large seeds of winter barley have emerged more rapidly and produced higher density stands than small seeds in Trial 1 (years 1990–1991) but not in Trial 2 (years 1991–1992), and plants grown from large seed were somewhat larger in spring, but seed size had no other effect on growth or yield.

On the basis of the above-mentioned facts, the objective of the investigation was to determine whether there are any effects of varying seed size on germ length, rootlet length, germinability and grain yield.

Zusammenfassung

Im Laufe des Jahres 1996 wurden Laborforschungen über den Einfluß der Sommerhafersamengröße (Kultursorte Vesna) auf die Keimfähigkeit, Keimlings- und Wurzellänge durchgeführt. Gleichzeitig wurde auch ein Feldversuch über den Einfluß der Samengröße auf den Kornertrag angestellt. Die Fraktionen mit Samendurchmesser von 2,8, 2,5 und 2,2 mm wurden isoliert und analysiert. Es wurden auch ungesiebte Samen als Kontrolle benutzt.

Die Fraktion mit Samendurchmesser von 2,8 mm hatte die größte Keimfähigkeit (99 %), dann folgt die Fraktion mit Samendurchmesser von 2,5 mm und ungesiebte Samen (97 %) und die niedrigste Keimfähigkeit hatte die Fraktion mit Samendurchmesser von 2,2 mm (95 %). Die Keimfähigkeitsunterschiede zwischen den Samenfraktionen sind statistisch hoch signifikant (P < 0,01). Ähnliche Resultate wurden auch beim Einfluß der Samengröße auf die Keimlings- und Wurzellänge ermittelt. Die Fraktion mit einem Samendurchmesser von 2,8 mm hatte die längsten (8,3 cm) Keimlinge und die längsten Wurzeln (9,8 cm). Die niedrigsten Werte hatte die Fraktion mit einem Samendurchmesser von 2,2 mm (Keimlingslänge 6,5 cm und Wurzellänge 8,0 cm). Die Unterschiede in der Keimlings- und Wurzellänge sind statistisch hoch signifikant (P < 0,01).

Die höchsten Erträge Sommerhafers wurden bei der Saat der Samen mit einem Durchmesser von 2,8 mm (4,467 t/ha) erzielt und die geringsten Erträge ergaben sich bei der Saat der Samen mit einem Durchmesser von 2,2 mm (3,376 t/ha) gewonnen. Die beobachteten Unterschiede zwischen den Samenfraktionen sind statistisch signifikant (P < 0,05).

Schlagworte: Hafer, Samengröße, Samenfraktion, Keimfähigkeit, Keimlingslänge, Wurzellänge, Kornernte.

Summary

During 1996, some laboratory tests have been conducted to determine the influence of seed size in spring oat (variety VESNA) on the germinability, germ length and rootlet length. Also, field trial has been conducted to determine the influence of seed size on the grain yield. Seed calibration has been performed and seed fractions (mm of diameter) as follows: 2,8; 2,5; 2,2 were analysed; as well as unsieved seed as a control.

The seed fraction of 2,8 mm has had the largest values of germinability (99 %), further the seed fraction of 2,5 mm and unsieved seed (97 %), whereas the lowest values were attained with the seed fraction of 2,2 mm (95 %). The differences in germinability found between seed fractions have been statistically very significant ($P < 0,01$). Similar results were also achieved with the seed size influence on germ length and rootlet length. Seed fraction of 2,8 mm had the largest values of germ length (8,3 cm) and rootlet length (9,8 cm), whereas the lowest values were attained with the seed fraction of 2,2 mm, respectively (germ length 6,5 cm and rootlet length 8,0 cm). The found differences in germ length and rootlet length between seed fractions have been statistically very significant ($P < 0,01$).

The greatest grain yield of spring oats were attained with the seed fraction of 2,8 mm (4,467 t/ha), and the smallest grain yield with the seed fraction of 2,2 mm (3,376 t/ha). The found differences between seed fractions have been statistically significant ($P < 0,05$).

Key words: oat, seed size, seed fraction, germinability, rootlet length, germ length, grain yield, seed stuff.

2. Material and methods

During 1996, the investigation was carried out in the laboratory of the Osijek Agricultural Faculty on the spring oat variety VESNA, which was originated at Faculty of Agronomy in Zagreb. Variety VESNA has a low stem (80–85 cm), 1000-kernels weight 28–32 g and genetic potential 5 t/ha (KOLAK, 1994). Seed fractions were separated on the device after EBC. Four seed fractions were included in testing (mm of diameter) as follows: 2,8; 2,5; 2,2; and unsieved seed previously served as control. This was followed by measurements of the 1000-kernel weight in four replications for each seed size.

In the laboratory tests, for the analysis influence of seed size on total germinability we applied the standard method for testing germinability in four replications on filter paper as a pad. Each replication has had one hundred seeds. The wetted filter paper with seeds left at 5° C during five days and then at 20° C during seven days. After that, the total germinability was found out.

The determination of influence of seed size on germ length and rootlet length was preceded by taking samples of 1000 seeds from each seed size, and from unsieved seed. The trial was established in ten replications (each replication value was average of one hundred single measurements). The investigation included 4000 seeds and 4000 single measurements, respectively (four treatments, ten replications and one hundred seeds). The seed was placed on wetted filter paper, covered with another filter paper and wrapped into rolls, whose lower part was dipped into a pot with water. The rolls were kept at 20° C for seven days. After that, the measurements of the germ length and rootlet length were done using a sliding scale (mm) and the data obtained in investigation were processed by the statistical analysis of variance and tested using the Lsd-test.

The field trial was conducted during 1995 growing seasons on Osijek euteric cambisol of a normal degree of soil fertility, whose agrochemical characteristics are given in Table 1.

Table 1: Soil analysis data on Osijek euteric cambisol (Eastern Croatia)
Tabelle 1: Angaben über die Bodenuntersuchung (Osijek euterischer Cambisol)

Humus	(%)	1,00
pH (H_2O)		6,08
N-NO_3	mg/100 g	2,43
N-NH_4	mg/100 g	0,81
P	mg/100 g	1,66
K	mg/100 g	7,79
Ca	mg/100 g	26,51
Active clay	(%)	20,51

Previous crop was soybean. Also, there were used four seed fractions as follows: 2,8 mm, 2,5 mm, 2,2 mm and unsieved seed previously served as control in field trial. The field experiment was conducted by the latin square design with four treatments and exp. plot size 50 m^2 (10 m x 5 m). The sowing rate was 550 germinable seeds/m^2. Interrow spacing was 12,5 cm. Before sowing, the seeds were treated with

VITAVAX preparation (fungicide). During vegetation, the crops were not treated with herbicide and insecticide. Fertilizers were added in soil as follows: 100 kg N, 80 kg P_2O_5 and 80 kg K_2O. The results of field investigation were processed statistically using the variance analysis (latin square) and tested with LSD-test.

3. Results

3.1 Laboratory testing

After seed size separation, the 1000-kernels weight was measured for each seed fraction and the results are shown in Table 2. The results suggest that the 1000-kernels weight was decreasing with smaller seeds of spring oats.

Table 2: 1000-kernels weight of spring oat seed size
Tabelle 2: Einfluß der Samengröße auf das 1000-Korngewicht des Sommerhafers

	1000-kernels weight (g)			
Seed size (mm)	2,8	2,5	2,2	Unsieved seed
Replication 1	34,45	31,33	24,84	30,12
Replication 2	35,06	32,14	24,80	30,06
Replication 3	34,64	31,78	23,14	29,78
Replication 4	33,98	31,39	24,06	29,93
Average	34,53	31,66	24,21	29,97

The results of testing the influence of seed size on germinability of spring oats, as well as the results of the statistical data processing are shown in Table 3. The largest values of germinability were attained with the seed fraction of 2,8 mm (99 %), and the lowest with the seed fraction of 2,2 mm (95 %). The differences were very significant ($P < 0,01$).

Table 3: The influence of seed size on germinability of spring oat
Tabelle 3: Einfluß der Samengröße auf die Keimfähigkeit des Sommerhafers

	Germinability (%)			
Seed size (mm)	2,8	2,5	2,2	Unsieved seed
Replication 1	99	97	95	97
Replication 2	10	97	95	98
Replication 3	98	98	95	97
Replication 4	99	96	95	96
Average	99	97	95	97
F = 21,33333**	**$LSD_{0,05}$ = 1,0895**		**$LSD_{0,01}$ = 1,5275**	

The results of testing the influence of seed size on germ length are shown in Table 4. Depend on the seed size, the largest values of germ length were attained with the seed fraction of 2,8 mm (8,3 cm), and the lowest with the seed fraction of 2,2 mm (6,5 cm).

Similar connection was found between seed size and rootlet length (Table 5). The largest values of rootlet length were attained with the seed fraction of 2,8 mm (9,8 cm), and the lowest with the seed fraction of 2,2 mm (8,0 cm), respectively. The differences in germ length and rootlet length between seed fractions were very significant ($P < 0,01$).

Table 4: Influence of seed size on germ length of spring oat
Tabelle 4: Einfluß der Samengröße auf die Keimlingslänge des Sommerhafers

	Germ length (cm)			
Seed size (mm)	2,8	2,5	2,2	Unsieved seed
Replication 1	8,5	7,5	6,7	6,8
Replication 2	8,2	7,6	6,5	6,7
Replication 3	8,4	7,7	6,3	6,9
Replication 4	8,3	7,5	6,5	6,8
Replication 5	8,3	7,3	6,2	6,7
Replication 6	8,3	7,3	6,5	6,8
Replication 7	8,1	7,5	6,8	6,9
Replication 8	8,5	7,4	6,8	6,7
Replication 9	8,3	7,5	6,2	6,8
Replication 10	8,1	7,7	6,5	6,9
Average	8,3	7,5	6,5	6,8
F = 268,9091**	**$LSD_{0,05}$ = 0,1355**		**$LSD_{0,01}$ = 0,1781**	

Table 5: Influence of seed size on rootlet length of spring oat
Tabelle 5: Einfluß der Samengröße auf die Wurzellänge des Sommerhafers

	Rootlet length (cm)			
Seed size (mm)	2,8	2,5	2,2	Unsieved seed
Replication 1	9,8	8,9	8,0	9,2
Replication 2	9,7	8,7	7,9	9,1
Replication 3	9,9	8,8	8,1	9,5
Replication 4	9,8	8,8	7,7	8,9
Replication 5	9,9	8,9	8,3	9,2
Replication 6	9,8	8,8	7,9	9,3
Replication 7	9,7	8,7	8,0	9,2
Replication 8	10,0	8,6	8,1	9,0
Replication 9	9,8	9,0	7,8	9,4
Replication 10	9,6	8,8	8,2	9,2
Average	9,8	8,8	8,0	9,2
F = 250,2413**	**$LSD_{0,05}$ = 0,1323**		**$LSD_{0,01}$ = 0,1739**	

3.2 Field experiment

In field investigation (Table 6 and Figure 1), the greatest grain yield was attained with the seed fraction of 2,8 mm (4,467 t/ha), and the smallest grain yield with the seed fraction of 2,2 mm (3,376 t/ha). The differences found in grain yields between seed fractions were statistically significant ($P < 0{,}05$).

Table 6: Influence of seed size on grain yield of spring oat
Tabelle 6: Einfluß der Samengröße auf den Ertrag des Sommerhafers

	Grain yield (t/ha)			
Seed size (mm)	2,8	2,5	2,2	Unsieved seed
Replication 1	4,315	4,155	3,382	4,013
Replication 2	4,493	3,390	3,576	3,524
Replication 3	4,586	4,175	3,055	3,888
Replication 4	4,476	3,901	3,494	4,114
Average	4,467	3,905	3,376	3,884
F = 6,651*	**LSD $_{0,05}$= 0,4882**		**LSD $_{0,01}$ = 0,7396**	

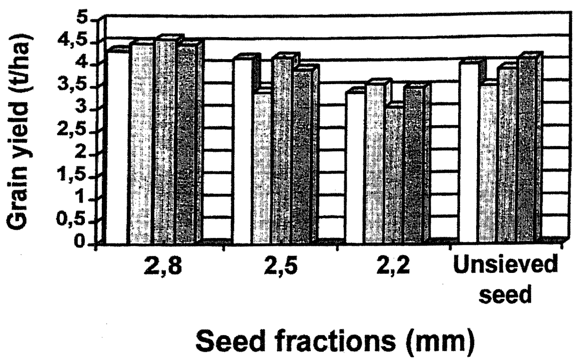

Figure 1: Influence of seed size on grain yield of spring oat
Abbildung 1: Einfluß der Samengröße auf den Ertrag des Sommerhafers

4. Discussion

The 1000-kernels weight has had the largest values with the seed size of 2,8 mm (34,53 g) and the lowest ones were obtained with the seed fraction of 2,2 mm (24,21 g). Such results were expected since larger seed has a larger endosperm, which means also a larger portion in the total kernel weight.

MARTINČIĆ et al. (1990) reported that larger seeds have a larger endosperm and larger laboratory germinability. So they stated that with smaller seeds there is also a reduction of the above-mentioned nutrients portion, which has had a negative impact on the total germinability.

Such high germinability rate of the largest seed was probably due to the fact that large seed has a large endosperm, as compared to the smaller seed. A larger endosperm means in the most cases a more vigorous endosperm, which implies that a larger quantity of nutrients and energy matters are available to the young germ (MARTINČIĆ et al., 1991). These matters might have had larger effects on germinability in the largest seed. Similar results were obtained by MATOTAN (1992), who found that larger seed has a robust and a more vigorous germ which needs less time to emerge on the soil surface.

Also, seed size and 1000-kernels weight have a positive effect on the germ length and rootlet length. Such greatly revealed differences in the germ and rootlet length among certain seed size in spring oats might have been the consequence of the very seed size, endosperm filling with nutrient matters and the presence of a larger quantity of physiologically active matters in larger seed. Such larger seeds have a larger quantity of reserve, nutrient and energy matters, which are available to the young germ at germination and emergence. This must have had positive effects on the speed and growth rate of the germ and rootlet. Seed size which is used in seed production (2.8 and 2.5 mm in diameter) gave statistically very significant differences in germ length and rootlet length, as compared to the smallest seed diameter tested. Large seeds of spring oats always have longer germ length and rootlet length than small seeds (UJEVIĆ, 1988). On the basis of the above-mentioned facts, it is evident that the seed size is positively correlated with the germ length and rootlet length. Larger seed has a larger content of organic matters which during the first phenophases of the development (germination and emergence) largely brings about a quicker and more intensive growth of the primary rootlets. This is particularly important from the standpoint of seed production of spring oats, where we should use primarily larger seed fractions of 2,8 and 2,5 mm as sowing stuff. With the use of such seed material, the probability of young seed crops decaying as caused by negative environmental factors is reduced to the minimum rate (MARTINČIĆ et al., 1994).

Seed size of white winter wheat has had no effect on laboratory germination, but seedlings from large seed have emerged more rapidly in the field. Plants grown from large seed were taller, heavier, and had more tillers than plants grown from small seed. Planting large seed had no effect on grain yield in Trial 1 (year 1990), but plants grown from large seed produced 4,2 % greater grain yield than from small seed in Trial 2 (year 1991, CHASTAIN et al., 1995).

JEVTIĆ (1981) has concluded that large seeds of cereals always have longer germ length and rootlet length and greater grain yield. Oats grown from large seed has produced greater grain yield than oats grown from small seed and seed size has had considerable influence on quality and grain yield (MIHALIĆ, 1985; KASTORI, 1984). SARIĆ (1981) had similar results and concluded that plants grown from large seeds had 20–30 % greater grain yield than plants grown from small seeds.

The results of the investigation suggest that we should make efforts during seed processing to provide the highest possible percentual share of the largest seeds, regardless of the seed category, and particularly in consideration of the seed grown under unfavorable climatic and soil conditions. In this way we would produce little quantities of seed of a top-quality, which is one of the preconditions for stable growing and stable grain yield of spring oats.

5. Conclusion

During 1995, laboratory and field investigations on spring oat has shown that the seed fraction of 2,8 mm had the largest values of germinability (99 %), seed fraction of 2,5 mm had 97 % of germinability, while the seed fraction of 2,2 mm had the lowest germinability (95 %). Seed fraction of 2,8 mm had the largest values of germ length (8,3 cm) and rootlet length (9,8 cm). The lowest values were attained with the seed fraction of 2,2 mm. Also, the large seeds attained the greatest grain yield.

To conclude, the large seed fraction of 2,8 mm had significantly greater germinability, germ and rootlet length and grain yield than small seed fraction of 2,2 mm.

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