Seed size, yield and harvest characteristics of three Croatian spring malting barleys

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Korngröße, Ertrag und Erntemerkmale bei drei kroatischen Sommergerstensorten

1. Introduction

Seed size is an important physical indicator of seed quality that affects vegetative growth and is frequently related to yield, market grade factors and harvest efficiency.

Generally, large seed has better field performance than small seed. Many investigators have determined that within a genotype, either greater seed mass or larger seed size will produce more vigorous seedlings and higher grain yields (McDaniel, 1969; Wood et al., 1977; Rao, 1981). Spilde (1989) reported additional attributes of spring barley and wheat grain harvested from the large seed-sized plot such as advanced maturity, lower seed moisture content and higher test mass in both crops.

On the other hand TeKrony et al. (1991) stated that crop stand and grain yield of soft red winter wheat were similar regardless of seed size in no-tillage systems. Chastain et al. (1995a, b) found no consistent yield or grain quality advantages obtained from large winter wheat and barley seed.

Examples discussed above show that the literature on this topic is contradictory. Furthermore, there is less published information relating seed size to other aspects of crop yield and performance. The objectives of this study were (i) to evaluate three Croatian spring malting barleys, each represented by four different seed sizes, (ii) to evaluate the relative influence of seed size on grain yield and yield components, (iii) to determine the effect of seed size on grain characteristics important for malting.

2. Materials and methods

Cultivars were Croatian spring malting barleys 'Knin', 'Tomislav' and 'Trojanac'. All three cultivars are early maturing, two-rowed, with genetic yield potential of about 8 t/ha, moderate disease resistance, high lodging resistance, and medium grain quality. They were introduced in commercial production in 1996 and their production areas have been increasing, particularly in Northwestern Croatia where they

Zusammenfassung

In einem Feldversuch mit drei kroatischen Sommergerstensorten (*Hordeum vulgare* L.) wurde der Einfluss der Korngröße auf den Kornertrag, Ertragskomponenten und einige für die Brauindustrie wichtige Kornmerkmale untersucht. Die Verwendung von Saatgut höherer Korngröße hatte eine höhere Bestandsdichte, Bestockungskapazität, Haupthalmlänge, Hektoliter- und Tausendkorngewicht, Keimenergie und Ertrag, früheres Reifen und niedrigeren Kornwassergehalt zur Folge. Allgemein hatte die Aussaat von größeren Körnern eine verbesserte Gesamtleistung zur Folge.

Schlagworte: Korngröße, Sommerbraugerste, Kornertrag, Ertragskomponenten, Kornmerkmale.

Summary

In a field experiment with three Croatian spring malting barleys (*Hordeum vulgare* L.) the effect of seed size on yield components, grain yield and grain characteristics important for malting was determined. With increasing seed size spike production and density, number of tillers, main stem length, thousand kernel mass, test mass, seed vigor and yield increased, maturity was advanced and seed moisture content at harvest decreased. There were varietal differences. Altogether, sowing large seeds improved total performance.

Key words: seed size, spring malting barley, grain yield, yield components, grain characteristics.

were present the most popular cultivars. Their mean yield in commercial production is approximately 3.8 t/ha. Estimated planted areas of those three cultivars were 12, 15 and 9 % of the Croatian crop total for spring barley respectively.

Seed samples of the three cultivars were sieved and placed into four sizes. Large, medium, small and very small seed were retained on perforated screens with 3.3-mm, 2.8-mm, 2.5-mm and 2.2-mm-diameter perforations respectively. The field trial was sown on 2 April 1997 at the experimental field of the Faculty of Agriculture, Zagreb, on sand loam soil. Seeding rate was 400 seeds/m^2. Laboratory germination test has shown that all samples produced 97 % normal seedlings. The experimental design was a two-factorial (three cultivars, four different seed sizes) Latin rectangle with four replicates. Plot size was 12 m^2. In order to eliminate the detrimental edge effect that very often arises in the experiments that include small grains, the center area of 7 m^2 was harvested for grain yield with a plot combine. Spike density was measured just prior to harvest on a 1 m^2 section randomly selected in each plot. Spike production (expressed as number and seed mass per spike), main stem length, and the number of secondary tillers per plant were calculated as average values from ten randomly selected plants in each plot. Clean grain yield (expressed on an as-is basis following air drying), test mass and thousand kernel mass were determined after harvest. Grain moisture content was determined with an electronic moisture tester within 24 h after harvest. Seed germination and vigor values were determined in the laboratory according to the Association of Official Seed Analysts rules (ASSOCIATION OF OFFICIAL SEED ANALYSTS, 1981). The germination substrate was rolled towels wetted in distilled water.

Analysis of variance was carried out using SAS 6.12. Data expressed as percentages were transformed prior to analysis of variance by using arc sin transformation. F-test and Duncan's Multiple Range Test were used to test null hypotheses.

3. Results and discussion

F test results indicate significant influence of both cultivars and different seed sizes on grain yield and most of other agronomic characteristics. A significant interaction between cultivars and seed sizes was found for spike density. On the other hand, the absence of interaction between cultivars and seed sizes for all other agronomic characteristics indicated that the three cultivars responded similarly to seed calibration (Table 1).

This study has shown that grain yield produced from large seed was significantly greater than that from medium and small-sized seed (Table 2). Accordingly, we observed significant differences in spike production due to seed size in spring barley; specifically, kernel number and mass per spike were the most reliable indicators of grain yield reduction affected by small seed. Furthermore, with increasing seed size spike density significantly increased. Reduced spike density associated with small seed is likely indicative of less tillering capacity, as noted in previous study (SPILDE, 1989). On the other hand, CHASTAIN et al. (1995a, b) found no significant differences in spike density in winter wheat and barley between large and small seed and concluded that increase tillering must have taken place to offset the reduced stand density of plants grown from small seed.

Some studies suggested that there was a positive correlation between a higher grain yield and an increased plant length (WADDINGTON and CARTWRIGHT, 1986; KOVAČEVIĆ, 1991). Our data indicate that main stem development was influenced by seed size. Plants grown from large seed were taller and had more fertile tillers than those grown from small seed (Table 2), which indicated that increased tillering capacity was an additional benefit impacted by seed size. CHASTAIN et al. (1995a, b) reported similar results.

Table 1: Results of analysis of variance for the examined agronomic characteristics
Tabelle 1: Ergebnisse der Varianzanalyse für die untersuchten agronomischen Merkmale

Effect	Agronomic characteristics (Probability values)										
	Yield	Spike density	Spike production		Main stem length	Tillers	Moisture content	Thousand kernel mass	Test mass	Germination	Seed vigor
	kg/7 m^2	no/m^2 number	kernel mass (g)	kernel	cm	no/plant	%	g	kg/m^3	%	%
Cultivars (C)	0.0045	0.0053	0.0229	0.0194	0.0004	0.0752	P<0.0001	0.0406	0.0002	0.5311	0.0005
Seed sizes (S)	0.0354	P<0.0001	0.0053	0.0002	P<0.0001	P<0.0001	P<0.0001	0.0358	0.0282	0.6355	0.0194
Interaction C x S	0.0511	0.0229	0.0738	0.0594	0.0682	0.0805	0.0652	0.0926	0.0892	0.5794	0.0748

α (the level of significance) = 0.05

Table 2: The effect of seed size on grain yield and other agronomic characteristics of spring barley
Tabelle 2: Einfluss der Korngrösse auf Kornertrag und andere agronomische Merkmale der Sommergerste

Seed size	Agronomic characteristics (Mean values)									
	Yield	Spike density	Spike production		Main stem length	Tillers	Moisture content	Thousand kernel mass	Test mass	Germination	Seed vigor
	kg/7 m²	no/m² number	kernel mass (g)	kernel	cm	no/plant	%	g	kg/m³	%	%
Large	4.78 a	1130 a	18.5 a	0.74 a	53.5 a	3.7 a	16.2 a	45.8 a	63.8 a	98.0 a	91 a
Medium	4.36 b	1105 a	18.4 a	0.72 a	52.3 ab	3.5 a	16.6 a	45.3 a	62.5 a	98.5 a	87 a
Small	4.32 b	1033 b	17.7 b	0.66 b	51.5 b	3.0 b	18.9 b	43.3 b	60.1 b	97.5 a	81 b
Very small	4.31 b	1026 b	17.4 b	0.63 b	51.3 b	2.9 b	19.1 b	43.0 b	59.5 b	97.8 a	73 c

Within columns, means followed by different letters are significantly different at the 0.05 probability level

Seed moisture content at harvest is an important economic factor. Increased moisture content of grain at harvest indicates an extended maturity period. SPILDE (1989) concluded that influence of seed size on seedling vigor is manifested in grain produced from large or heavy seed and found that grain moisture levels were significantly less than that for light, medium, or small seed. Similarly, our data clearly indicate that moisture content of grain at harvest significantly decreased when large seed was sown, providing for slightly earlier harvest or reduced artificial drying costs (Table 2).

An important effect associated with large seed was also manifested in greater test mass (Table 2), like the results of SPILDE (1989) whose study indicated that kernel size was more critical than mass in determining harvest grain test mass; however, CHASTAIN et al. (1995a) found that test mass in winter wheat was not affected by seed size. Another adverse effect of small seed resulted in lower thousand kernel mass that along with test mass represents an important indicator of barley quality for malt industry. By comparison, BANIAAMEUR and CADDEL (1976) found that thousand kernel mass and kernel size were associated with seed size in spring barley.

We could not detect any significant differences in laboratory germination values among different seed sizes (Table 2), whereas GUBERAC et al. (1998) found that large seed of spring oat had significantly higher laboratory germination than small. Nevertheless, seed vigor significantly increased when large seed was sown. High seed vigor will increase yield when plant density is less than that required to maximize yield, or in late plantings (TEKRONY and EGLI, 1991). The influence of seed size on seedling vigor observed by EVANS and BHATT (1977) and SPILDE (1989) was manifested in subsequent greater grain yield. CHASTAIN et al. (1995a) reported that large seed of winter wheat produced seedlings that emerged more rapidly than small seed, but final stand density was not greater for large seed. LAFOND and BAKER (1986) also showed that large seed produced heavier seedling plants in spring wheat, but unlike most other investigations, they found that small seed attained more rapid field emergence rates than large seed.

'Knin' produced the highest grain yield and consequently the highest spike production, whereas 'Trojanac' attained equivalent but lower grain yield. 'Tomislav' produced significantly poorer yield than the other cultivars tested. In addition, 'Knin' achieved the highest test mass and thousand kernel mass values. 'Tomislav' produced fewer spikes per area unit than other two cultivars. No significant differences in spike density were noted between 'Knin' and 'Trojanac'. Furthermore, there were no significant differ-

Table 3: The effect of cultivar on grain yield and other agronomic characteristics of spring barley
Tabelle 3: Des Einfluss der Sorte auf Kornertrag und andere agronomische Merkmale von Sommergerste

Cultivars	Agronomic characteristics (Mean values)									
	Yield	Spike density	Spike production		Main stem length	Tillers	Moisture content	Thousand kernel mass	Test mass	Germination	Seed vigor
	kg/7 m²	no/m² number	kernel mass (g)	kernel	cm	no/plant	%	g	kg/m³	%	%
Knin	4.70 a	1107 a	18.7 a	0.75 a	58.0 a	3.2 a	17.4 a	44.6 a	62.3 a	97.5 a	92.5 a
Tomislav	3.99 b	1033 b	17.8 b	0.66 b	47.5 c	3.3 a	17.6 a	42.6 b	60.9 b	98.0 a	83 b
Trojanac	4.63 a	1081 a	17.9 ab	0.71 ab	50.9 b	3.4 a	16.7 b	44.9 a	60.1 b	98.5 a	89 a

Within columns, means followed by different letters are significantly different at the 0.05 probability level ences in the number of fertile tillers per individual plant among cultivars. No differences in laboratory germination values were found among cultivars; however, 'Knin' was taller and emerged more rapidly than 'Tomislav' and 'Trojanac'. Significant differences among cultivars were observed in seed moisture content in harvest; particularly, 'Trojanac' exhibited the lowest moisture content in seed than 'Knin' and 'Tomislav' (Table 3).

4. Conclusions

Our results have shown that field performance of cultivars was clearly influenced by seed size. In addition to increased grain yield, this study has emphasized the influence of seed size on harvest efficiency and market value of the product, which frequently are of greater economic importance than expected yield differences. Advanced maturity and lower grain moisture content at harvest demonstrated an economic benefit associated with large seed. Additional attributes were risk minimization associated with reduced plant stands, increased seed vigor, greater test and thousand kernel mass. It appears that large seed consistently produced plants that achieved greater early growth, making these plants more likely to be competitive with weeds or survive attack from pests. By all accounts, sowing large seed ensures adequate plant populations across the wide range of field conditions that occur during emergence, vegetative growth and generative development.

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Eingelangt am 12. Juli 2001
Angenommen am 17. September 2001