The effect of different sowing strategies and nitrogen fertilization on the yield and technological quality of winter wheat grain

Summary

This study was undertaken to examine the influence of the sowing date, sowing density, and split spring application of N fertilizer on the grain yield and technological quality of winter wheat (*Triticum aestivum* L.) grown in north-eastern (NE) Poland between 2018 and 2021. The experiment involved three factors: (i) sowing date (early: 3–6 September, delayed by 14 days, and delayed by 28 days), (ii) sowing density (200, 300, and 400 live grains m^{-2}), and (iii) split application of N fertilizer in spring (40+100, 70+70, and 100+40 kg ha^{-1} in BBCH stages 22–25 and 30–31, respectively). The experiment had a split-split-plot design (sowing date was assigned to whole plot treatments, sowing density was assigned to subplot treatments, and the split spring application of N fertilizer was assigned to sub-subplot treatments) with three replications. Plot size was 15 m^2 (10 m by 1.5 m). The preceding crop was winter oilseed rape (*Brassica napus* L.).

In NE Poland, grain yields peaked when winter wheat was sown between 17 September and 4 October (10.52–10.58 Mg ha^{-1}). In late-sown winter wheat, grain yields increased due to a higher number of spikes m^{-2} and higher grain weight. The highest sowing density (400 live grains m^{-2}) induced a greater increase in grain yields than the lowest sowing density (200 live grains m^{-2}) (10.25 *vs.*10.02 Mg ha^{-1}). In winter wheat sown at a density of 400 live grains m^{-2}, the increase in grain yields resulted in a higher number of spikes m^{-2}. Grain yields peaked in response to 100 kg N ha^{-1} applied in BBCH stages 22–25 and 40 kg N ha^{-1} applied in BBCH stages 30–31 (this split N rate increased the number of spikes m^{-2}). In turn, the highest straw yield (6.23 Mg ha^{-1}) was obtained when the second split of N fertilizer was applied in BBCH stages 30–31 (40 + 100 kg N ha^{-1}). Straw yields decreased significantly (by 6%) when winter wheat was sown late (early October). Delayed sowing (mid-September and early October) increased the harvest index (HI) of winter wheat by 5–7%. Split spring N application influenced grain and straw yields, but it had no effect on the HI of winter wheat.

A sowing delay of 14–28 days increased grain bulk density by 1–1.5 percent points (%p), vitreousness by 3–6%p, and the total protein content of grain by 1–2%. A sowing delay of 14 days increased grain hardness (by 5%), the flour extraction rate (by 1.4%p), and the falling number (by 3%) while decreasing grain uniformity (by 1.9%p). In turn, a sowing delay of 28 days increased the wet gluten content of grain (+0.5–0.6%p) and improved the quality of the protein complex in the Zeleny sedimentation test (+1.5%). An increase in sowing density from 200 to 300 live grains m^{-2} led to a decrease in grain uniformity (by 2.6%p), the total protein content (by 1.5%), and the wet gluten content of grain (by 0.7%p). A further increase in sowing density decreased grain

vitreousness (by 1.4%p). The grain of winter wheat fertilized with 40 and 100 kg N ha^{-1} in BBCH stages 22–25 and 30–31, respectively, was characterized by the highest hardness (64.7), vitreousness (93%), flour extraction rate (73.9%), total protein content (134 g kg^{-1} DM), wet gluten content (36%), and Zeleny sedimentation index (69 mL).

A 28-day delay in sowing increased the total protein content (by 2%) and the water absorption capacity of flour (by 1.1%p), dough development time and stability, and the degree of softening (by 6% and 14–33%, respectively). When sowing was delayed by 14 or 28 days, crumb density decreased by 4% without affecting loaf volume. A sowing density of 400 grains m^{-2} had a positive impact on flour color (flour whiteness increased by 2–3%p), dough stability (increase of 8–11%), and loaf volume (increase of 1.5%). Flour color (78.1% of the whiteness standard) and dough stability (7.7 min) were enhanced when N was applied at 100 + 40 kg ha^{-1} in BBCH stages 22–25 and 30–31, respectively. In turn, the total protein content of flour (132 g kg^{-1} DM) peaked when it was applied at 40 + 100 kg N ha^{-1}. The quality of flour improved when winter wheat was sown at a density of 400 live grains m^{-2} with a delay of 14 or 28 days and supplied with 100 kg N ha^{-1} in the full tillering stage and 40 kg N ha^{-1} in the first node stage.