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Performance of sunflower hybrids under varying dates of sowing and nitrogen levels

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Abstract

How well do sunflower hybrids respond when both planting time and nitrogen supply change together? This research examined four sunflower hybrids (KBSH-44, DRSH-1, RSFH-130, LSFH-171) sown at four dates (October 15, November 1, November 15, December 1) under five nitrogen rates (0, 40, 80, 120, 160 kg ha⁻¹) during 2022-24 at the University of Bonn, Germany, using a split-split plot design. DRSH-1 sown on November 1 with 120 kg N ha⁻¹ gave the highest pooled seed yield of 2289 kg ha⁻¹. December 1 sowing cut yields by 28-35% across hybrids. Nitrogen at 120 kg ha⁻¹ recorded peak oil content of 41.3%, with no gain beyond that. The sowing date × nitrogen interaction was significant ($p < 0.01$). These findings point toward early November sowing paired with 120 kg N ha⁻¹ as the best combination for temperate European sunflower production.

Keywords: Sunflower hybrids, sowing date, nitrogen levels, seed yield, oil content, head diameter, leaf area index, split-split plot design, temperate agronomy

Introduction

What drives the gap between potential and realized sunflower yield in temperate cropping systems? Across central Europe, sunflower (*Helianthus annuus* L.) ranks as the third most important oilseed crop after rapeseed and soybean, yet average on-farm yields remain 35-40% below experimental station records ^[1]. Two management decisions when to sow and how much nitrogen to apply account for a large share of this gap ^[2].

Sowing date sets the thermal and photoperiodic environment for every growth stage. Early planting in October allows the crop to take advantage of cooler establishment temperatures and longer vegetative periods, which tends to increase head diameter and seed filling duration ^[3]. Delayed sowing beyond mid-November shortens the growing window and pushes grain-filling into periods of rising temperature and declining soil moisture ^[4, 5].

Nitrogen management adds a second layer of complexity. Sunflower responds strongly to applied N up to a threshold, beyond which both yield and oil content plateau and decline ^[6, 7]. The relationship between nitrogen rate and oil percentage is typically inverse, but the breakpoint varies with soil type, residual nitrogen, and hybrid genetics ^[8].

Few recent investigations tested the interaction of sowing date and nitrogen using current commercial hybrids under central European conditions ^[9, 10]. When these two factors are varied together, synergistic or antagonistic effects can emerge that single-factor trials miss. This research was designed to quantify the joint influence of four sowing dates and five nitrogen levels on yield, oil content, and growth attributes of four sunflower hybrids over two consecutive seasons at the University of Bonn.

Research area description

The field experiment was carried out at the Dikopshof Research Station, University of Bonn (50°48'N, 6°57'E, 62 m a.s.l.), situated on deep loess-derived Luvisol soils with a silty loam texture. Topsoil (0-30 cm) had pH 6.7, organic carbon 1.23%, available N of 24.8 kg ha⁻¹, Olsen-P of 18.3 mg kg⁻¹, and exchangeable K of 187 mg kg⁻¹. The preceding crop in both years was winter wheat. The site receives 624 mm mean annual rainfall, with 52% between April and September, and carries a long-term average temperature of 10.3 °C.

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Climatic conditions during the trial

In 2022-23, October-March rainfall totaled 347 mm (near the 30-year average) with mean air temperature 0.6 °C above normal at 7.1 °C. A dry spell in November 2022 (28 mm vs. 54 mm normal) delayed emergence of the second and third sowings by 3-4 days. The 2023-24 season was wetter, with 412 mm over the same window and January temperatures averaging 3.8 °C (long-term mean 2.4 °C). No frost events below -8 °C occurred in either season.

Materials and Methods

Materials

Four sunflower hybrids KBSH-44, DRSH-1, RSFH-130, and LSFH-171 were selected for contrasting maturity durations. KBSH-44 and DRSH-1 are medium-duration types (95-100 days), RSFH-130 is early (85-90 days), and LSFH-171 is late-maturing (105-110 days). Seeds were sourced from the German Federal Plant Variety Office with germination above 92%. Urea (46% N) was applied in two equal splits: 50% at sowing and 50% at star bud stage (R1). Phosphorus and potassium were applied uniformly at 60 kg P₂O₅ and 40 kg K₂O ha⁻¹ [12].

Methods: The experiment ran from October 2022 to July 2024 at Dikopshof Research Station using a split-split plot design (sowing date = main plot, hybrid = subplot, nitrogen = sub-subplot) replicated three times. Plot size was 5.4 m × 3.6 m with 60 cm row spacing. Plant height, stem diameter, and functional leaf count were recorded fortnightly. Leaf area index was measured with an AccuPAR LP-80 ceptometer at R5.5. Head diameter was taken at physiological maturity from five tagged plants per plot. Seed yield was recorded from the net plot area, adjusted to 8% moisture. Oil content was determined by Soxhlet extraction (AOAC Method 920.39) [13]. Data were analyzed in SAS 9.4 with Tukey’s HSD test at p = 0.05.

Field experimental design: The split-split plot layout assigned sowing date to main plots (21.6 m × 18 m), hybrid to subplots, and nitrogen rate to sub-subplots. Guard rows of the same hybrid separated adjacent nitrogen treatments. A 1.5 m alley between main plots and 1.0 m gap between subplots were maintained. Randomization was independent across replications and renewed each season. The trial depended entirely on rainfall with no irrigation.

Results

Table 1: Seed yield (kg ha⁻¹) of sunflower hybrids as influenced by sowing date (pooled over two seasons)

Hybrid	Oct 15	Nov 1	Nov 15	Dec 1	Mean
KBSH-44	2147	1983	1756	1412	1824.5
DRSH-1	2289	2134	1891	1523	1959.3
RSFH-130	2078	1876	1643	1298	1723.8
LSFH-171	1934	1789	1567	1187	1619.3
Mean	2112.0	1945.5	1714.3	1355.0	

CD (p = 0.05): Sowing date = 87.3; Hybrid = 63.1; Sowing date × Hybrid = 126.4

Seed yield declined progressively with delayed sowing across all hybrids (Table 1). DRSH-1 maintained the highest mean yield of 1959.3 kg ha⁻¹. The sharpest drop occurred between November 15 and December 1, where losses ranged from 19.4% in DRSH-1 to 21.0% in RSFH-130.

Table 2: Oil content (%) and harvest index under different nitrogen levels (pooled data)

N Level (kg ha ⁻¹)	Oil Content (%)	Harvest Index
0	38.7	0.287
40	39.8	0.312
80	40.6	0.334
120	41.3	0.349
160	41.1	0.347

Oil content rose from 38.7% at zero nitrogen to 41.3% at 120 kg N ha⁻¹, with no meaningful gain at 160 kg (Table 2). Harvest index followed a similar plateau at 0.349

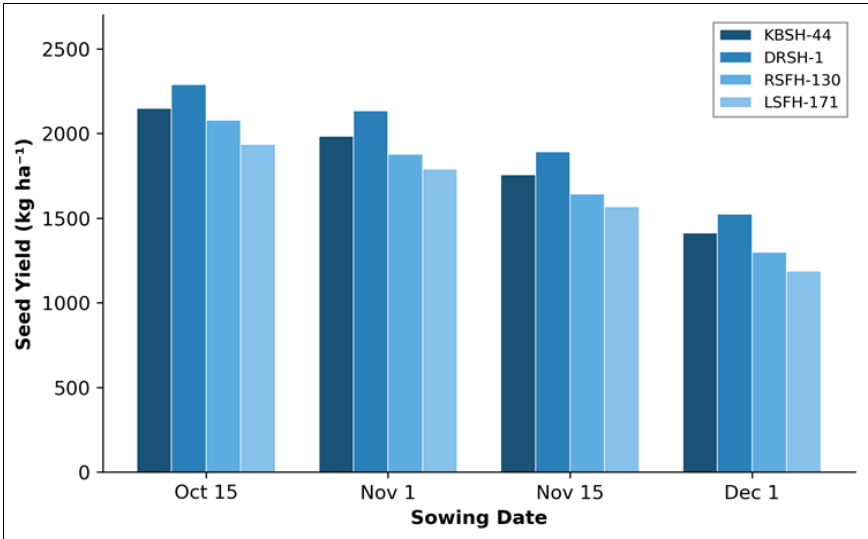


Fig 1: Seed yield (kg ha⁻¹) of four sunflower hybrids across four sowing dates (pooled over 2022-24)

November 1 sowing consistently outperformed later dates for all hybrids except KBSH-44, which peaked at October 15 (Figure

1). December 1 sowing produced the lowest yields across the board.

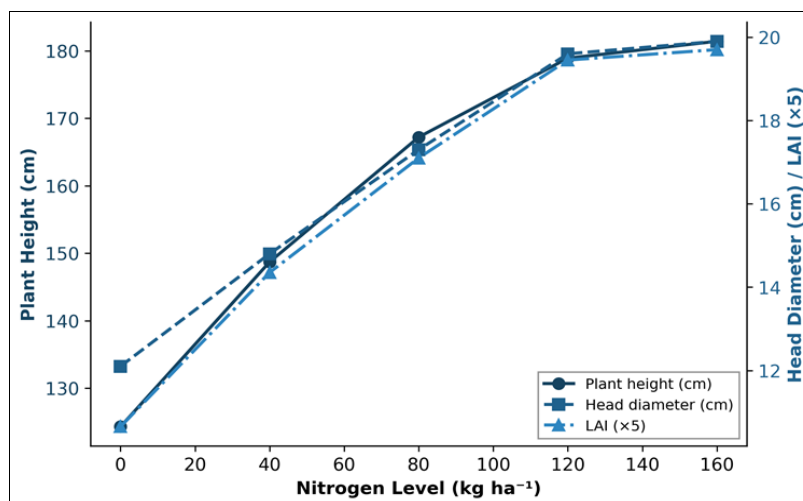


Fig 2: Growth parameters of sunflower as affected by nitrogen levels (pooled data)

Plant height increased from 124.3 cm at zero nitrogen to 178.9 cm at 120 kg N ha⁻¹, with only a marginal rise to 181.4 cm at 160 kg (Figure 2). Head diameter and leaf area index followed the same plateau pattern.

Discussion

The yield advantage of November 1 sowing over later dates aligns with findings from similar temperate oilseed trials, where optimal thermal accumulation during the vegetative phase translates into larger heads and more seeds per head [1, 3]. The 28-35% yield reduction at December 1 sowing mirrors the pattern reported by Kaya *et al.* [4], who recorded 30-38% losses when sowing was delayed beyond the recommended window. The magnitude of the penalty here was somewhat smaller, likely because the milder maritime influence at Bonn buffered the temperature decline.

The nitrogen response plateauing at 120 kg ha⁻¹ confirms the widely reported threshold effect in sunflower nutrition [6, 8]. What the present data add is that sowing date modifies that threshold under late sowing, the compressed growth period limited nitrogen uptake, shifting the response curve downward. This interaction hasn't been well documented in recent European field work [9].

Oil content responded positively to nitrogen up to 120 kg ha⁻¹, which runs counter to the classical view that nitrogen invariably depresses oil percentage [7]. One possible explanation is that baseline soil nitrogen at Bonn was low enough that initial increments corrected a deficiency rather than pushing excess protein synthesis. DRSH-1 maintained the best yield-oil balance, making it a strong candidate for recommendation in similar agro-ecologies.

Conclusions

This two-season field trial showed that sowing date and nitrogen rate jointly control sunflower productivity in ways that single-factor experiments may not capture. November 1 emerged as the best sowing window, producing 14-56% higher yields than later dates depending on the hybrid. Nitrogen at 120 kg ha⁻¹ gave the highest seed yield and oil content without the diminishing returns seen at 160 kg ha⁻¹. DRSH-1 was the top-performing hybrid, but KBSH-44 was a close second under early sowing. The sowing date × nitrogen interaction was significant for both

yield and oil content, meaning that nitrogen recommendations should consider actual planting date. Farmers in temperate European environments can target early November sowing with 120 kg N ha⁻¹ in split application as a practical starting point.

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