# FACTORS AFFECTING OIL CONTENT IN SOYBEAN SEEDS

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**Abstract:** Oil content is a critical quality parameter in soybean (*Glycine max L.*), influencing both its economic value and suitability for food and industrial uses. This study reviews and analyzes the major factors that affect oil accumulation in soybean seeds, including genetic variation, environmental conditions (temperature, moisture, sunlight), agronomic practices, and nutrient availability. Experimental observations and literature findings indicate that optimal fertilization, irrigation timing, and selection of high-oil-yielding cultivars can significantly increase oil content. Additionally, heat and drought stress during the seed-filling stage were found to negatively impact oil synthesis. Understanding these factors is essential for developing targeted strategies to enhance oil yield and overall crop quality in soybean production systems.

**Keywords**: Soybean, oil content, seed composition, genotype, environment, fertilization, irrigation, drought stress, lipid synthesis.

Introduction Soybean (*Glycine max L.*) is globally recognized as one of the most important oilseed crops, with its seeds containing 17–23% oil, depending on genotype and growing conditions. Soybean oil is widely used in food processing, livestock feed, biodiesel production, and various industrial applications. Therefore, increasing the oil content in soybean seeds has become a key breeding and agronomic objective.

Oil accumulation in soybean is a complex trait influenced by multiple factors. Genetic variation is fundamental—different cultivars have varying potentials for oil synthesis. However, environmental conditions such as temperature, sunlight duration, and soil moisture also play significant roles, especially during the seed development phase. Agronomic practices, including fertilizer management, irrigation schedules, and planting density, can further influence oil biosynthesis.

Moreover, nutrient elements like nitrogen, phosphorus, sulfur, and potassium are involved in enzymatic pathways critical to lipid metabolism. Heat and water stress during the reproductive stage can inhibit these processes, leading to reduced oil content.

This study aims to identify and evaluate the key agronomic, genetic, and environmental factors that affect oil accumulation in soybean seeds. The goal is to provide recommendations for maximizing oil yield while maintaining overall crop productivity and sustainability.

Materials and Methods

Experimental Site and Conditions

The field experiment was conducted during the 2024 growing season at the Research Farm of the Rice and Legume Crops Research Institute, Uzbekistan. The area has a semi-arid climate with an average temperature of 28–34°C during the soybean reproductive stage. The soil was loamy with moderate fertility and neutral pH.

Soybean Varieties and Experimental Design

Three soybean cultivars with known variation in oil content were used:

- 'Navbahor' (medium oil)
- 'Chirchiq-21' (high oil)
- 'Uzsoy-4' (stable under stress)

The study was laid out in a split-plot design with three replications. Main plots included irrigation regimes:

- Full irrigation (100% ETc)
- Moderate deficit (75% ETc)
- Severe deficit (50% ETc)

Sub-plots involved nitrogen fertilizer rates:

- 0 kg/ha
- 40 kg/ha
- 80 kg/ha

Measurements

- Oil content (% dry weight) was measured using Soxhlet extraction.
- Seed yield (t/ha) and biomass were recorded at physiological maturity.
- Weather data (temperature and rainfall) were collected from an on-site meteorological station.
- Soil nutrient levels were analyzed before planting and after harvest.
- Statistical analysis was performed using two-way ANOVA ($p < 0.05$).

Results

Effect of Irrigation and Nitrogen on Oil Content

| Treatment (ETc/N rate) | Avg. Oil Content (%) |
|---|---|
| 100% ETc, 0 N | 19.8 ± 0.3 |
| 100% ETc, 80 N | 22.1 ± 0.4 |
| 75% ETc, 40 N | 20.4 ± 0.2 |
| 50% ETc, 0 N | 17.5 ± 0.3 |
| 50% ETc, 80 N | 18.6 ± 0.3 |

Full irrigation with 80 kg/ha nitrogen gave the highest oil content across all varieties.

Varietal Differences

| Variety | Oil Content (%) | Seed Yield (t/ha) |
|---|---|---|
| Navbahor | 20.1 ± 0.3 | 2.42 |
| Chirchiq-21 | 22.5 ± 0.4 | 2.70 |
| Uzsoy-4 | 19.6 ± 0.2 | 2.31 |

'Chirchiq-21' showed the highest oil concentration and seed yield under both optimal and stress conditions.

Environmental Influence

- High day temperatures (>35°C) during seed filling reduced oil accumulation, especially under 50% ETc.
- Moisture stress significantly decreased oil content and seed weight, particularly in ‘Navbahor’.

Summary of Results:

- Oil content in soybean is significantly influenced by irrigation level, nitrogen rate, and genotype.
- The best results were obtained with adequate water and moderate to high nitrogen levels.
- The cultivar ‘Chirchiq-21’ consistently produced high oil content even under moderate water stress.
- Water deficit and heat stress negatively affected oil synthesis, emphasizing the need for proper irrigation scheduling during seed filling.

Discussion

The findings of this study confirm that soybean oil content is influenced by a complex interplay of genetic, environmental, and agronomic factors. Among the environmental conditions, irrigation level had the most significant impact. Water deficit during the critical seed-filling stage led to reduced oil synthesis, likely due to impaired photosynthesis and lipid metabolism. This aligns with previous research indicating that drought stress limits the supply of carbon skeletons and energy needed for oil formation.

Nitrogen application also played a key role. While nitrogen is often associated with protein accumulation, moderate to high nitrogen levels in this study improved overall seed biomass and indirectly contributed to oil content. This may be due to

improved leaf area and longer photosynthetically active duration, which supports both protein and oil biosynthesis.

In terms of genetic influence, ‘Chirchiq-21’ exhibited the highest and most stable oil content across irrigation and nitrogen treatments. This suggests a strong genotypic advantage in terms of oil accumulation potential and stress tolerance. Such genotypes can be prioritized in breeding programs aimed at high-oil soybean cultivars.

Moreover, this study reinforces the importance of managing water and nutrient inputs together, as both affect plant physiology and final seed composition. The observed interaction between nitrogen and water availability implies that balanced agronomic practices can mitigate the negative effects of environmental stress on oil content.

Conclusion

- Soybean oil content is significantly affected by irrigation regime, nitrogen fertilization, and varietal characteristics.
- The highest oil content (22.5%) was observed in the variety ‘Chirchiq-21’ under full irrigation and 80 kg/ha nitrogen.
- Water stress during seed development significantly reduces oil accumulation, especially under low nitrogen conditions.
- Cultivars with stable oil expression under stress (e.g., ‘Chirchiq-21’) are promising for drought-prone regions.
- Optimizing irrigation and nutrient management practices is essential for enhancing the oil quality of soybean in both intensive and resource-limited farming systems.

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