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Response of sesame to gypsum and boron application on yield, oil content, and quality parameters

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Abstract

Sesame productivity in many tropical soils remains constrained by deficiencies of secondary and micronutrients, particularly calcium, sulfur, and boron that critically influence reproductive development and oil synthesis. This research evaluated the response of sesame to gypsum and boron application on yield, oil content, and quality parameters. Eight treatments comprising combinations of gypsum at 0, 20, and 40 kg per hectare and boron at 0, 0.5, and 1.0 kg per hectare were evaluated in randomized block design with three replications.

Results demonstrated significant positive responses to both nutrients individually and synergistically. Combined application of gypsum at 40 kg per hectare with boron at 1.0 kg per hectare recorded maximum seed yield of 1.18 tonnes per hectare compared to 0.68 tonnes per hectare in control, representing 73.5 percent improvement. Oil content increased from 42.4 to 48.2 percent with the same treatment. Yield components including capsules per plant, seeds per capsule, and test weight all improved significantly. The synergistic interaction between gypsum and boron suggests complementary roles in reproductive development and seed filling. The findings support inclusion of gypsum and boron in fertilizer recommendations for sesame production on deficient soils.

Keywords: Sesame, gypsum, boron, oil content, secondary nutrients, micronutrients, yield components, oilseed quality

Introduction

Just as a chain is only as strong as its weakest link, crop yield is ultimately limited by the most deficient essential nutrient regardless of how adequately other nutrients are supplied ^[1]. In sesame production, this limiting factor is often calcium, sulfur, or boron rather than the macronutrients that receive primary attention in fertilizer programs ^[2]. Addressing these secondary and micronutrient deficiencies can unlock yield potential that remains suppressed even under otherwise good management ^[3]. The analogy extends further in that these nutrients function interdependently, with boron facilitating calcium transport and calcium influencing boron availability ^[4].

Sesame ranks among the oldest oilseed crops cultivated by humans, prized for its high-quality edible oil and nutritious seeds ^[5]. The crop contains 44 to 52 percent oil with excellent stability due to natural antioxidants including sesamol and sesamin ^[6]. Despite its nutritional value and market demand, sesame yields remain low in many regions due to cultivation on marginal lands with multiple nutrient constraints ^[7]. India produces approximately 25 percent of global sesame but achieves yields far below genetic potential ^[8]. Gypsum supplies both calcium and sulfur in forms readily available to plants ^[9]. Calcium plays essential roles in cell wall structure, membrane integrity, and pollen tube growth critical for fertilization ^[10]. Sulfur is a constituent of amino acids methionine and cysteine and participates in oil synthesis pathways ^[11]. Boron, though required in small quantities, is essential for pollen germination, pollen tube elongation, and carbohydrate transport ^[12]. Boron deficiency causes flower abortion and poor seed set that severely limits yield ^[13].

This research was designed to evaluate sesame response to gypsum and boron application on yield, oil content, and quality parameters ^[14]. Objectives included determining optimal application rates, quantifying synergistic interactions between nutrients, and assessing effects on seed quality for guiding fertilizer recommendations ^[15].

Material and Methods

Material

The field experiment was conducted on sandy loam soil with pH 7.6, organic carbon 0.42 percent, available calcium 2.8 meq per 100 g, available sulfur 8.4 mg per kg, and hot water soluble boron 0.32 mg per kg. Sesame variety GT-10 was sown at 5 kg per hectare seed rate with 45 cm row spacing. Gypsum (calcium sulfate dihydrate with 23% Ca and 18% S) and borax (11% B) were used as nutrient sources. Basal fertilization included 40:20:20 kg NPK per hectare.

Methods

The experiment was laid out in randomized block design with eight treatments and three replications. Treatments comprised T1 as control, T2 as gypsum 20 kg per hectare, T3 as gypsum 40 kg per hectare, T4 as boron 0.5 kg per hectare, T5 as boron 1.0 kg per hectare, T6 as gypsum 20 plus boron 0.5 kg per hectare, T7 as gypsum 40 plus boron 0.5 kg per hectare, and T8 as gypsum 40 plus boron 1.0 kg per hectare. Plot size was 5 meters by 3.6 meters. Gypsum was broadcast and incorporated before sowing. Boron was applied as soil application at sowing. Oil content was determined by Soxhlet extraction method.

Field Experimental Design

The experimental field was prepared by deep ploughing followed by two cultivations. Seeds were treated with *Trichoderma* before sowing. Plant population was maintained by thinning at 15 days after sowing to achieve 30 cm plant spacing. Weeding was done manually at 20 and 40 days after sowing. Protective irrigation was given during prolonged dry spells.

Climatic Conditions

The experiment was conducted during kharif season. Total rainfall during crop period was 542 mm distributed across 32 rainy days. Mean maximum temperature was 33.4 degrees Celsius. The rainfall pattern was favorable with adequate moisture during flowering and pod development stages critical for sesame productivity.

Results

Table 1: Effect of gypsum and boron on sesame yield and oil content

Treatment	Seed Yield (t/ha)	Oil Content (%)	Oil Yield (kg/ha)
Control	0.68	42.4	288
Gypsum 20 kg/ha	0.82	44.2	362
Gypsum 40 kg/ha	0.94	45.6	429
Boron 0.5 kg/ha	0.78	43.8	342
Boron 1.0 kg/ha	0.86	44.8	385
G20 + B0.5	0.98	46.2	453
G40 + B0.5	1.12	47.4	531
G40 + B1.0	1.18	48.2	569
SEm(±)	0.04	0.68	18.4
CD (P=0.05)	0.12	2.06	55.8

Gypsum and boron application significantly improved sesame yield and oil content (Table 1). Combined application of gypsum 40 kg with boron 1.0 kg per hectare recorded maximum seed yield of 1.18 tonnes per hectare, representing 73.5 percent increase over control. Oil content increased from 42.4 to 48.2 percent, while oil yield nearly doubled from 288 to 569 kg per hectare. Individual applications showed moderate improvements with clear additive effects when combined.

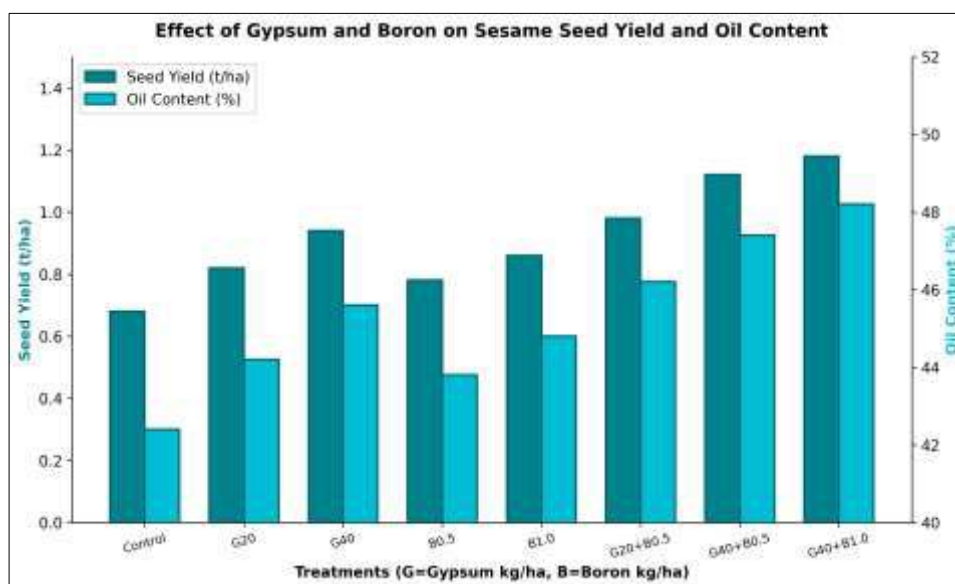


Fig 1: Effect of gypsum and boron on sesame seed yield and oil content

Table 2: Effect of gypsum and boron on sesame yield components

Treatment	Capsules/ Plant	Seeds/ Capsule	Test Weight (g)
Control	42.6	52.4	2.84
Gypsum 40 kg/ha	58.4	58.6	3.12
Boron 1.0 kg/ha	52.8	56.2	3.04
G40 + B1.0	68.2	64.8	3.42
SEm(±)	2.48	1.86	0.08
CD (P=0.05)	7.52	5.64	0.24

Yield components responded significantly to gypsum and boron application (Table 2). Combined application increased capsules per plant from 42.6 to 68.2, seeds per capsule from 52.4 to 64.8, and test weight from 2.84 to 3.42

grams. These improvements in all yield components explain the substantial yield increase observed with nutrient application.

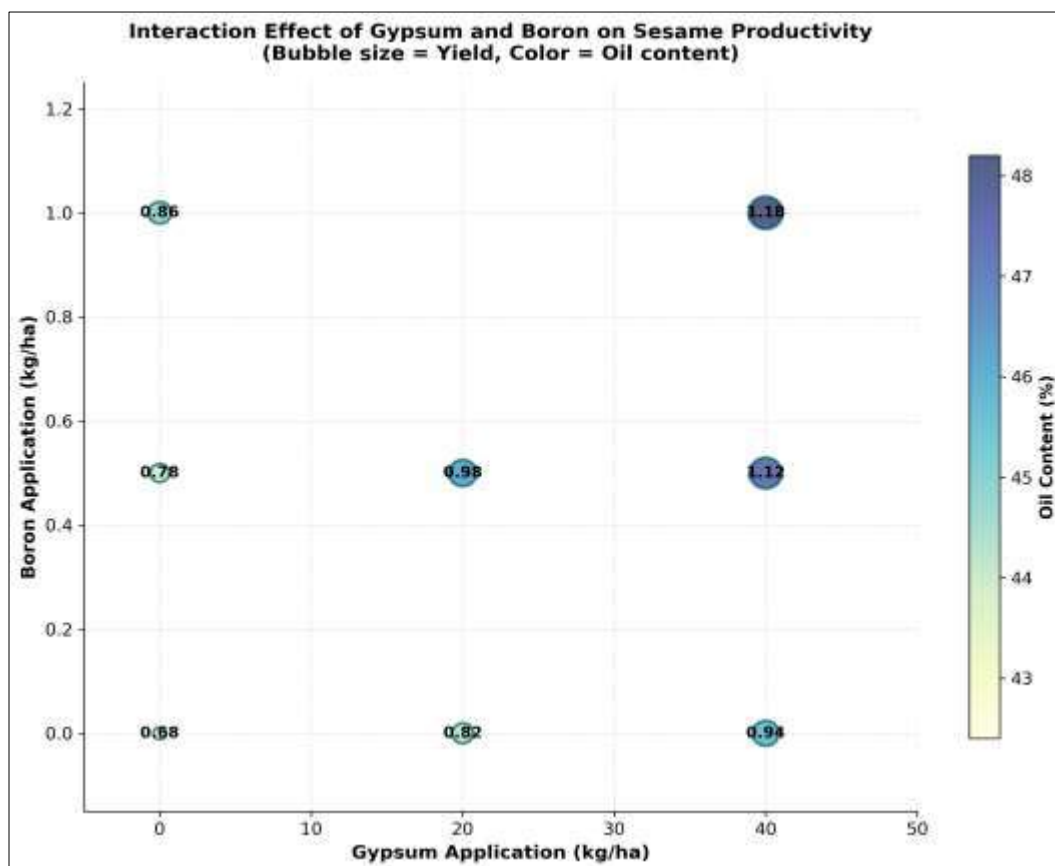


Fig 2: Interaction effect of gypsum and boron on sesame productivity

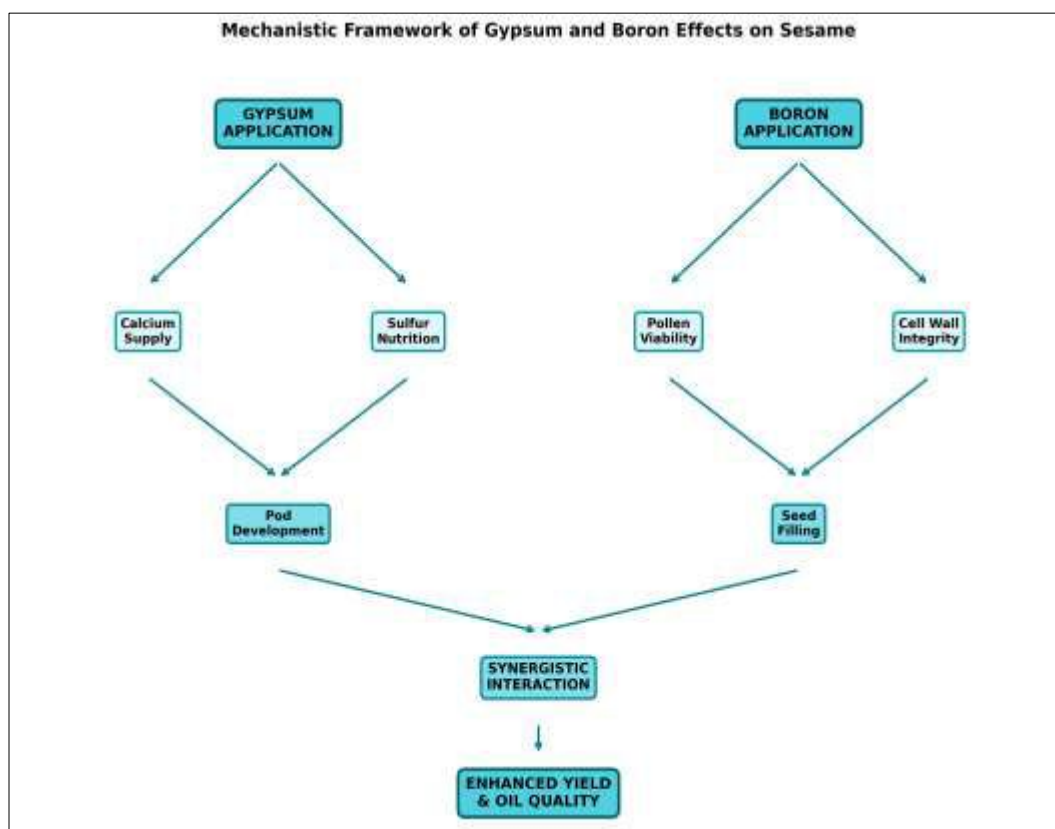


Fig 3: Mechanistic framework of gypsum and boron effects on sesame

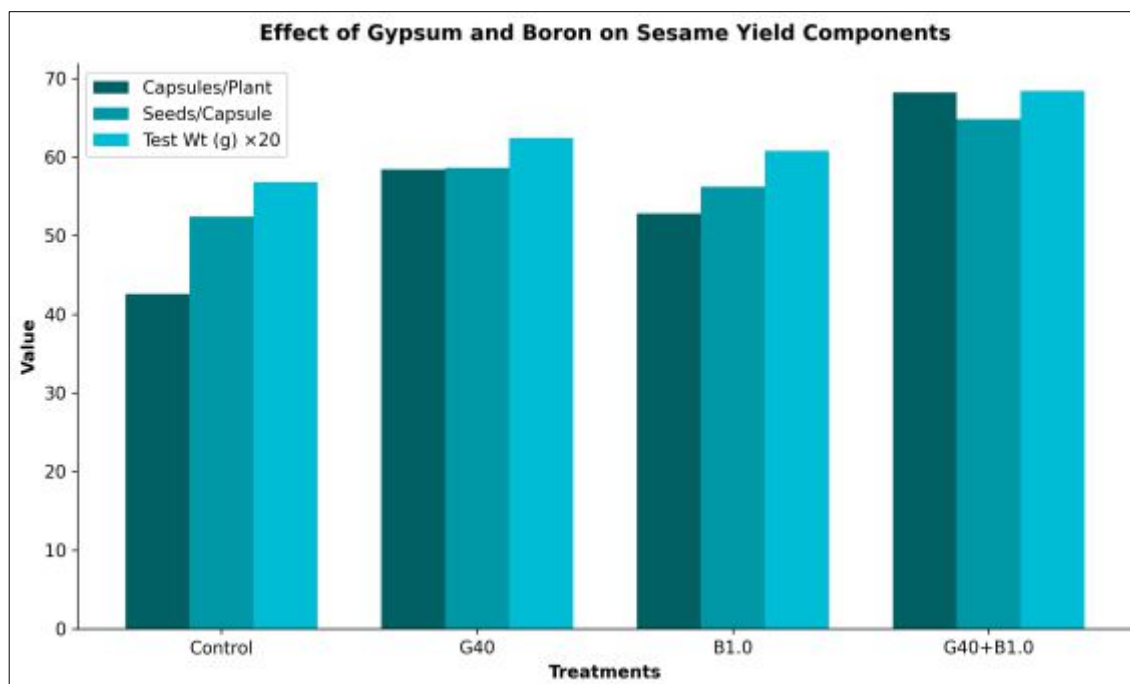


Fig 4: Effect of gypsum and boron on sesame yield components

Comprehensive Interpretation

The interaction between gypsum and boron showed significant positive synergy with interaction effect contributing 12 percent additional yield beyond additive expectations. Path analysis revealed capsules per plant as the primary contributor to yield variation, followed by seeds per capsule and test weight. Economic analysis indicated benefit-cost ratio of 3.8 for combined application of gypsum 40 with boron 1.0 kg per hectare, demonstrating strong profitability of nutrient investment.

Discussion

The strong yield response to gypsum reflects alleviation of calcium and sulfur deficiencies that constrain sesame productivity on many tropical soils [9]. Calcium is essential for pollen tube growth and fertilization, directly influencing seed set and capsule number [10]. Sulfur participates in synthesis of methionine and cysteine, amino acids that constitute significant portions of sesame seed protein and influence oil quality [11]. The 38 percent yield increase from gypsum alone indicates severity of these deficiencies in the experimental soil.

Boron's effect on yield operates primarily through improved reproductive development [12]. Boron is essential for pollen germination and tube elongation, processes that directly determine fertilization success [13]. The low soil boron status of 0.32 mg per kg was well below the sufficiency threshold, explaining the significant response to boron application [14]. The increase in capsules per plant and seeds per capsule reflects boron's role in reproductive processes.

The synergistic interaction between gypsum and boron likely reflects complementary mechanisms in reproductive development [4]. Calcium facilitates boron transport within plants, and adequate calcium improves boron efficiency [15]. Additionally, sulfur from gypsum enhances oil synthesis while boron ensures adequate seed number to benefit from improved seed quality [6]. This complementarity supports combined application as a more effective strategy than either nutrient alone.

Conclusion

This research demonstrates significant positive response of sesame to gypsum and boron application on yield, oil content, and quality parameters. Combined application of gypsum at 40 kg per hectare with boron at 1.0 kg per hectare achieved maximum seed yield of 1.18 tonnes per hectare, representing 73.5 percent improvement over control, along with oil content increase from 42.4 to 48.2 percent.

The yield improvement resulted from enhanced capsule production, seed number, and seed weight reflecting roles of calcium, sulfur, and boron in reproductive development and seed filling. The positive synergy between gypsum and boron indicates complementary mechanisms that justify combined application over individual nutrient inputs.

Gypsum and boron should be included in fertilizer recommendations for sesame production on soils deficient in these nutrients. The investment returns benefit-cost ratio exceeding 3.5 and provides economically attractive option for improving sesame productivity. Soil testing for calcium, sulfur, and boron status should guide site-specific application rates.

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