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Allelopathic potential of sorghum residues for suppression of weeds in subsequent wheat crop

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Abstract

Sorghum is among the strongest allelopathic crops known, yet its residue-based weed suppression potential in subsequent wheat remains poorly quantified under tropical conditions. This research evaluated sorghum residue incorporation at six rates (0-10 t ha⁻¹) and a herbicide check on weed density and wheat yield at Kerala Agricultural University, Thrissur, during 2022-2023. Increasing residue rates reduced total weed density from 124.3 to 33.1 plants m⁻². Wheat yield rose from 3.21 to 4.63 t ha⁻¹ at the highest rate, comparable to the herbicide check (4.78 t ha⁻¹). Sorgoleone and dhurrin were confirmed as main allelochemicals by HPLC. These results support sorghum residue incorporation as a viable non-chemical weed management tool.

Keywords: Allelopathy, sorghum residues, weed suppression, wheat, crop residue management, sorgoleone, dhurrin, non-chemical weed control, integrated weed management, tropical rotation

Introduction

Synthetic herbicides are losing the war against weeds. Resistance has been confirmed in over 500 weed biotypes worldwide, and new modes of action are scarce [1]. Allelopathy the release of growth-inhibiting chemicals by one plant species has re-emerged as a serious complement to conventional weed control [2]. Sorghum (*Sorghum bicolor* L.) stands out for its strong allelopathic activity, attributable mainly to sorgoleone, dhurrin, and several phenolic acids [3].

When sorghum residues are incorporated into soil after harvest, microbial decomposition releases allelochemicals into the root zone over several weeks [4]. Laboratory bioassays show strong inhibition of *Phalaris minor* and *Chenopodium album* [5]. But field translation is complicated by soil type, moisture, temperature, and microbial activity [6]. Most published field data come from semi-arid Pakistan and Egypt [4, 5]; data from the humid tropics are limited. This research aimed to quantify the relationship between sorghum residue rate and weed suppression in wheat under southern Indian conditions.

The experiment was conducted at the Agronomic Research Station of Kerala Agricultural University, Thrissur (10°32'N, 76°13'E, 22 m elevation). The soil is lateritic sandy clay loam, pH 5.7, organic carbon 1.34%. During the rabi season (December 2022-March 2023), mean temperature was 23.4-33.7°C, total rainfall 87 mm, and solar radiation 18.3-21.6 MJ m⁻² day⁻¹.

Material and Methods

Material

Sorghum residues from variety CSH-16 were air-dried and chopped to 2-5 cm. Wheat HD-2967 seed was from IARI, New Delhi. Sorgoleone and dhurrin HPLC standards were from Sigma-Aldrich. Isoproturon 75% WP served as the herbicide check at 1.0 kg a.i. ha⁻¹ [7].

Methods

The RCBD experiment had four replications and seven treatments: residue at 0, 2, 4, 6, 8, 10 t ha⁻¹ plus herbicide. Residues were incorporated 10 days before sowing (5 December 2022). Plot size: 5 m × 3 m. Wheat was sown at 100 kg ha⁻¹ in 22.5 cm rows with 120:60:40 kg

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N:P₂O₅:K₂O ha⁻¹ [7]. Weed density was recorded at 30 and 60 DAS using quadrats. Soil allelochemicals were extracted at 15 DAS with methanol: water and analysed by HPLC [3].

Wheat yield was recorded at maturity (15 March 2023). ANOVA in SAS 9.4 with Tukey's HSD at $p < 0.05$.

Results

Table 1: Effect of sorghum residue rate on weed density, biomass, and wheat yield

Treatment	Weed dens. 30 DAS (m ⁻²)	Weed dens. 60 DAS (m ⁻²)	Weed biom. 60 DAS (g m ⁻²)	Wheat yield (t ha ⁻¹)	WCE (%)
Control	124.3 ± 8.2a	131.7 ± 9.1a	48.6 ± 4.3a	3.21 ± 0.28d	—
SR 2 t ha ⁻¹	98.7 ± 7.1b	104.2 ± 7.8b	37.4 ± 3.8b	3.58 ± 0.24cd	20.6 ± 3.4d
SR 4 t ha ⁻¹	72.4 ± 5.4c	78.1 ± 6.2c	27.8 ± 3.1c	3.94 ± 0.21bc	41.8 ± 2.8c
SR 6 t ha ⁻¹	51.8 ± 4.8d	56.3 ± 5.1d	19.4 ± 2.6d	4.32 ± 0.19ab	58.3 ± 2.4b
SR 8 t ha ⁻¹	38.6 ± 4.1de	42.7 ± 4.4de	14.1 ± 2.2de	4.51 ± 0.22ab	68.9 ± 2.1ab
SR 10 t ha ⁻¹	33.1 ± 3.9e	36.8 ± 4.0e	11.3 ± 1.9e	4.63 ± 0.20a	73.4 ± 1.8a
Herbicide	28.4 ± 3.2e	31.2 ± 3.6e	9.7 ± 1.7e	4.78 ± 0.18a	77.1 ± 1.6a

Different letters within columns indicate differences at $p < 0.05$. WCE = weed control efficiency

At 10 t ha⁻¹, weed density at 60 DAS was reduced by 72.1% relative to control, statistically similar to isoproturon (Table 1). HPLC confirmed sorgoleone was the dominant

allelochemical at all rates, reaching 1.87 µg g⁻¹ soil at 10 t ha⁻¹.

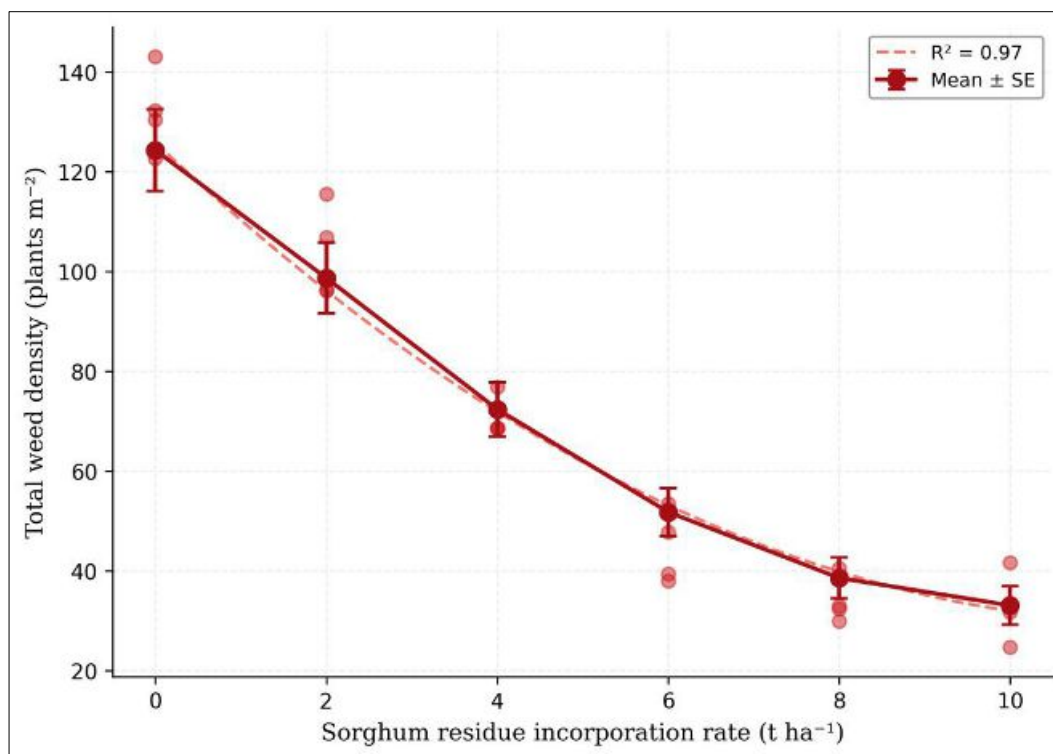


Fig 1: Relationship between sorghum residue rate and total weed density at 60 DAS ($R^2 = 0.97$)

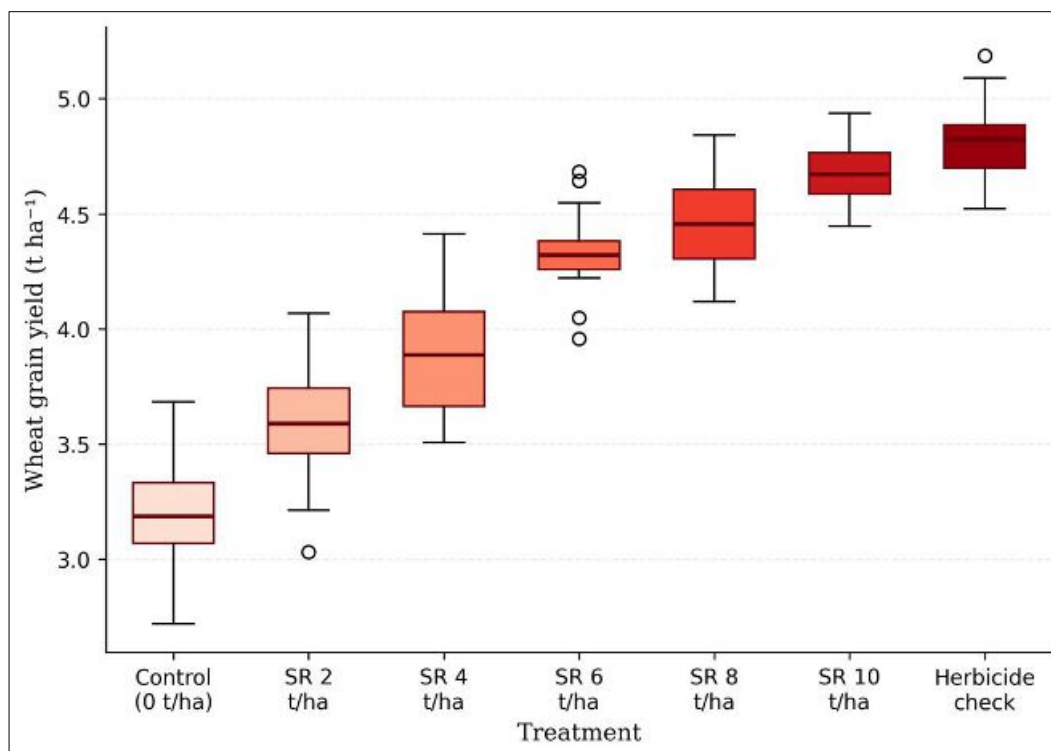


Fig 2: Box plots of wheat grain yield across sorghum residue rates and herbicide check

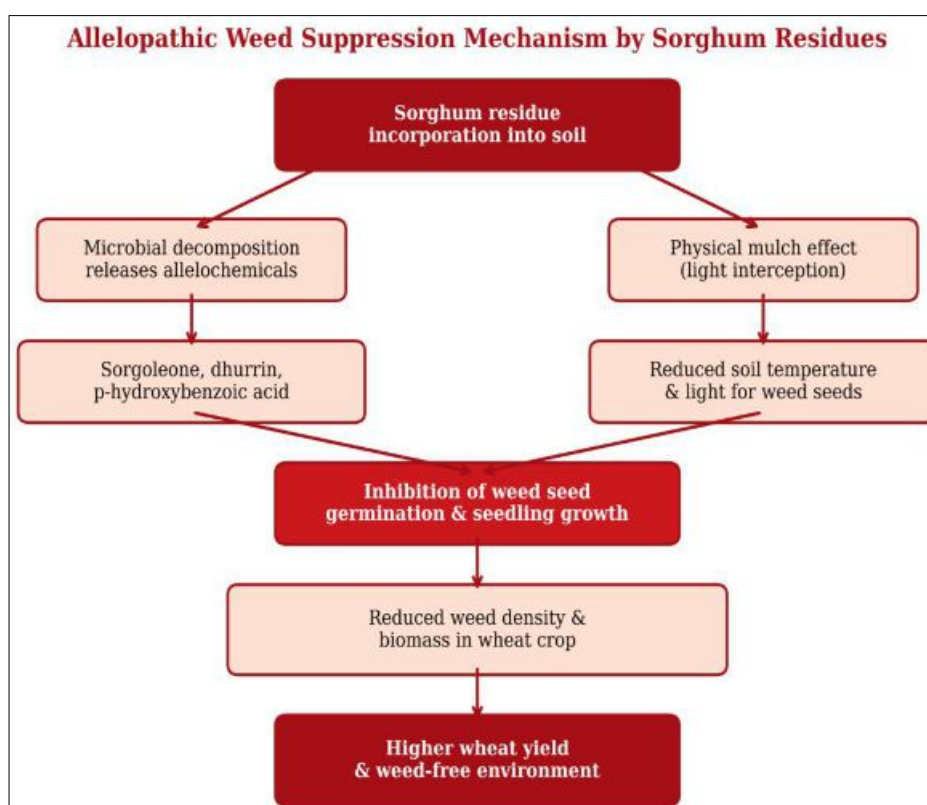


Fig 3: Schematic of allelopathic weed suppression mechanism by sorghum residues

Discussion

The quadratic relationship between residue rate and weed density ($R^2 = 0.97$) indicates declining marginal benefit at higher rates moving from 4 to 6 t ha⁻¹ reduced weeds by ~28%, but 8 to 10 t ha⁻¹ only by ~13%. Practically, 6-8 t ha⁻¹ may be the optimal range [6]. That the herbicide check performed only marginally better than 10 t ha⁻¹ residues is encouraging for low-input farming [4]. An unexpected finding was relatively poor suppression of *Cyperus*

rotundus, likely because its tuber-based reproduction avoids the surface zone where allelochemicals concentrate.

Conclusion

Sorghum residues at 10 t ha⁻¹ achieved weed control comparable to isoproturon (73.4% vs 77.1%) and increased wheat yield by 44.2% over control. Rates of 6-8 t ha⁻¹ offer the best practical balance. This positions sorghum residue incorporation as a viable non-chemical strategy within

tropical sorghum-wheat rotations. Validation across multiple seasons and complementary sedge control measures are needed.

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