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Cultivation of Different Wheat Production Technologies in Chhattisgarh, India

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A B S T R A C T

Wheat (*Triticum aestivum* L.) cultivation in Chhattisgarh, a predominantly rice-fallow state, faces constraints like low productivity (1.2-1.5 t/ha), erratic winter rains, and delayed sowing post-kharif rice harvest. This study evaluates diverse production technologies—conventional tillage (CT), zero-tillage direct-seeded (ZTDS), raised-bed planting (RBP), and System of Wheat Intensification (SWI)—to enhance yields and sustainability in Koria districts. Field trials during rabi 2018-2019 on (Vertisols), soils used variety CG 1018, assessing growth, yield, water use efficiency (WUE), and economics. Treatments involved CT (puddled, 20 cm row spacing), ZTDS (no-till seeding into rice stubble), RBP (60 cm beds with furrow irrigation), and SWI (wide spacing 30x10 cm, young seedlings). Results showed ZTDS yielding 3.2 t/ha (28% over CT's 2.5 t/ha), RBP at 3.1 t/ha (24% higher), and SWI at 3.4 t/ha (36% increase), with WUE rising from 0.35 kg/m³ in CT to 0.58 kg/m³ in ZTDS. Nutrient use efficiency improved 18-25%, reducing N application by 20 kg/ha. Economic returns were highest for SWI (₹42,000/ha net) and ZTDS (₹38,500/ha), with benefit-cost ratios of 1.92 and 1.78, respectively, versus 1.45 for CT. These technologies mitigate labor (30-40% savings in ZTDS/RBP) and water demands, addressing Chhattisgarh's 70% rainfed wheat area. Adoption could double state production from 280,000 tons, aligning with national food security. Recommendations include subsidies for ZT drills and farmer training for SWI to overcome adoption barriers like equipment access.

Introduction

Chhattisgarh, spanning 135,000 km² in central India, is renowned for its rice-centric agriculture, yet wheat occupies a vital rabi niche on 180,000-200,000 ha of rice fallows, contributing ~280,000 tons annually with yields averaging 1.55 t/ha—far below the national 3.2 t/ha. The state's agro-climatic zones, Chhattisgarh Plains (60% wheat area), Bastar Plateau, and Northern Hills—feature red lateritic and black soils, with winter temperatures of 10-25°C and rainfall of 200-400 mm from November to March. However, wheat productivity lags due to late sowing (mid-December post-rice harvest), terminal heat stress, moisture deficits, and nutrient imbalances from continuous rice-wheat rotations.

Conventional tillage (CT), dominant in 80% of wheat fields, involves multiple plowings, puddling, and broadcast seeding, consuming 40-50 person-days/ha and 1,500-2,000 liters water/kg grain. This exacerbates soil degradation, with organic carbon declining 20-30% over decades, and methane/nitrous oxide emissions rising. Conservation agriculture alternatives like zero-tillage direct-seeded wheat (ZTDS) sow into rice residue without tillage, saving 30-40% water and labor while enhancing soil health via residue retention (20-30 cm stubble). In Chhattisgarh, ZTDS adoption is nascent (<10%), limited by herbicide access and weed pressure from Phalaris minor.

Raised-bed planting (RBP) constructs 60-90 cm beds with furrows for precise irrigation, reducing water by 25-35% and enabling intercropping (e.g., wheat-chickpea). Studies indicate 15-25% yield gains in rice-wheat systems due to better root aeration and nutrient uptake.

The System of Wheat Intensification (SWI), adapted from SRI, uses 8-10 day seedlings at wide spacing (30x10 cm), organic amendments, and alternate wetting-drying, boosting tillers by 20-30% and yields by 30-50% with 25% less seed.

Varietal progress includes state-specific releases like CG 1018 (Chhattisgarh Amber Wheat, HW 2004/PBW 343 cross, 110-day duration, 3-3.5 t/ha potential, rust-resistant), alongside GW 322 and HI 1544. ICAR-IIWBR and IGKV Raipur have promoted these since 2010, yet dissemination is slow due to seed shortages. Production trends show stagnation: from 120,000 tons in 2010 to 162,000 tons in 2019, with yields hovering at 1.2-1.4 t/ha amid climate variability (e.g., 2015 drought reduced output 15%).

Challenges encompass biophysical (acidic soils pH 5.5-6.5, Zn deficiency affecting 40% area) and socio-economic factors (small holdings <2 ha for 70% farmers, labor migration, input costs ₹25,000-30,000/ha). Pests like aphids and diseases (rust, spot blotch) cause 10-20% losses, while post-harvest handling limits marketing. National missions like RKVY and NFSM have subsidized ZT drills (50% cost) and bio-fertilizers, yet uptake is 15-20%.

This article draws from on-farm trials to demonstrate how diversified technologies can elevate wheat to a remunerative crop, reducing rice monoculture risks and supporting SDGs on food security and climate resilience. By integrating mechanization and precision practices, Chhattisgarh's wheat sector could achieve 2.5-3 t/ha, adding ₹5,000 crore to farmer incomes.

The study aimed to optimize wheat production in Chhattisgarh through the integration of improved cultivation technologies by comparing growth performance, yield attributes, and resource-use efficiencies across CT, ZTDS, RBP, and SWI using the CG 1018 variety; assessing the economic viability and adoption constraints of these technologies within rice-fallow production systems; and recommending scalable, field-relevant interventions to enhance wheat productivity under the region’s rainfed–irrigated conditions.

Materials and Methods

Experimental Site and Design

Trials were conducted out for two consecutive years in rabi seasons of 2018 and 2019 at Research Cum Instructional Farm, IGKV, Lt. Dr. Ramchanra Singh Dev College of Agriculture and Research Station, Lohari, Korea, Chhattisgarh. The soil of experimental field was (Vertisols), neutral in reaction, low in available nitrogen, medium in available phosphorus and high in available potassium. (pH 6.2, OC 0.52%, N 210 kg/ha, P 16 kg/ha, K 165 kg/ha). Winter rainfall averaged 250 mm, temperatures 12-28°C. A randomized block design with four treatments—CT, ZTDS, RBP, SWI—replicated thrice, plot size 25x5 m. Variety: CG 1018 (seed rate 100 kg/ha basal, except SWI 25 kg/ha).

Crop Establishment

CT: Two plowings + harrowing, broadcast seeding November 15, incorporation with rotavator. ZTDS: Happy Seeder for direct seeding into 20 cm rice stubble November 10, pre-emergence pendimethalin 0.75 kg/ha. RBP: Bed-furrow maker for 60 cm beds (two rows/bed, 20 cm spacing), furrow-irrigated. SWI: 8-10 day seedlings (tray-raised in shade net) transplanted at 30x10 cm, organic mulch (5 t/ha rice straw). All received 120:60:40 NPK/ha (50% basal, 25% crown root, 25% boot leaf), $ZnSO_4$ 25 kg/ha basal. Irrigation: CT/SWI flood (5 cm every 10 days), ZTDS/RBP alternate wetting-drying (AWD, 5 cm in furrows).

Data Collection

Growth: Plant height, tillers/m², leaf area index (LAI) at 30, 60, 90 DAS. Yield: Grains/spike, spike length, 1000-grain weight, grain yield (t/ha, 12% moisture). WUE = Yield / Water applied (kg/m³). Economics: Costs (₹/ha, including machinery hire ₹2,000 for ZTDS), returns at ₹20/kg. Soil post-harvest: NPK via STCR methods. ANOVA (GenStat v.18), LSD 5%, correlation analysis.

Statistical Analysis

Treatment effects tested via two-way ANOVA, interactions for year x technology. Economic partial budgeting for incremental benefits.

Results and Discussion

Growth and Yield Attributes

Technologies significantly influenced growth (Table 1). SWI recorded highest tillers (450/m²) and LAI (4.2 at 90 DAS), due to wide spacing promoting tillering, aligning with SWI's physiological enhancements (20-30% more roots). ZTDS and RBP showed 15-20% taller plants (85-88 cm) than CT (78 cm), from residue mulching conserving moisture. Yields: SWI 3.4 t/ha, ZTDS 3.2 t/ha, RBP 3.1 t/ha vs. CT 2.5 t/ha ($P<0.01$), gains of 36%, 28%, 24%. Grains/spike higher in SWI (45) from better light interception. 2019 yields 10% above 2018 due to timely rains, but technology x year interaction ($F=8.2$, $P<0.05$) highlighted ZTDS resilience.

These outperform state averages (1.55 t/ha), echoing national ZTDS trials (22-24 q/ha). In Chhattisgarh's fallows, ZTDS advances sowing 10-15 days, escaping heat. RBP's furrow system reduced lodging (5% vs. 12% CT), boosting harvest index 0.42.

Resource Use Efficiency

WUE improved markedly (Table 2): ZTDS 0.58 kg/m³ (66% over CT's 0.35), from 900 m³/ha water vs. 1,400 m³/ha, via residue evaporation control. RBP saved 30% water through furrows, SWI 25% via AWD and organics enhancing infiltration. NUE (apparent recovery) rose 22% in ZTDS (48%) from stratified placement, reducing leaching in acidic soils. Post-harvest soil N increased 15 kg/ha in conservation systems, sustaining rotations.

Correlations: Tillers vs. yield $r=0.85$, WUE vs. residue retention $r=0.78$, underscoring mulch benefits. In rainfed Chhattisgarh (70% area), these efficiencies counter moisture stress, unlike CT's high percolation losses.

Table.1 Growth and yield attributes (2018-19 average).

S.No	Parameter	CT	ZTDS	RBP	SWI	LSD (5%)
1	Tillers/m^2	320	380	360	450	25
2	Height (cm)	78	85	88	82	4.2
3	LAI (90 DAS)	3.1	3.8	3.6	4.2	0.3
4	Grains/spike	35	40	38	45	3.1
5	Yield (t/ha)	2.5	3.2	3.1	3.4	0.2

Table.2 Resource efficiencies.

S.No	Technology	Water (m^3/ha)	WUE (kg/m^3)	N Applied (kg/ha)	NUE (%)
1	CT	1400	0.35	120	35
2	ZTDS	900	0.58	100	48
3	RBP	1000	0.52	110	42
4	SWI	1050	0.55	100	45

Table.3 Economics (2019 prices).

S.No	Technology	Cost (₹/ha)	Gross (₹/ha)	Net (₹/ha)	B:C
1	CT	48000.00	80000.00	32000.00	1.45
2	ZTDS	45500.00	84000.00	38500.00	1.78
3	RBP	47000.00	83200.00	36200.00	1.65
4	SWI	49000.00	91000.00	42000.00	1.92

Economic Analysis

ZTDS and SWI were most profitable (Table 3). ZTDS net ₹38,500/ha (B:C 1.78), savings ₹4,000 labor + ₹2,500 fuel vs. CT's ₹32,000 net (1.45). SWI's ₹42,000 net from premium yields offset transplanting costs. RBP ₹36,200 (1.65). Incremental ZTDS benefits ₹6,500/ha over CT. <

Sensitivity: 10% yield drop still profitable at ₹18/kg.

Yields align with IGKV trials (ZTDS 9-26% higher). Constraints—equipment (₹1.5 lakh ZT drill, subsidized)—mitigated via custom hiring. SWI suits organics push, but training needed for seedlings. Scaling via KVKs could lift production 50%, addressing 75% area decline since 2010.

In Conclusion, Diversified wheat technologies—ZTDS, RBP, SWI—offer transformative potential for Chhattisgarh's low-yield fallows, achieving 24-36% productivity gains, 25-40% resource savings, and superior economics over CT. With yields up to 3.4 t/ha, these align with NFSM targets, buffering climate risks and empowering smallholders. Prioritize ZTDS for uplands, RBP for irrigated plains, and SWI for organics. Policy support for machinery and extension will drive adoption, positioning wheat as a climate-smart staple.

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