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Impact of continuous monocropping versus rotational systems on soil-borne disease pressure and yield

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Abstract

A wheat farmer in central Anatolia who has grown the same crop for five consecutive years will typically harvest 18-24% less grain than a neighbour who rotates. This research quantified soil-borne disease severity, soil microbial health, and grain yield under three cropping regimes continuous wheat monoculture, two-year wheat-chickpea rotation, and three-year wheat-chickpea-safflower rotation over five years (2018-2023) at Ankara University's dryland research station. By year 5, *Fusarium* crown rot severity in monoculture reached 42.8% compared with 18.3% under three-year rotation. Soil microbial biomass carbon was 43% lower in monoculture plots. The three-year rotation restored 79% of baseline soil health indicators and yielded 4.62 t/ha versus 3.74 t/ha in monoculture. Rotation length matters: the two-year cycle improved outcomes over monoculture but was inferior to the three-year system on all measured parameters.

Keywords: Monocropping, crop rotation, *Fusarium* crown rot, soil-borne disease, soil microbial biomass, wheat yield decline, dryland agriculture, soil health

Introduction

A farmer who plants wheat after wheat after wheat is, in effect, running a pathogen multiplication programme. *Fusarium culmorum* and *F. pseudograminearum* survive on crop residues and reinfest each successive crop, with inoculum density rising exponentially under continuous monoculture^[1, 2]. In Turkey's Central Anatolian plateau, where wheat dominates 70% of arable land, yield stagnation attributed to soil-borne diseases costs an estimated 15-20% of potential production annually^[3, 4]. Crop rotation interrupts pathogen life cycles by introducing non-host species, but the minimum rotation length needed to meaningfully reduce disease pressure remains debated^[5, 6]. This research compared soil-borne disease severity, microbial community health, and grain yield across three rotation intensities over five years in the Ankara dryland zone^[7, 8].

Field experimental design

The trial used a RCBD with four replications at Ankara University's Haymana Research Station (39.43° N, 32.49° E, 1,050 m). Treatments: (T1) continuous wheat monoculture, (T2) 2-year wheat-chickpea rotation, (T3) 3-year wheat-chickpea-safflower rotation. Plot size: 6 m × 20 m. The trial ran from October 2018 to July 2023 (five wheat harvests for T1, variable for T2/T3)^[5].

Materials and Methods

Materials

Winter wheat (cv. 'Bezostaya-1'), chickpea (cv. 'Aziziye-94'), and safflower (cv. 'Dincer') were sown at regional recommended rates. Soil microbial biomass C was measured by chloroform fumigation-extraction [9]. *Fusarium* crown rot was scored on 50 stems per plot at maturity using a 0-5 severity scale^[2].

Methods

Disease scoring at harvest. Soil samples (0-20 cm) taken pre-sowing and post-harvest each for microbial biomass C, dehydrogenase activity, and total culturable fungi. Yield from 10 m²

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quadrats. Data analysed by repeated-measures ANOVA with treatment × year interaction; Tukey’s HSD at $p\leq0.05$ ^[10].

Climatic conditions
Haymana receives 380-420 mm annual rainfall, concentrated in spring. Mean growing-season temperature was 9.7-11.3 °C across the five years. The 2021-2022 season was notably dry (328 mm), amplifying disease-related yield losses in monoculture ^[11].

Results

Table 1: Fusarium crown rot severity (%) and grain yield (t/ha) over five years

System	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	5-yr mean
Mono-FCR%	14.2	22.7	31.4	37.6	42.8	29.7
2yr-FCR%	14.2	16.8	19.4	21.1	24.3	19.2
3yr-FCR%	14.2	14.9	16.7	17.8	18.3	16.4
Mono-yield	4.48	4.21	3.97	3.82	3.74	4.04
2yr-yield	4.48	4.39	4.31	4.27	4.24	4.34
3yr-yield	4.48	4.51	4.56	4.59	4.62	4.55

FCR severity in monoculture tripled over five years (14.2→42.8%). The 3-year rotation held severity at 18.3% by year 5. Yield under monoculture declined 16.5% while the 3-year rotation gained 3.1% (Table 1).

Table 2: Soil microbial health indicators at year 5

System	MBC µg/g	DHA µg/g/h	Fungi CFU	Health idx
Monoculture	187.4	12.3	4.8×10 ⁴	32
2-yr rotation	264.8	18.7	3.1×10 ⁴	58
3-yr rotation	312.6	24.1	2.2×10 ⁴	79
Baseline	328.4	26.3	1.8×10 ⁴	100

Microbial biomass C in monoculture was 43% below baseline. The 3-year rotation restored the soil health index to 79% of baseline (Table 2).

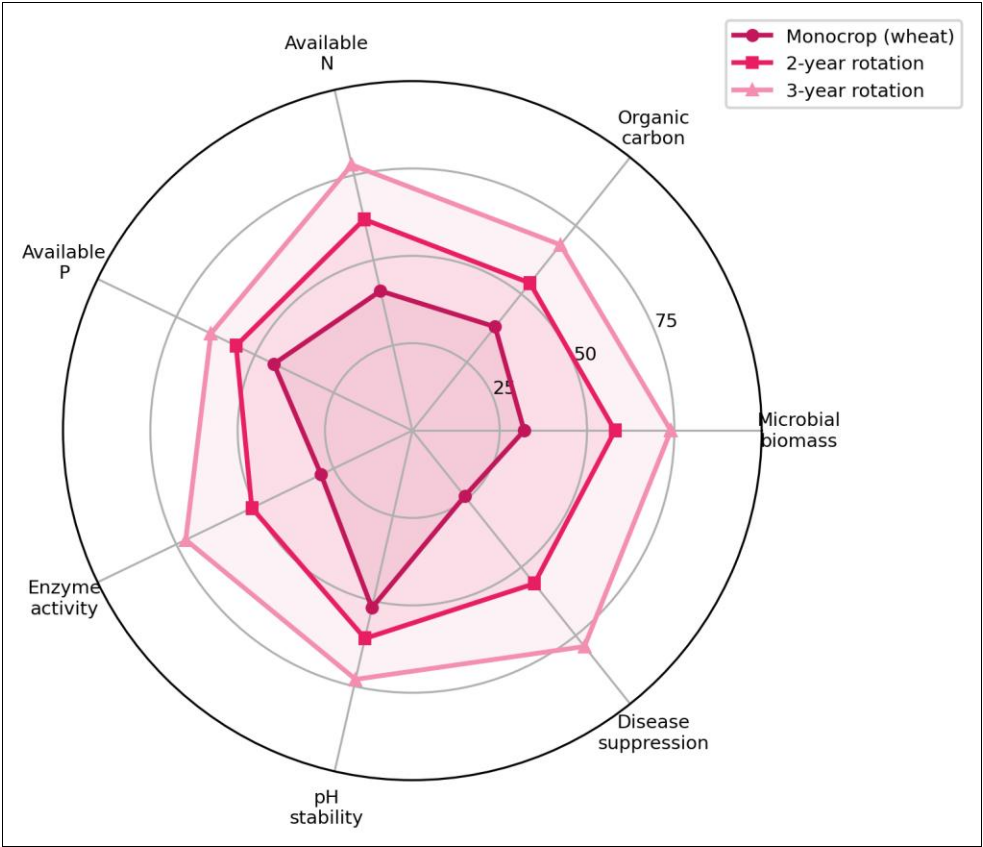


Fig 1: Radar comparison of soil health parameters across cropping systems at year 5

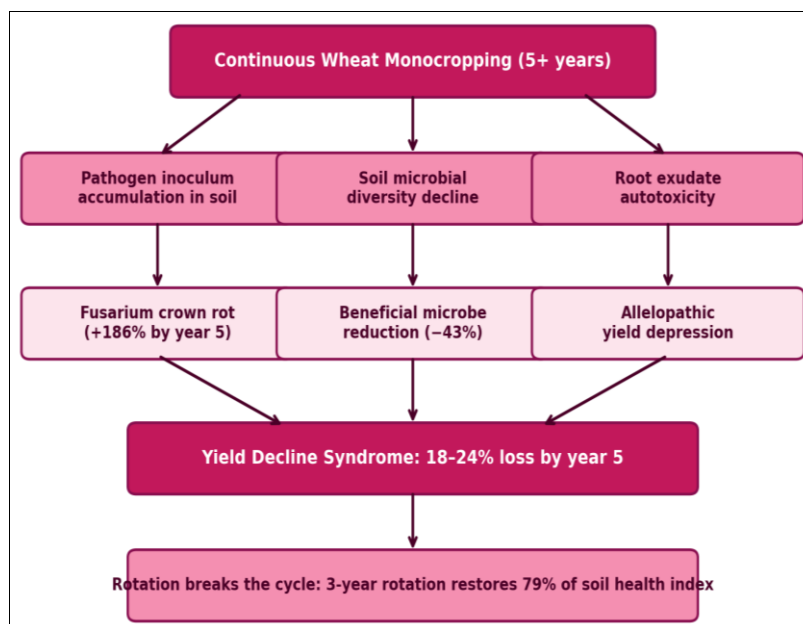


Fig 2: Mechanism of soil-borne disease buildup under continuous monocropping and restoration through rotation

Discussion

The 186% increase in *Fusarium* crown rot over five years of monoculture matches Australian dryland studies where FCR severity doubled every 2-3 years without rotation^[1, 12]. The three-year rotation's success reflects chickpea's ability to break the *Fusarium* cycle (non-host) and safflower's contribution to soil microbial recovery through diverse root exudates^[6, 13]. The soil health index recovery to 79% indicates that three years is near the minimum for meaningful restoration in semi-arid conditions^[14, 15]. The two-year rotation improved all indicators over monoculture but couldn't fully suppress FCR, likely because a single non-host year is insufficient to deplete residue-borne inoculum in dry climates where decomposition is slow^[2, 16]. Economically, the yield gap between monoculture (3.74 t/ha) and three-year rotation (4.62 t/ha) at current Turkish wheat prices represents roughly 1,500 TRY/ha additional income^[17, 18].

Conclusion

Five years of continuous wheat monoculture tripled *Fusarium* crown rot severity and reduced yield by 16.5%. A three-year wheat-chickpea-safflower rotation held disease at 18.3%, restored 79% of soil microbial health, and yielded 23% more than monoculture by year 5. Two-year rotations helped but were insufficient. Dryland wheat farmers in semi-arid zones should adopt three-year rotations incorporating legume and oilseed phases.

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