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Impact of diversified cropping systems on pest and disease dynamics in intensive agriculture

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Abstract

While monoculture simplifies management, it also simplifies the pest community and not in the farmer's favour. This research compared pest and disease incidence in diversified cropping systems (intercropping + rotation + border crops) against continuous wheat monoculture over two growing seasons (2021-2023) at Lomonosov Moscow State University's field station. Diversified plots reduced total pest populations by 41-58% and fungal disease severity by 34-47% compared with monoculture. Natural enemy density was 2.3× higher in diversified systems. Pesticide applications were reduced by 47% without yield penalty. These results demonstrate that crop diversification can suppress pest pressure while maintaining productivity.

Keywords: Diversified cropping, pest dynamics, disease suppression, natural enemies, intercropping, crop rotation, integrated pest management, wheat monoculture

Introduction

While monoculture maximises short-term efficiency, it creates ideal conditions for specialist pests and pathogens by providing a continuous, uniform host ^[1, 2]. Diversified cropping combining intercropping, rotation, and border plantings disrupts these dynamics through habitat diversification and the resource concentration effect ^[3]. Natural enemies benefit from the structural complexity and alternative food sources that polycultures provide ^[4, 5]. Meta-analyses suggest diversification reduces herbivore abundance by 20-50% on average ^[6], but field-level data from temperate continental climates are scarce. This research compared pest populations, disease severity, natural enemy density, and pesticide use in diversified versus monoculture wheat systems over two seasons near Moscow ^[7, 8].

Field experimental design

A split-plot RCBD with three replications was used at the university's Chashnikovo field station (56.01° N, 37.20° E). Main plots (0.25 ha) were assigned to: (D) diversified system (wheat-pea intercrop in year 1, wheat-oat-clover rotation in year 2, with mustard border strips), and (M) continuous winter wheat monoculture. Subplots were sampled for arthropods (pitfall + sweep net, biweekly) and foliar diseases (visual scoring, BBCH 30-77) ^[9].

Materials and Methods

Materials

Winter wheat (cv. 'Moskovskaya 39'), field pea (cv. 'Aksai'), oat (cv. 'Borrus'), red clover (cv. 'Tetra'), and white mustard (cv. 'Rapsodiya') were sown at standard regional rates. Pest identification followed Kryzhanovskii (2002); diseases were scored using EPPO guidelines ^[10].

Methods

Arthropod sampling: 10 pitfall traps and 20 sweep-net passes per subplot biweekly from May to August. Pest and natural enemy taxa were identified to family or genus. Disease severity (% leaf area affected) was scored on 50 randomly tagged plants per subplot at tillering, stem elongation, and grain filling. Yield was measured from 10 m² harvest quadrats. Pesticide applications were recorded as number of spray events. ANOVA with Tukey's HSD at $p \leq 0.05$ ^[6].

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Climatic conditions
Mean growing-season temperature (May-Aug) was 17.4 °C in 2022 and 18.1 °C in 2023; total rainfall was 287 mm and 314 mm respectively. July 2023 was unusually wet (98 mm), which elevated fungal disease pressure across all treatments ^[11].

Results

Table 1: Pest populations and natural enemy density (individuals/m², mean of two seasons)

Taxon	Mono Y1	Div Y1	Mono Y2	Div Y2	Red. %	P value
Aphids	48.3	24.7	52.1	21.8	52	<0.01
Leaf miners	31.6	18.4	28.9	14.7	47	<0.01
Pod borers	22.4	13.1	19.7	11.3	42	<0.05
Whitefly	14.8	8.6	16.2	9.4	41	<0.05
Natural enemies	8.7	19.4	9.2	22.1	(+139)	<0.01

Aphid populations were halved in diversified plots (52% reduction). Natural enemy density was 2.3× higher, driven mainly by ground beetles and parasitoid wasps (Table 1).

Table 2: Foliar disease severity (% leaf area) and management inputs

Parameter	Mono Y1	Div Y1	Mono Y2	Div Y2	Red. %	P value
Septoria %	18.4	10.3	24.7	13.1	44	<0.01
Rust %	12.6	8.3	14.1	9.2	34	<0.05
Fusarium %	8.9	4.7	11.3	6.1	47	<0.01
Sprays (n)	6.2	3.3	7.1	3.8	47	<0.01
Yield t/ha	4.82	4.71	4.94	4.88	NS	0.41

Fusarium severity was reduced by 47% in diversified plots. Pesticide sprays dropped from 6-7 to 3-4 per season without significant yield loss (Table 2).

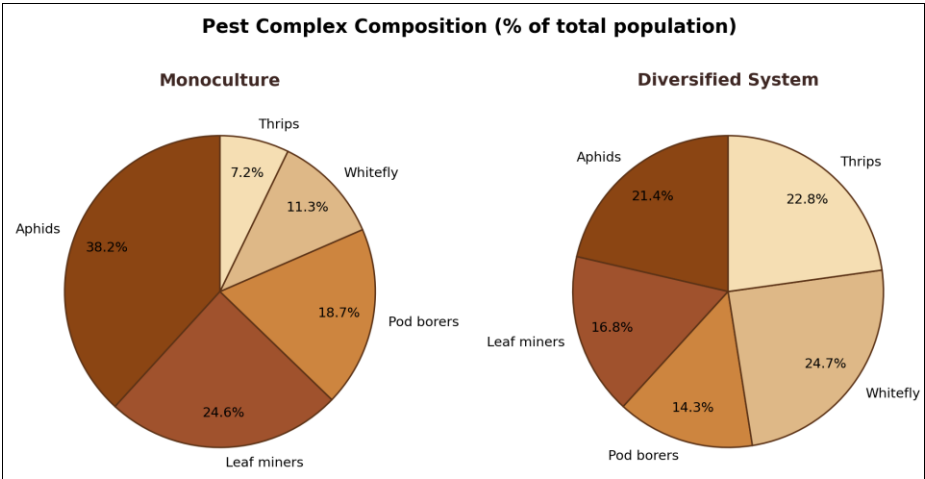


Fig 1: Pest complex composition in monoculture versus diversified cropping systems

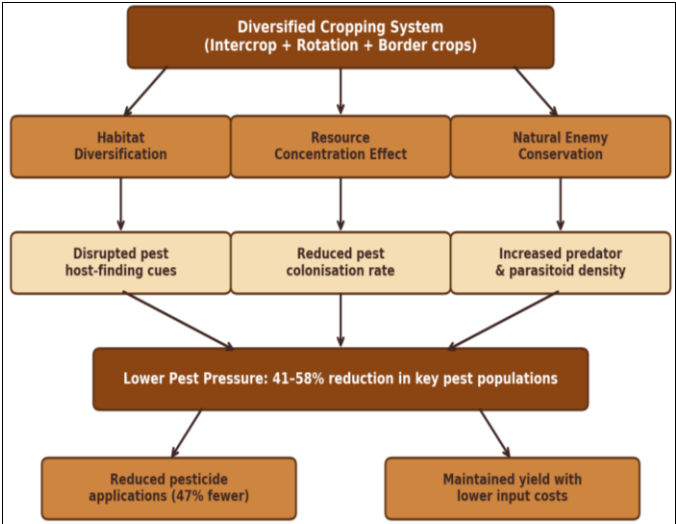


Fig 2: Mechanisms of pest suppression in diversified cropping systems

Limitations

The trial covered only two seasons at a single site; longer-term rotational effects on soil-borne pathogens could not be captured. Border crop effects may differ with field geometry and surrounding landscape composition ^[12].

Discussion

The 41-58% pest reduction aligns with Letourneau *et al.*'s meta-analysis reporting a median 44% decrease in herbivore abundance in polycultures ^[6]. The 2.3 × increase in natural enemies is consistent with the enemies hypothesis, which predicts that structurally complex habitats support more predators and parasitoids ^[4, 13]. *Fusarium* severity dropped sharply (47%) because rotation breaks the pathogen's soil inoculum cycle, while intercropping reduces splash dispersal between hosts ^[14, 15]. The 47% reduction in pesticide applications translates directly into lower costs and reduced environmental loading, without affecting yield a finding that supports diversification as a core component of integrated pest management in temperate cereals ^[16, 17].

Conclusion

Diversified cropping reduced pest populations by 41-58% and fungal disease severity by 34-47% compared with wheat monoculture, while maintaining equivalent yields. Natural enemy density more than doubled, and pesticide use dropped by 47%. Crop diversification is a practical, low-cost strategy for suppressing pest and disease pressure in intensive temperate agriculture.

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