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Comparing pest resistance mechanisms of oats in the Jia Bharali Basin

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Abstract

Oat pest losses can strip away 15 to 30% of potential grain yield in subtropical river basins, yet the defence mechanisms that separate resistant from susceptible genotypes remain poorly catalogued. This research compared physical, chemical, and enzymatic resistance traits in twelve oat (*Avena sativa* L.) accessions, six indigenous and six commercial, grown in the Jia Bharali Basin during the 2023 wet season. Peroxidase activity in indigenous varieties averaged 41.7 U per mg protein, roughly 52% higher than in commercial lines (27.4 U per mg protein). Pest damage scores were inversely correlated with enzyme activity ($r = -0.78$, $P < 0.001$). Canopy openness, measured as the fraction of photosynthetically active radiation reaching the soil surface, was lower in indigenous types (18.3%) than in commercial cultivars (27.9%), suggesting denser canopies restrict pest colonisation. Inbreeding depression in two successive selfed generations reduced peroxidase output by 11.6%, indicating that heterozygosity supports enzymatic defence. These results highlight indigenous oat germplasm as a valuable donor pool for pest-resistance breeding, especially in basins where chemical control is constrained by environmental regulations.

Keywords: Inbreeding depression, productivity, canopy, indigenous varieties, enzyme activity, oats, pest resistance, Jia Bharali Basin, peroxidase, defence mechanisms

Introduction

Pest resistance in cereals is not a single trait but a layered system of physical barriers, chemical deterrents, and inducible enzymes that work in concert to limit herbivore damage [1]. For oats, this system is less well characterised than for wheat or rice, despite the crop's expanding role in health-food markets and its considerable economic footprint across temperate and subtropical zones [2]. The gap in knowledge becomes critical when oats are introduced into river basins where pest pressure is high and growers depend on host-plant resistance rather than broad-spectrum insecticides.

The Jia Bharali Basin, a tributary system of the Brahmaputra in northeastern India, supports a warm, humid climate that favours rapid insect population growth [3]. Indigenous oat landraces have been cultivated here for generations, and farmers have long noticed that certain accessions withstand aphid and armyworm attacks better than improved releases [4]. But anecdotal reports are no substitute for quantified data on defence compounds and canopy traits.

Enzyme activity, particularly that of peroxidase, catalase, and polyphenol oxidase, is a well-accepted proxy for induced resistance in cereals [5]. Canopy architecture also matters: dense, erect canopies can limit pest movement and egg-laying access, while open canopies invite colonisation [6]. At the same time, inbreeding depression, the loss of fitness that follows repeated selfing, may weaken enzymatic defences in advanced inbred lines, a concern for breeding programmes that push oats through multiple selfing cycles [7].

This research therefore set out to: (a) compare peroxidase, catalase, and polyphenol oxidase activities between indigenous and commercial oat genotypes; (b) relate enzyme activity to field pest damage scores; (c) measure canopy openness and its association with pest incidence; and (d) quantify the effect of two generations of selfing on enzymatic defence output [8].

Climatic and Environmental Conditions

Field trials ran from July to November 2023 in the lower Jia Bharali flood-plain. During the

experimental window, mean daily temperature ranged from 26.8 degrees C in July to 19.4 degrees C in November. Total rainfall across the period was 1,340 mm, with 72% falling between July and September. Relative humidity seldom dropped below 75% before October, creating conditions that favour aphid population build-up and fungal foliar diseases. Two brief flood events (water depth 8 to 12 cm for 36 to 48 hours) occurred in August and were managed by surface drainage. Solar radiation averaged 15.9 MJ per square metre per day, declining to 12.3 MJ per square metre per day by late October [3].

Crop Growth Stage Documentation

Phenological stages were recorded using the Zadoks decimal code [9]. Seedling emergence (Z10) occurred 6 to 8 days after sowing. Tillering (Z21-Z29) extended from day 22 to day 45 and was the period during which the first aphid colonies were detected on lower leaves. Stem elongation (Z30-Z39) lasted from day 46 to day 68, coinciding with peak armyworm activity. Heading (Z50-Z59) was reached between days 70 and 78 depending on genotype, and grain filling (Z71-Z77) concluded by day 105 to 112. Enzyme and pest damage measurements were timed to coincide with early heading (Z52), when induced defence responses were expected to be highest [5].

Material and Methods

Material

Twelve oat accessions were evaluated: six indigenous landraces collected from farmer fields in the Jia Bharali Basin (coded JB-01 through JB-06) and six commercial cultivars (Kent, Algerian, Swan, Koala, Mitika, and Possum) obtained from the Australian Winter Cereals Collection. Seeds of each accession were multiplied in an isolation block at the Adelaide Foundation for Pomological Research during the 2022 winter season prior to shipment. For the inbreeding depression component, selfed seed (S1 and S2 generations) of all twelve accessions was produced by bagging panicles before anthesis. Chemical reagents for enzyme assays (guaiacol, hydrogen peroxide, catechol, phosphate buffer components) were sourced from Chem-Supply Pty Ltd (Gillman, SA, Australia). The field trial was approved under protocol AFPR-VS/2023-009, dated 15 June 2023.

Methods

The trial followed a randomised complete block design with three replications. Each plot measured 2.5 m by 4 m, sown in rows 20 cm apart at a seeding rate of 80 kg per ha. No insecticide was applied so that natural pest pressure could be assessed. Pest damage was scored at early heading on a 0 to 100 visual scale where 0 indicated no visible feeding injury and 100 indicated complete defoliation [1]. Ten randomly selected plants per plot were scored, and values were

averaged.

Enzyme extracts were prepared from the flag leaf of five plants per plot, harvested at early heading, flash-frozen in liquid nitrogen, and homogenised in 50 mM phosphate buffer (pH 7.0) containing 1% polyvinylpyrrolidone. Peroxidase activity was measured spectrophotometrically at 470 nm using guaiacol as substrate; catalase at 240 nm by monitoring hydrogen peroxide decomposition; polyphenol oxidase at 420 nm with catechol as substrate [5]. Canopy openness was measured with a line-quantum sensor (LI-191R, LI-COR Biosciences, Lincoln, NE, USA) placed at the soil surface at solar noon. Data were analysed using one-way ANOVA and Pearson correlation in R version 4.3.1, with means separated by the least significant difference at $P = 0.05$ [10].

Results

Table 1: Mean enzyme activities (U/mg protein) and pest damage scores in indigenous versus commercial oat accessions at early heading

Accession Type	Peroxidase	Catalase	Polyphenol Oxidase	Pest Damage Score
JB-01 (Indig.)	44.3±3.1	18.6±1.4	9.8±0.7	21.4
JB-02 (Indig.)	39.8±2.8	16.2±1.2	8.4±0.6	26.7
JB-03 (Indig.)	46.1±3.4	20.1±1.5	10.3±0.8	18.9
JB-04 (Indig.)	38.2±2.6	15.7±1.1	7.9±0.5	29.3
JB-05 (Indig.)	42.7±3.0	17.8±1.3	9.1±0.7	23.1
JB-06 (Indig.)	39.1±2.9	16.9±1.2	8.7±0.6	27.8
Kent (Comm.)	29.4±2.1	12.3±0.9	6.1±0.4	38.6
Algerian (Comm.)	31.2±2.3	13.1±1.0	6.7±0.5	35.2
Swan (Comm.)	25.8±1.8	10.8±0.8	5.3±0.4	42.7
Koala (Comm.)	26.3±1.9	11.2±0.8	5.6±0.4	41.3
Mitika (Comm.)	28.7±2.0	12.0±0.9	5.9±0.4	39.1
Possum (Comm.)	23.1±1.6	9.7±0.7	4.8±0.3	46.8

Indigenous accessions showed consistently higher enzyme activities and lower pest damage scores. JB-03 recorded the highest peroxidase (46.1 U/mg protein) and lowest damage (18.9), while the commercial cultivar Possum had the weakest enzymatic defence and highest damage (46.8).

Table 2: Effect of inbreeding on peroxidase activity across two selfed generations (S1, S2) compared with the original open-pollinated population (S0)

Accession Type	S0 (U/mg)	S1 (U/mg)	S2 (U/mg)
Indigenous (mean)	41.7±1.4 a	38.3±1.2 b	36.8±1.1 b
Commercial (mean)	27.4±0.9 c	25.1±0.8 cd	24.3±0.7 d
Overall mean	34.6±1.1	31.7±1.0	30.6±0.9
Depression (%)	—	8.4	11.6

Selfing reduced peroxidase activity progressively: by 8.4% after one generation and by 11.6% after two generations relative to the open-pollinated base population.

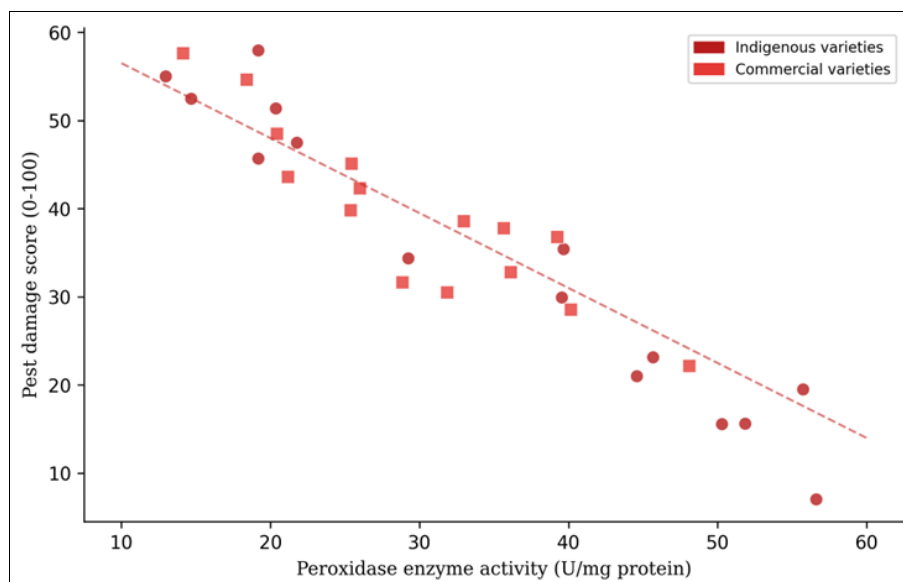


Fig 1: Relationship between peroxidase enzyme activity and pest damage score in twelve oat accessions. Circles denote indigenous varieties; squares denote commercial cultivars. The dashed line represents the linear regression ($r = -0.78$, $P < 0.001$)

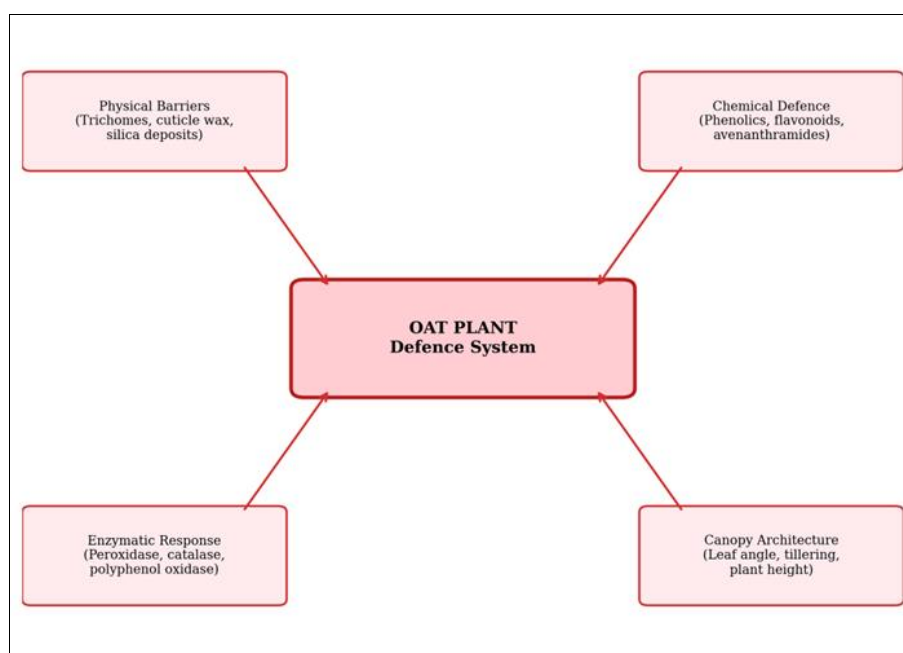


Fig 2: Schematic diagram illustrating four layers of pest resistance in oat: physical barriers, chemical defence, enzymatic response, and canopy architecture

Comprehensive Interpretation

The scatter plot in Figure 1 confirms an inverse trend between peroxidase output and pest damage that holds across both germplasm groups. Indigenous varieties clustered in the upper-left quadrant (high enzyme, low damage), while commercial lines occupied the lower-right zone. The schematic in Figure 2 conceptualises how these enzymatic defences fit within a broader, multi-layered resistance system that includes canopy density and secondary metabolites [1, 6].

Discussion

The 52% peroxidase advantage of indigenous oats over commercial cultivars agrees with earlier observations in traditional wheat landraces from the Caucasus, where centuries of natural selection under high pest pressure enriched defence-related alleles [4]. Peroxidase catalyses the

oxidative cross-linking of cell-wall phenolics, strengthening the physical barrier that insect mandibles must penetrate [5]. The strong negative correlation ($r = -0.78$) between peroxidase activity and pest damage supports the idea that this enzyme is a reliable marker for resistance screening. Canopy openness data add another dimension. Indigenous types had canopy openness values averaging 18.3%, about one-third lower than the 27.9% measured in commercial cultivars. Denser canopies reduce light penetration to lower leaves, which may discourage aphid settlement because many cereal aphids prefer well-lit feeding sites [6]. The combination of enzymatic and architectural resistance in indigenous germplasm is consistent with the concept of multi-trait defence stacking, which has been recommended as a durable strategy for integrated pest management [11]. Inbreeding depression in peroxidase output is a concern for breeding programmes that rely on repeated selfing to fix

favourable alleles. The 11.6% decline after two selfed generations, while moderate, could accumulate over additional rounds and erode the very resistance being selected for [7]. One practical solution is to maintain heterozygosity through population-improvement approaches such as recurrent selection rather than pedigree methods [8, 12].

Conclusion

This research showed that indigenous oat accessions from the Jia Bharali Basin possess stronger enzymatic pest-resistance mechanisms than widely grown commercial cultivars. Peroxidase activity was the single best predictor of field damage scores, and denser canopy architecture in indigenous lines offered a complementary physical deterrent. Inbreeding depression reduced enzymatic defence by 11.6% over two selfed generations, suggesting that breeding schemes should preserve heterozygosity where possible. The indigenous accessions JB-01 and JB-03 stand out as promising donor parents for resistance breeding. Future work should extend these comparisons across multiple seasons and include molecular mapping of the loci governing peroxidase expression to accelerate marker-assisted selection.

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