

## INHERITANCE OF MORPHOLOGICAL AND AGRONOMIC TRAITS IN TRITICALE

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**Abstract:** Triticale ( $\times$  Triticosecale), a hybrid of wheat (*Triticum* spp.) and rye (*Secale cereale*), combines high yield potential with environmental resilience. This study extensively analyzes the inheritance of morphological and agronomic traits, including plant height, spike length, number of grains per spike, 1000-grain weight, growth duration, abiotic stress tolerance (drought and salinity), and disease resistance. Fifteen genotypes were evaluated over two growing seasons in a randomized complete block design with three replications. Traits were assessed for heritability, genotype  $\times$  environment (G $\times$ E) interactions, phenotypic–genotypic correlations, heterosis, and segregation patterns. High heritability was observed for spike length, 1000-grain weight, and growth duration ( $H^2 > 0.6$ ), whereas stress tolerance and disease resistance exhibited low heritability ( $H^2 < 0.4$ ). Positive correlations among key yield traits suggest that indirect selection may improve productivity, while G $\times$ E effects highlight the need for multi-environment trials. These results provide a comprehensive framework for breeding high-yielding, resilient, and environmentally adaptable triticale varieties.

**Keywords:** Triticale, Morphological traits, Agronomic traits, Heritability, Breeding, Plant height, Spike length, Grain weight, Growth duration, Genotype  $\times$  Environment (G $\times$ E), Stress tolerance, Disease resistance, Heterosis, Selection strategies, Molecular breeding

### Introduction

Triticale is a synthetic amphiploid cereal developed by hybridizing wheat and rye. It combines wheat's high yield potential, grain quality, and nutrient content with rye's adaptability, stress tolerance, and disease resistance. Since its development, triticale has been cultivated in Europe, Asia, and the Americas for both food and feed purposes.

Morphological and agronomic traits in triticale are complex and polygenic. Plant height, spike length, grain number, and 1000-grain weight directly influence yield potential, whereas growth duration determines adaptability to different agroecological zones. Abiotic stress tolerance (e.g., drought and salinity) and disease resistance (e.g., rust, powdery mildew) are crucial for stable productivity under environmental variability.

Understanding heritability, correlations among traits, and G $\times$ E interactions is essential for designing effective breeding programs. Traits with high heritability can be improved through conventional selection, while traits influenced by environment require recurrent selection, genomic-assisted breeding, or pyramiding approaches. Recent studies suggest that integrating molecular tools with traditional breeding enhances selection efficiency and accelerates the development of superior triticale varieties (Kowalski, 2024; Zhang & Lee, 2023).

### Materials and Methods

## Plant Material

Fifteen triticale genotypes (local and introduced) were cultivated at the experimental farm of Termez State University of Engineering and Agro-technologies during two consecutive seasons (2022–2024). The genotypes were arranged in a randomized complete block design with three replications. Standard agronomic practices were followed.

## Traits Measured

Plant height (cm): measured from soil surface to spike tip.

Spike length and density (cm): measured on 10 representative spikes per genotype per plot.

Number of grains per spike: average of 10 spikes per replication.

1000-grain weight (g): determined using a precision balance.

Growth duration (days): from sowing to physiological maturity.

Abiotic stress tolerance: evaluated under controlled drought and salinity.

Disease resistance: assessed for rust (*Puccinia* spp.), powdery mildew (*Blumeria graminis*), and root rot.

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## Statistical Analysis

ANOVA was used to evaluate genotypic and environmental effects.

Broad-sense heritability ( $H^2$ ) and narrow-sense heritability ( $h^2$ ) were calculated.

Phenotypic and genotypic correlations were estimated.

Heterosis and segregation patterns were analyzed.

G×E interactions were assessed to determine trait stability.

## Results

### Heritability of Traits

High heritability ( $H^2 > 0.6$ ): spike length (0.68), 1000-grain weight (0.72), growth duration (0.65).

Moderate heritability ( $H^2 = 0.4–0.6$ ): plant height (0.52), grain number per spike (0.48).

Low heritability ( $H^2 < 0.4$ ): drought tolerance (0.35), salinity tolerance (0.32), disease resistance (0.30).

### Trait Correlations

Spike length positively correlated with 1000-grain weight ( $r = 0.61$ ,  $p < 0.01$ ).

Plant height correlated with growth duration ( $r = 0.58$ ,  $p < 0.01$ ).

Stress tolerance negatively correlated with yield under optimal conditions, indicating a trade-off.

#### Heterosis and Segregation

Crosses between high-yield and stress-tolerant genotypes showed heterosis for spike length (up to 15%) and 1000-grain weight (up to 12%).

Polygenic inheritance was observed for stress tolerance and disease resistance.

#### Genotype × Environment Interactions

G×E interactions were significant for plant height and grain number per spike ( $p < 0.05$ ), indicating the need for multi-environment trials.

#### Discussion

Triticale exhibits complex inheritance due to the combination of wheat and rye genomes. Traits like spike length and 1000-grain weight are mainly additive and highly heritable, suitable for direct selection. Stress tolerance and disease resistance are polygenic and environmentally influenced, requiring advanced breeding strategies.

Positive correlations among yield-related traits suggest that indirect selection may increase productivity. Heterosis observed for key traits indicates potential for hybrid breeding. Integrating molecular breeding tools, such as QTL mapping and marker-assisted selection (MAS), can accelerate the identification of superior genotypes and improve selection efficiency (Kowalski, 2024). Multi-environment evaluation remains essential for selecting stable genotypes adapted to diverse agroecological zones.

#### Conclusion

Highly heritable traits in triticale, such as spike length, 1000-grain weight, and growth duration, can be effectively selected through conventional breeding. Traits with moderate or low heritability, including stress tolerance and disease resistance, require multi-environment evaluation and genomic-assisted selection. This comprehensive study provides a scientific foundation for breeding high-yielding, resilient, and environmentally adaptable triticale varieties.

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