Genetic studies of lablab bean [Lablab purpureus (L.) Sweet] for tolerance to drought

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Abstract

Drought is a major abiotic stress that disrupts plant growth and is expected to become more prolonged in arid and semi-arid regions as climate change progresses. Lablab (*Lablab purpureus* [L.] Sweet) is a versatile, nitrogen-fixing food and fodder legume adapted to diverse environments, yet it remains underutilised, and its drought tolerance mechanisms are poorly understood. This study aimed to: (i) evaluate the morpho-physiological and biochemical responses of lablab seedlings to water stress; (ii) screen mature lablab for drought tolerance; (iii) estimate combining ability for drought tolerance; and (iv) identify quantitative trait loci (QTL) for drought tolerance.

Seeding responses: Ten genotypes were grown under well-watered, moderate and severe water stress at the University of Nairobi. Severe stress significantly ($p < 0.001$) reduced shoot length (29.4 to 15.4 cm), root length (11.15 to 7.8 cm) and photosynthetic efficiency, with significant genotype × stress interactions for most traits. Drought increased oxidative damage but also activated antioxidant enzymes (GPX, APX and CAT) and osmoprotectants such as proline. Genotypes D3 and D6 sustained the best growth, and D1, D6, and D7 showed the strongest protective responses, whereas D8 was among the most sensitive in growth and D9 and D10 were weaker in several tolerance traits.

Responses at maturity: In field trials at Kabete over two seasons, severe stress slightly delayed flowering and maturity, reduced plant height by 25% and sharply reduced yield: pods per plant fell from 22.45 to 4.58 and seed weight from 17.15 g to 3.30 g. Photosynthetic efficiency, chlorophyll content and shoot biomass also declined markedly. Seed weight was strongly correlated with pods per plant ($r = 0.83$). Genotype D7 best maintained pod and seed traits, whereas D4 declined the most.

Combining ability: A 7 × 7 half-diallel evaluated at MUARIK, Uganda, showed significant ($p < 0.01$) general and specific combining ability under severe stress, indicating both additive and non-additive gene action. Parents D3 and D8 were good general combiners for yield traits and D10 for stress-adaptive physiological traits, while crosses D3×D6, D4×D5, D5×D10, D3×D4 and D1×D3 showed favourable specific combining ability.

QTL mapping. A mapping population ($n = 142$) from drought-tolerant Makueni Black and susceptible Mbeere Cream was phenotyped under well-watered and severe stress and genotyped with high-density SNP markers. We detected 16 QTL, most with small effects ($R^2 < 4\%$), confirming that drought tolerance is polygenic; a major QTL for days to flowering on chromosome 3 explained up to 16.71% of the variation.

Conclusion: Drought tolerance in lablab involves coordinated growth, photosynthetic, antioxidant and osmotic responses and is controlled by many small-effect loci. The superior genotypes, parents, crosses and genomic regions identified provide a foundation for marker-assisted selection and the breeding of climate-resilient lablab varieties.