### 6.2 Verification of the applicability of watermelon fruit weight models across different ecological environments

Beyond goodness-of-fit within a single dataset, watermelon weight models must be evaluated for applicability across environments, especially when environmental factors are explicit inputs. Work on the adaptive potential of large watermelon collections illustrates that genotypes differ strongly in environmental plasticity for average marketable fruit weight, quantified using regression coefficients of genotype response (bi) and stability parameters such as Sgi and general adaptive capacity across multiple years and sites. These parameters effectively characterize how robust fruit weight performance is to fluctuating conditions, providing a conceptual analogue for assessing the environmental robustness of predictive models that incorporate fruit weight as an output trait (Serhiienko et al., 2023).

Model applicability across environments can also be approached through genotype×environment or drought-environment interaction analyses using multivariate tools. In muskmelon, AMMI and GGE biplot models were applied to fruit weight data across irrigation regimes, treating each drought level as an environment and identifying genotypes with stable fruit weight under mild to severe soil water depletion. The GGE biplot classified irrigation regimes into a single mega-environment and distinguished genotypes with wide adaptability and stability, demonstrating that statistical modeling of performance across contrasting water regimes can objectively test whether a predictive framework (or genotype response surface) remains valid under varying ecological conditions (Rad and Bakhshi, 2020).

### 6.3 Sensitivity and stability analysis of watermelon fruit weight models

Sensitivity and stability analyses clarify how strongly fruit weight predictions depend on specific inputs or environmental drivers, and whether the model behaves reliably under stress or management changes. In a simplex lattice design modeling watermelon fruit weight as a function of poultry, cow, and goat manures, second-order mixture models were fitted and evaluated using analysis of variance; significant F-values and low p-values indicated that the quadratic models were adequate for prediction and captured the effects and interactions of nutrient components on fruit weight. Examining the estimated coefficients and interaction terms provided practical insight into which manure sources most strongly influenced model outputs and under what combinations the model predicted maximum fruit weight per plant.

Stability in the face of environmental variability is also addressed indirectly in studies that quantify genotype stability and plasticity for average fruit weight across multi-year, multi-environment trials. Using parameters such as genotype stability (Sgi), specific adaptive capacity, and plasticity coefficient (bi), large watermelon collections were partitioned into intensive, medium, and highly plastic groups with respect to total and marketable yield and average fruit weight, effectively ranking genotypes by how consistently they express fruit weight under changing conditions. While these analyses focus on biological responses rather than explicit prediction models, the same stability statistics and multi-environment frameworks can be incorporated into model validation protocols to test whether watermelon fruit weight prediction models maintain performance across diverse ecological and management scenarios (Serhiienko et al., 2023).

## 7 Case Study: Application of Watermelon Fruit Weight Prediction Based on Multiple Environmental Conditions

### 7.1 Data sources from typical watermelon cultivation regions

Case studies on watermelon fruit weight modeling can draw on diverse cultivation systems, from rain-shelter or greenhouse production to fully open-field systems. Under rain-shelter structures, fertigation trials with water-soluble NPK generated detailed records of leaf traits, fruit weight and quality, enabling regression analyses that identified 125% of the conventional NPK rate as optimal for fruit weight in protected conditions (Figure 3) (Hafiz et al., 2024). In contrast, open-field experiments with soil-moisture-sensor-based drip irrigation under different mulches in North Dakota produced multi-year datasets combining average fruit weight, diameter, and quality traits with rainfall and irrigation records, providing a basis for environment-response modeling in a cool, continental climate (Vaddevolu et al., 2021).