**GA Model Output Explanation**

This output represents the **recommended price decision** generated by a **Genetic Algorithm (GA)** model. It combines price optimization, demand prediction, and profit estimation based on historical sales data, competitor pricing, and market trends.

**🔹 Recommended Pricing & Profitability**

* **Recommended Price:** **₹95.45**  
  → The GA model suggests setting today’s product price at ₹95.45 for optimal balance between sales volume and profit.
* **Best Price (Raw):** **₹96.68**  
  → The model initially found ₹96.68 as the highest profit point, but after adjustment for competition and business rules, the recommendation is slightly lower at ₹95.45.
* **Predicted Sales Volume:** **14,562 units (approx.)**  
  → Expected demand at the recommended price.
* **Expected Profit:** **₹1,40,958 (approx.)**  
  → Profit estimated after considering cost, demand, and competitor pricing.

**🔹 Market & Cost Context (Today’s Snapshot)**

* **Date:** 31st December 2024
* **Yesterday’s Price:** ₹94.45
* **Cost per Unit:** ₹85.77
* **Competitor Price Mean:** ₹95.31  
  → The suggested price is slightly **above yesterday’s price** and **in line with competitor average**.

**🔹 Model Performance (Accuracy of Predictions)**

The GA model was trained and tested on historical data. Performance metrics are given below:

**Training Data (historical fit)**

* **MAE:** 201.68 → On average, predictions differ from actuals by ~202 units.
* **RMSE:** 256.87 → Average prediction error magnitude.
* **MAPE:** 1.45% → Low average percentage error.

**Test Data (future/generalization)**

* **MAE:** 566.84 → Larger average error in test data.
* **RMSE:** 733.50 → Higher deviation on unseen data.
* **MAPE:** 4.05% → Average error ~4%, acceptable but less accurate than training.

⚠️ **Interpretation:** The model fits past data very well, but test performance shows room for improvement. Still, prediction error remains within a manageable business tolerance (~4%).

**🔹 Key Features Used by the Model**

The GA selected the most important variables influencing demand and pricing:

* dow **(Day of Week)**
  + Captures weekday vs weekend patterns.
  + Example: Sales may be higher on Fridays (before long trips) and lower on Mondays.
* price\_gap\_mean **(Average price difference vs competitors)**
  + Measures how much above/below competitors you are.
  + Example: If your price = ₹97, competitors = ₹95 → gap = +₹2 (customers may buy less).
* volume\_roll7 **(7-day moving average of sales volume)**
  + Smooths recent sales trends.
  + Example: If daily volumes = [13k, 14k, 15k…], the 7-day rolling average shows demand momentum.
* volume\_lag7 **(Volume from 7 days ago)**
  + Captures weekly cycles.
  + Example: Demand on Sundays may repeat weekly (picnic trips, family outings).
* margin **(Profit per unit)**
  + Defined as *(price – cost)*.
  + Example: If price = ₹97, cost = ₹86 → margin = ₹11/litre.
* price\_gap\_mean\_lag1 **(Yesterday’s competitor gap)**
  + Captures whether you were cheaper/expensive yesterday, and its effect today.
  + Example: If yesterday you were ₹2 higher than competitors and sales fell, model learns sensitivity.
* dayofyear **(Seasonality)**
  + Catches annual patterns (festivals, holidays, vacations).
  + Example: Year-end travel (December) → higher sales regardless of price.
* price\_lag7 **(Price 7 days ago)**
  + Weekly pricing cycle memory.
  + Example: If last week’s price was ₹96, today’s demand may still reflect customer memory.
* price\_lag1 **(Yesterday’s price)**
  + Captures short-term stickiness.
  + Example: Customers may recall yesterday’s price, so sudden hikes can reduce demand sharply.
* cost **(Unit cost of product)**
  + Input constraint for profit calculations.
  + Example: If cost = ₹85.77, pricing below this is a loss.
* comp\_spread **(Competitor price spread)**
  + Measures competition intensity (difference between highest and lowest competitor).
  + Example: If competitors = [95, 96, 98], spread = 3 (aggressive competition).
* price\_roll7 **(7-day average price trend)**
  + Smooths out own pricing trend.
  + Example: If you’ve been steadily raising prices, customers may expect stability and resist further hikes.

✅ These features show that the model heavily relies on **competitor pricing, recent sales trends, seasonality, and margin** when recommending prices.

**📌 Final Business Insight**

* The **recommended price is ₹95.45**, which aligns well with competitor pricing and ensures healthy margins above cost (₹85.77).
* **Profit potential is strong (~₹1.41 lakh)** with estimated sales of ~14,562 units.