Use of JMP V.5 for Teaching and Research of Applied Stat/Math Methods in Life Sciences

Mohammed Al-Qinna, University of Arkansas, Fayetteville
Aim

• Need to characterize, visualize, analyze, and interpret measured data,
• Studying an arbitrary real-world phenomenon requires the use of different mathematical and statistical techniques, models and assumptions to translate the problem from its natural environment to a mathematical concept then to investigate and simplify such entity into a descriptive reality or result,
• Familiarize researchers with developments in modeling and data mining techniques using JMP 5.0 as a tool to visualize, understand and properly interpret data.
Content

• Data presentation,
• Data exploration,
• Data analyses,
• Spatial statistics,
• Modeling concepts,
• Models of growth and decay,
• Development of conservation and rate equations,
• Compartmental analysis and chemical kinetics,
• Numerical approximations of functions and equations.
JMP is a business unit of SAS, the world leader in business intelligence software and services powered by market-leading analytics.
Why JMP?

- JMP provides a comprehensive set of statistical tools as well as Design of Experiments and Statistical Quality Control in a single package.
- Empower researchers and students at all levels to explore and conduct data analysis closer to the actual process.
- Reduce time and risk of errors with fewer steps.
- Visual investigation and modeling of data.
- Designed for anyone who wants to discover relationships and outliers in their data.
Example

An experiment conducted at UARK to compare germination models for two plant species (corn and bean) over time.
<table>
<thead>
<tr>
<th>DAYS AFTER PLANTING</th>
<th>Germination</th>
<th>Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.00465116</td>
<td>corn</td>
</tr>
<tr>
<td>2</td>
<td>0.09362326</td>
<td>corn</td>
</tr>
<tr>
<td>3</td>
<td>0.23902326</td>
<td>corn</td>
</tr>
<tr>
<td>4</td>
<td>0.42325581</td>
<td>corn</td>
</tr>
<tr>
<td>5</td>
<td>0.48372093</td>
<td>corn</td>
</tr>
<tr>
<td>6</td>
<td>0.65348837</td>
<td>corn</td>
</tr>
<tr>
<td>7</td>
<td>0.69767442</td>
<td>corn</td>
</tr>
<tr>
<td>8</td>
<td>0.74418605</td>
<td>corn</td>
</tr>
<tr>
<td>9</td>
<td>0.77209302</td>
<td>corn</td>
</tr>
<tr>
<td>10</td>
<td>0.79634884</td>
<td>corn</td>
</tr>
<tr>
<td>11</td>
<td>0.85511526</td>
<td>corn</td>
</tr>
<tr>
<td>12</td>
<td>0.87908977</td>
<td>corn</td>
</tr>
<tr>
<td>13</td>
<td>0.9527907</td>
<td>corn</td>
</tr>
<tr>
<td>14</td>
<td>0.97209302</td>
<td>corn</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>corn</td>
</tr>
<tr>
<td>16</td>
<td>0</td>
<td>bean</td>
</tr>
<tr>
<td>17</td>
<td>0.00966184</td>
<td>bean</td>
</tr>
<tr>
<td>18</td>
<td>0.01449276</td>
<td>bean</td>
</tr>
<tr>
<td>19</td>
<td>0.02415459</td>
<td>bean</td>
</tr>
<tr>
<td>20</td>
<td>0.0821256</td>
<td>bean</td>
</tr>
<tr>
<td>21</td>
<td>0.41545894</td>
<td>bean</td>
</tr>
<tr>
<td>22</td>
<td>0.5748723</td>
<td>bean</td>
</tr>
<tr>
<td>23</td>
<td>0.67149758</td>
<td>bean</td>
</tr>
<tr>
<td>24</td>
<td>0.77294686</td>
<td>bean</td>
</tr>
</tbody>
</table>
### Crop = corn

#### Distributions

#### Germination

![Graph showing normal distribution with parameters](chart)

**Quantiles**

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.0%</td>
<td>1.0000</td>
</tr>
<tr>
<td>99.5%</td>
<td>1.0000</td>
</tr>
<tr>
<td>97.5%</td>
<td>1.0000</td>
</tr>
<tr>
<td>90.0%</td>
<td>0.9833</td>
</tr>
<tr>
<td>75.0% quartile</td>
<td>0.8791</td>
</tr>
<tr>
<td>50.0% median</td>
<td>0.7442</td>
</tr>
<tr>
<td>25.0% quartile</td>
<td>0.4233</td>
</tr>
<tr>
<td>10.0%</td>
<td>0.0577</td>
</tr>
<tr>
<td>2.5%</td>
<td>0.0047</td>
</tr>
<tr>
<td>0.5%</td>
<td>0.0047</td>
</tr>
<tr>
<td>0.0% minimum</td>
<td>0.0047</td>
</tr>
</tbody>
</table>

**Moments**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.635369</td>
</tr>
<tr>
<td>Std Dev</td>
<td>0.3173057</td>
</tr>
<tr>
<td>Std Err Mean</td>
<td>0.081926</td>
</tr>
<tr>
<td>upper 95% Mean</td>
<td>0.811687</td>
</tr>
<tr>
<td>lower 95% Mean</td>
<td>0.460251</td>
</tr>
<tr>
<td>N</td>
<td>15</td>
</tr>
<tr>
<td>Sum Wgts</td>
<td>15</td>
</tr>
<tr>
<td>Sum</td>
<td>9.5395349</td>
</tr>
<tr>
<td>Variance</td>
<td>0.1006829</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.800066</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.394157</td>
</tr>
<tr>
<td>CV</td>
<td>49.893262</td>
</tr>
</tbody>
</table>

#### Fitted Normal

**Parameter Estimates**

<table>
<thead>
<tr>
<th>Type</th>
<th>Parameter</th>
<th>Estimate</th>
<th>Lower 95%</th>
<th>Upper 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Mu</td>
<td>0.6359690</td>
<td>0.4602510</td>
<td>0.8116870</td>
</tr>
<tr>
<td>Dispersion</td>
<td>Sigma</td>
<td>0.3173057</td>
<td>0.2323079</td>
<td>0.5004225</td>
</tr>
</tbody>
</table>

#### Goodness-of-Fit Test

**Shapiro-Wilk W Test**

<table>
<thead>
<tr>
<th>W</th>
<th>Prob=W</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.910688</td>
<td>0.1394</td>
<td></td>
</tr>
</tbody>
</table>

**CDF Plot**

![CDF Plot](chart)
### Oneway Analysis of Germination By Crop

#### Summary of Fit
- Rsquare: 0.013042
- Adj Rsquare: -0.02221
- Root Mean Square Error: 0.372189
- Mean of Response: 0.594635
- Observations (or Sum Wgts): 30

#### t Test
- Assuming equal variances:
  - Difference: -0.08267
  - Estimate: -0.608
  - Std Error: 0.13590
  - Lower 95%: -0.36106
  - Upper 95%: 0.19572

- Unequal Variances:
  - Difference: -0.08267
  - Estimate: -0.608
  - Std Error: 0.13590
  - Lower 95%: -0.36199
  - Upper 95%: 0.19666

#### Analysis of Variance

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Ratio</th>
<th>Prob &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop</td>
<td>1</td>
<td>0.0512548</td>
<td>0.051255</td>
<td>0.3700</td>
<td>0.5479</td>
</tr>
<tr>
<td>Error</td>
<td>28</td>
<td>3.8786901</td>
<td>0.138525</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Total</td>
<td>29</td>
<td>3.9294449</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Means for Oneway Anova

<table>
<thead>
<tr>
<th>Level</th>
<th>Number</th>
<th>Mean</th>
<th>Std Error</th>
<th>Lower 95%</th>
<th>Upper 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>bean</td>
<td>15</td>
<td>0.553301</td>
<td>0.09610</td>
<td>0.35645</td>
<td>0.75015</td>
</tr>
<tr>
<td>corn</td>
<td>15</td>
<td>0.635969</td>
<td>0.09610</td>
<td>0.43912</td>
<td>0.83282</td>
</tr>
</tbody>
</table>

Std Error uses a pooled estimate of error variance

#### Means Comparisons

<table>
<thead>
<tr>
<th>Dif=Mean[i]-Mean[j]</th>
<th>corn</th>
<th>bean</th>
</tr>
</thead>
<tbody>
<tr>
<td>corn</td>
<td>0.00000</td>
<td>0.08267</td>
</tr>
<tr>
<td>bean</td>
<td>-0.08267</td>
<td>0.00000</td>
</tr>
</tbody>
</table>

Alpha= 0.05

Comparisons for each pair using Student's t
- t: 2.04841
- Alpha: 0.05

Abs(Dif)-LSD
- corn: -0.27830
- bean: -0.19572

Positive values show pairs of means that are significantly different.

Level  Mean
- corn A 0.63596899
- bean A 0.55330113

Levels not connected by same letter are significantly different
Bivariate Fit of Germination By DAYS AFTER PLANTING

**Polynomial Fit Degree=2 Crop="bean"**
Germination = -0.796536 + 0.0868023 DAYS AFTER PLANTING - 0.0015075 (DAYS AFTER PLANTING-15.9333)^2

**Summary of Fit**
- RSquare: 0.917536
- RSquare Adj: 0.903862
- Root Mean Square Error: 0.130213
- Mean of Response: 0.553301
- Observations (or Sum Wgts): 15

**Analysis of Variance**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>2</td>
<td>2.2656645</td>
<td>1.13283</td>
<td>66.8124</td>
</tr>
<tr>
<td>Error</td>
<td>12</td>
<td>0.2034651</td>
<td>0.01696</td>
<td>Prob &gt; F</td>
</tr>
<tr>
<td>C. Total</td>
<td>14</td>
<td>2.4691296</td>
<td>&lt;.0001</td>
<td></td>
</tr>
</tbody>
</table>

**Parameter Estimates**

| Term                  | Estimate | Std Error | t Ratio | Prob>|t| |
|-----------------------|----------|-----------|---------|------|
| Intercept             | -0.796536| 0.133699  | -5.97   | <.0001|
| DAYS AFTER PLANTING   | 0.0868023| 0.007612  | 11.40   | <.0001|
| (DAYS AFTER PLANTING-15.9333)^2 | -0.0015075| 0.001811 | -0.88   | 0.3979|

**Polynomial Fit Degree=2 Crop="corn"**
Germination = -0.338082 + 0.0656046 DAYS AFTER PLANTING - 0.0036236 (DAYS AFTER PLANTING-15.9333)^2

**Summary of Fit**
- RSquare: 0.966197
- RSquare Adj: 0.983896
- Root Mean Square Error: 0.040267
- Mean of Response: 0.635969
- Observations (or Sum Wgts): 15

**Analysis of Variance**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>2</td>
<td>1.3901037</td>
<td>0.695052</td>
<td>429.6744</td>
</tr>
<tr>
<td>Error</td>
<td>12</td>
<td>0.0194568</td>
<td>0.001621</td>
<td>Prob &gt; F</td>
</tr>
<tr>
<td>C. Total</td>
<td>14</td>
<td>1.4095605</td>
<td>&lt;.0001</td>
<td></td>
</tr>
</tbody>
</table>

**Parameter Estimates**

| Term                  | Estimate | Std Error | t Ratio | Prob>|t| |
|-----------------------|----------|-----------|---------|------|
| Intercept             | -0.338082| 0.041345  | -8.18   | <.0001|
| DAYS AFTER PLANTING   | 0.0656046| 0.002354  | 27.87   | <.0001|
| (DAYS AFTER PLANTING-15.9333)^2 | -0.0036236| 0.00056 | -6.47   | <.0001|
• Exponential Growth: \( Y = \alpha \times e^{\beta X} \)

• Monomolecular: \( Y = \alpha \times (1 - \gamma \times e^{-\beta X}) \)

• Mitscherlich: \( Y = \alpha \times (1 - e^{-\beta (X + \delta)}) \)

• Logistic: \( Y = \alpha / (1 + \gamma \times e^{-\beta X}) \)

• Gompertz: \( Y = \alpha \times \exp(-\gamma \times \exp(-\beta X)) \)
\[ a \cdot \text{Exp}\left[ -\left( c \cdot \text{Exp}\left[ -b \cdot \text{DAYS AFTER PLANTING} \right] \right) \right] \]
Fitting parameters in formula of Predictor column to Y column.

Select Columns:
- DAYS AFTER PLANTING
- Germination
- Crop
- Gompertz

Cast Selected Columns into Roles:
- Y, Response
- Germination
- X, Predictor Formula
- Gompertz
- Weight
- optional Numeric
- Freq
- optional Numeric
- Loss
- optional Numeric

By:
- Crop
- optional

X Predictor column must have formula:

Formulas:
- Predictor Parameter\((a = 1, c = 35, b = -0.3), a * \exp(-c * \exp(b * \text{DAYS AFTER PLANTING}))\)
Crop=bean

Nonlinear Fit

Control Panel

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Current</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iteration</td>
<td>59</td>
<td>60</td>
</tr>
<tr>
<td>Shortening</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Obj Change</td>
<td>0.000010943</td>
<td>0.0000001</td>
</tr>
<tr>
<td>Prm Change</td>
<td>0.0027220276</td>
<td>0.0000001</td>
</tr>
<tr>
<td>Gradient</td>
<td>2.0482439e-8</td>
<td>0.0000001</td>
</tr>
</tbody>
</table>

Edit Alpha   0.050
Convergence Criterion   0.000001
Goal SSE for CL   0.0265281135

Plot

DAYS AFTER PLANTING

Germination

Solution

SSE   DFE  MSE   RMSE
0.0190083644  12  0.001584  0.0397999

Parameter   Estimate   Approx:StdErr   Lower CL   Upper CL
a   1.0021421732   0.02421239   0.95064683   1.06282905
b   0.534408643   0.05368836   .   .

crop=corn

Nonlinear Fit

Control Panel

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Current</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iteration</td>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>Shortening</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Obj Change</td>
<td>0.0000187755</td>
<td>0.0000001</td>
</tr>
<tr>
<td>Prm Change</td>
<td>0.0003411888</td>
<td>0.0000001</td>
</tr>
<tr>
<td>Gradient</td>
<td>3.6294123e-7</td>
<td>0.0000001</td>
</tr>
</tbody>
</table>

Edit Alpha   0.050
Convergence Criterion   0.000001
Goal SSE for CL   0.0267119687

Plot

DAYS AFTER PLANTING

Germination

Solution

SSE   DFE  MSE   RMSE
0.0191401034  12  0.001595  0.0399376

Parameter   Estimate   Approx:StdErr   Lower CL   Upper CL
a   1.0012386663   0.03426018   0.93305445   1.09555761
b   0.2979902173   0.03204642   0.23224581   0.37700293

Conclusions

- Germination behavior of the two crops are nonlinearly related to time after planting.

- Beans germination growth shows more delay time but faster growth rate compared to corn.

- The best nonlinear predictive model that best fit the germination is Gompertz;
  Bean germination = 1.00 \times \exp (-1908.52 \times \exp (-0.53 \times \text{day after planting}))
  Bean germination = 1.00 \times \exp (-35.77 \times \exp (-0.30 \times \text{day after planting}))

- JMP Just Made it easy.