POTENTIAL KERNEL SET IN MAIZE PREDICTED FROM SIMPLE FLOWERING CHARACTERISTICS

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Introduction

- Prediction of kernel set is a critical component of most simulation models.
- These models perform well when yields are averaged across locations, but they often fail to predict kernel set accurately at a given location.
- We are developing methods to improve the accuracy of yield predictions by estimating kernel set from simple measures of flowering dynamics.

Objective

- Develop a mechanistic approach to predict potential kernel set in maize from typical field patterns of silking and pollen shed.

Procedure

- The dynamics of pollen shed and silk emergence were measured on a daily basis for a population of plants in the field.

1. Pollen shed dynamics

- Two alternative approaches:

$$\text{Pop Index} = \frac{\text{Start shed} + \text{Max shed}}{2} - \text{End shed}$$

$$PR = PR_x \times e^{-\frac{(t-t_x)^2}{2\times W^2}}$$

PR = polen rate (grains cm^{-2} GDD^{-1}) PR_x = maximum pollen rate
t_x = time when PR_x is reached W = curve width at half PR_x

2. Silking dynamics

- Cumulative percentage of plants with silks exposed (Pop) and cumulative number of silks emerged per ear (S_e):

$$Pop = \frac{Pop_x}{1+e^{-k(t-t_m)}}$$

$$S_e = S_x \times (1-e^{-b(t-t_0)})$$

Pop_x = maximum percentage of population; k = slope parameter; t_m = time when 50% of plants reach silking; S_x = total number of silks/ear; t_0 = beginning of silk appearance; b = slope parameter.

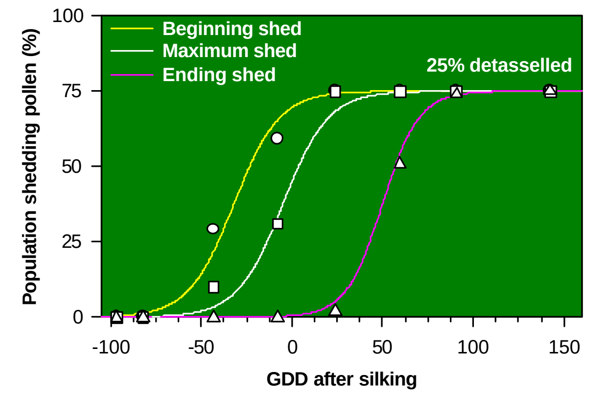
3. Potential kernel set:

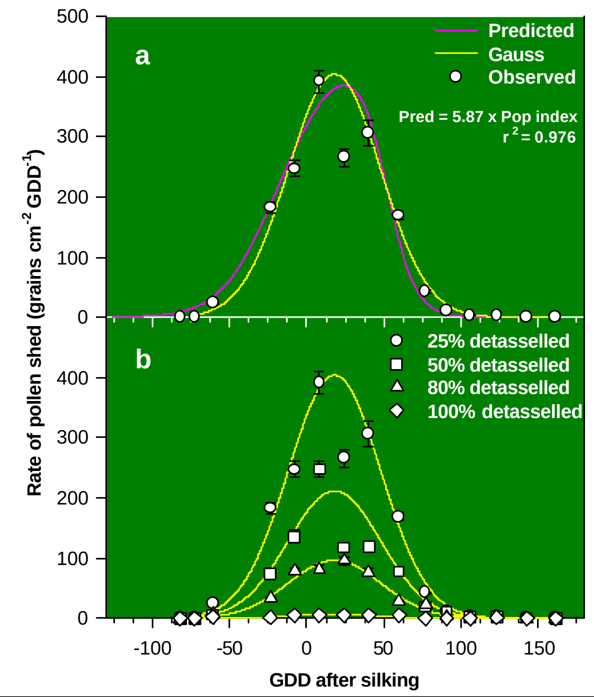
- Calculated on a daily basis from flowering dynamics and known relationship between kernel set and pollen shed intensity (Bassetti and Westgate, 1994):

$$ks = \frac{ks_x}{1+e^{-k(p-p_m)}}$$

ks = daily kernel set (%); ks_x = maximum kernel set;
k = slope parameter; p, p_m = daily and maximum pollen rates.

Results





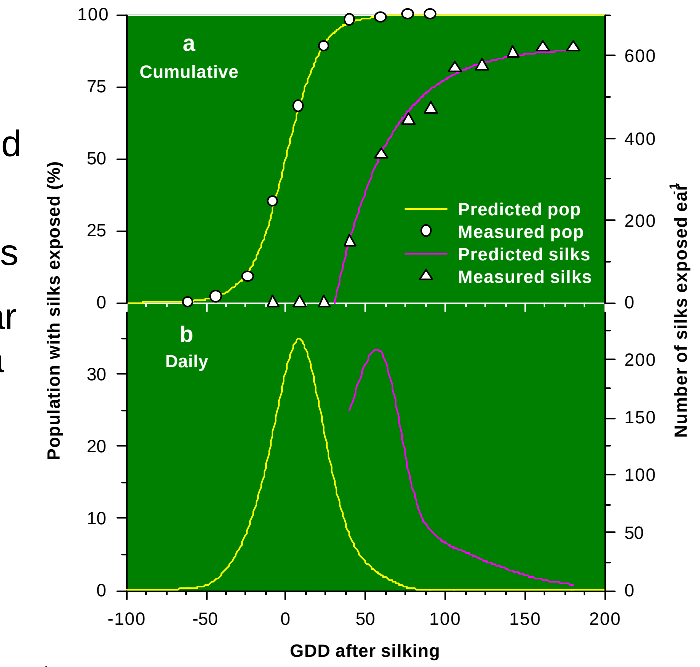
Pollen shed dynamics

- Percentage of population at three stages of pollen shed
- Sigmoidal logistic functions closely modeled population dynamics in the field

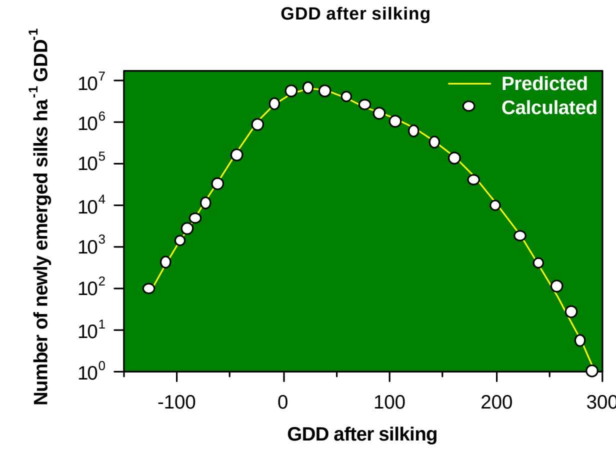
- Comparison of measured pollen shed intensities in the field with modeled estimates were based on:
  1. Population index (Pop Index) calculated from flowering dynamics (above)
  2. Gaussian curves
- Gaussian curves closely modeled field measured variations in pollen intensity with constant parameters t_x (time at maximum intensity) and W (curve width at half the maximum intensity).

Silking dynamics

- Percentage of population with silks extruded
- As with pollen shed, a sigmoidal logistic function closely modeled population dynamics
- Cumulative number of silks exposed per ear measured on a daily basis was modeled by a monomolecular function
- Daily number of plants with exposed silks, and of silks emerged from individual ears were calculated from cumulative values



- Number of newly-emerged silks calculated daily from individual ear and population dynamics
- Calculated values are closely modeled by a double Gauss function



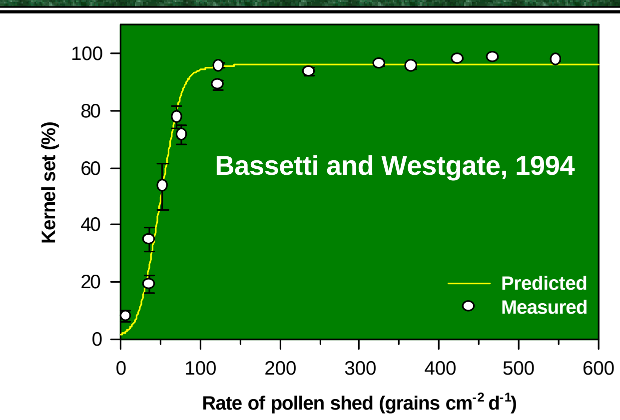
Potential kernel set

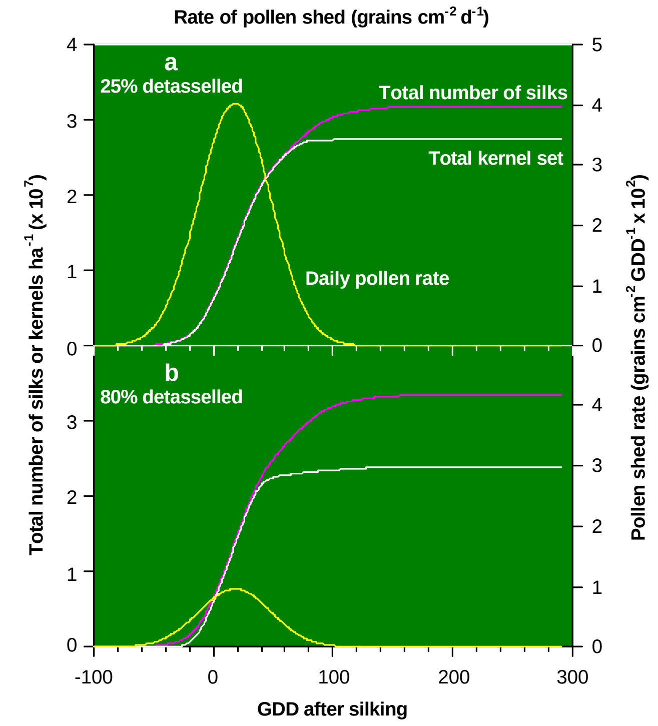
- Quantitative relationship (Bassetti and Westgate, 1994) used to relate daily pollen shed rates with percentage of pollinated silks (potential kernel set).
- Potential kernel set for the population was calculated as the integral of daily kernel set over the entire pollen-shed period. Silks were assumed to be viable during 6 days (Bassetti and Westgate, 1993).

Measured and predicted potential number of florets and kernels per unit of field area at various levels of tassel removal.

	Predicted	Observed	Difference (%)
		25% detasselling[1]	
Florets ha^{-1}	3.50 E+07	3.56 E+07	0.0
Kernels ha^{-1}	3.03 E+07	2.30 E+07	31.7
		50% detasselling[2]	
Florets ha^{-1}	3.30 E+07	3.35 E+07	0.0
Kernels ha^{-1}	2.70 E+07	2.08 E+07	29.8
		80% detasselling[3]	
Florets ha^{-1}	3.68 E+07	3.74 E+07	0.0
Kernels ha^{-1}	2.63 E+07	1.99 E+07	32.2
		100% detasselling[4]	
Florets ha^{-1}	3.70 E+07	3.75 E+07	0.0
Kernels ha^{-1}	0.40 E+07	0.43 E+07	0.1

[1] 51975 plants ha^{-1}; 1.1 ears $plant^{-1}$
[2] 44936 plants ha^{-1}; 1.2 ears $plant^{-1}$
[3] 54682 plants ha^{-1}; 1.1 ears $plant^{-1}$
[4] 54952 plants ha^{-1}; 1.1 ears $plant^{-1}$





Conclusions

- Mathematical models of flowering dynamics can be used to predict total floret numbers available for pollination and potential kernel set in maize.
- As expected, potential kernel numbers exceeded actual kernel set, except at very low pollen shed densities.
- This quantitative approach provides a rational mechanism to determine how loss of pollen viability, correlative inhibition of apical florets and secondary ears, loss of silk receptivity, or kernel abortion might contribute to the failure of maize ears to achieve their potential kernel set.

References

Bassetti and Westgate 1994 Agron J 86:699-703

Bassetti and Westgate 1993 Crop Sci 32:275-278