

Chapter 9:

Interpretation of Crop Growth Patterns Generated by COTMAN

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The COTMAN™ plant growth monitoring program consists of two expert systems: SQUAREMAN (which uses SquareMap data) and BOLLMAN [which uses *nodes above white flower*, (NAWF) data] (Oosterhuis et al., 1996). Both expert systems primarily utilize one common plant measurement: the number of squaring nodes. Squaring nodes are the number of fruiting branches (sympodia) that have a square, or a shed square, in the first position from the main axis. More simply, squaring nodes refer to the number of sympodia that have not developed to the flowering stage.

Prior to first flower, squaring nodes are equal to the number of sympodia, as determined by SquareMap. After flower initiation, squaring nodes are determined by counting NAWF. In relation to first-positions on sympodia, all nodes above a first-position white flower will potentially bear a square, while all nodes below the white flower will potentially bear a boll. As boll load increases, development of new main-stem nodes in the plant terminal slows, causing first-position flowers to occur progressively closer to the plant apex. Thus, the number of squaring nodes is an indicator of the fruiting dynamics of the plant throughout the effective fruiting period (Bourland et al., 1992).

Interpretation Standards

A growth curve based on fruiting dynamics is formed when squaring nodes obtained from sequential sampling dates are plotted by *days after planting* (DAP). When interpreting crop growth, the user must consider three standards: 1) square retention, 2) the *Target Development Curve* (TDC), and 3) the latest possible cutout date.

Square Retention

High or low square retention can greatly influence the interpretation of a particular growth curve slope. SQUAREMAN summarizes total square shed and shed rate by main-stem nodal position for all first-position squares. Evaluation of square retention is not available in BOLLMAN.

Target Development Curve (TDC)

The TDC assumes that first square appears at 35 DAP, first flower at 60 DAP with NAWF=9.25, and physiological cutout (defined as NAWF=5) at 80 DAP. Tharp (1960) indicated that a cotton square requires 25 days to develop into a white flower and that the vertical squaring interval (i.e., the average number of days for successive main-stem nodes to develop) is about 2.7 days. Thus, the NAWF apogee (NAWF=9.25, determined by dividing 25 by 2.7) indicates the number of main-stem nodes differentiated by the plant during the time required for the first square to develop into a white flower. TDC is assumed to represent a crop that combines an optimal degree of early maturation and high yield. Actual growth patterns measured in fields can then be compared to the TDC.

Latest Possible Cutout Date (LPC)

Latest possible cutout date (LPC) is the latest date from which a population of flowers has a high probability of developing into bolls having acceptable size and quality. COTMAN assumes that 850 heat units (DD60s) are required for a flower population to develop into mature bolls. Based on historical weather and a user-defined risk level, LPC is the latest date from which 850 DD60s can be expected to be accumulated prior to a pre-determined harvest completion date. If a field reaches physiological cut-

out (NAWF=5) prior to LPC date, then end-of-season management is based on crop maturation, and heat units (HU) are accumulated from the physiological cutout date. Otherwise, end-of-management is based on weather restraints and HU are accumulated from the LPC date.

Factors to Consider When Interpreting Crop Growth Patterns

1. Square retention (high or low).
2. Alignment of curve relative to TDC (left, near, or right).
3. Slope of curve relative to TDC (flatter, similar, or steeper).
4. Apogee of curve relative to TDC (less, near, or above).
5. Change in slope between consecutive sample dates.
6. Physiological cutout date relative to LPC date.

Generalized Growth Pattern Interpretations

Alignment of Curve with Slopes Equal to Target

Left of Target: Early and/or rapid development of plant structure. If accompanied with high square retention in SQUAREMAN, anticipate high demands for water and nutrients by the developing fruit load. In BOLLMAN, plants may be approaching cutout too early and stress may reduce yield.

Near Target: Development at pace for an optimal combination of earliness and yield.

Right of Target: Delayed and/or slow development of plant structure, often associated with late planting or low seedling vigor. High retention in early fruiting positions should be attained to avoid further delay in maturation and excessive vegetative growth.

Apogee (peak) of Curve at First Flower

Less than Target: Stress has reduced plant structure. If stress is not relieved (or if other stresses occur), premature cutout will occur. For optimal yield in situations with a low apogee, curve should flatten or temporarily increase (indicating additional terminal growth) before declining to physiological cutout.

On Target: Plants are growing at optimal pace with about 10 fruiting branches, which is ample structure for high yields if fruit is retained and an additional five main-stem nodes (non-productive nodes at top of mature plant) are added.

Above Target: Plants have attained vigorous nodal development. If accompanied by relatively high fruit retention and development, high yields are likely. Excessive vegetative growth may occur if a good fruit load is not maintained.

Slopes of SQUAREMAN Growth Curve (prior to apogee)

Slope Ascent Flatter than Target: Stressed plant growth, intensity of stress is indicated by flatness of curve and fewer squaring nodes.

Slope with Steeper Ascent than Target: Excess plant growth (often associated with fruit shed).

Slope Ascent Flattens Between Sampling Dates: Plants have become stressed, often associated with moisture deficiency.

Slope Ascent Steepens Between Sampling Dates: Plant stress relieved, e.g. rain/irrigation if water is deficient.

Slopes of BOLLMAN Growth Curve (after apogee)

Slope Descent Flatter than Target: Boll load (accumulative number and size of bolls) is low relative to vegetative growth of plant. Maturity is progressively delayed as curve flattens.

Slope Descent Steeper than Target: Boll load (accumulative number and size of bolls) is high relative to vegetative growth of plant. Steep descent is often associated with small plant structure and/or excessive stress. Time to crop maturity is progressively shortened as rate of descent increases.

Slope Descent Flattens Between Sampling Dates: Reduced rate of boll load accumulation has occurred due to loss of fruit and/or enhancement of vegetative growth (relieving stress conditions).

Slope Descent Steepens Between Sampling Dates: Boll load relative to vegetative growth has increased due to increased fruit development and/or stress conditions that slow terminal growth.

Curve Ascends after Declining Past NAWF=5: The ascent (sometimes going above NAWF=5) may indicate second growth of individual plants after

they ceased terminal growth, or that the sample includes late-maturing plants after the more dominant plants have matured. Neither second growth nor the late-maturing plants should dictate end-of-season decisions. Ceasing NAWF sampling when average NAWF drops below 5 eliminates confusion caused by either of these situations.

SQUAREMAN to BOLLMAN Transition

An inconsistency in number of squaring nodes may be attained during the transition from last SquareMap and first NAWF count. This transition, particularly obvious when the last SquareMap and first NAWF are taken on the same day, is related to variation in sampling. Samples for SquareMap include consecutive plants, while only plants with first-position white flowers are included in the NAWF sample. Thus, only plants that have initiated flowering, rather than all plants, are sampled for NAWF during early initiation of flowering.

SquareMap Squaring Nodes Relatively Same as NAWF: Relatively uniform plants within the field, such that most plants have initiated flowering near the same time.

NAWF > SquareMap Squaring Nodes: Non-uniform plant population. Early flowering plants are more dominant and vigorous than the rest of the plant population. The late, less dominant plants can cause flattening or ascent of the BOLLMAN curve as they begin to flower.

NAWF < SquareMap Squaring Nodes: Non-uniform plant population. Early flowering plants are less dominant and vigorous than rest of plant population. Bimodal fruiting curve may occur as the more dominant, late plants begin flowering.

Interpretation Examples

The 16 curves in Figures 1 through 4 provide a range of likely scenarios that may be experienced with crop growth patterns generated by COTMAN. Four SQUAREMAN curves are compared to TDC, a likely associated cause is proposed, and actions for high and low square retention situations are suggested (Fig. 1). BOLLMAN curves include situations where ascents of the curves derived by SQUAREMAN were on target (Fig. 2), above target (Fig. 3), and below target (Fig. 4). Each BOLLMAN curve is described and a likely cause is proposed. Com-

parison with an arbitrarily established LPC date is used to determine whether crop- or weather-oriented rules would be used, and physiological cutout date (i.e. days to NAWF=5) is determined. Finally, a production efficiency index—a subjective appraisal of potential yield and production risks—is assigned to each BOLLMAN curve. Rather than attempting to predict yields, this index should serve as a signal of growth pattern situations that are likely to be problematic.

Final Remarks

COTMAN provides a dynamic, interactive process to evaluate plant growth development throughout the fruiting period. These generalizations and examples should help users to better understand this dynamic process. Specific knowledge of growing conditions, including planting date, plant density, cultivar, soil, weather, pest problems, etc., within a field will greatly enhance the ability of the user to interpret growth curves. Each of these factors directly and indirectly (interacting with other factors) influences plant growth and development. A better understanding of these influences will provide insight for remedying in-season problems and minimizing risks associated with factors that cannot be adjusted within the season. The growth curve provides a composite picture of all direct and indirect influences that affect plant development. With experience, the user should be able to quickly evaluate and properly react to the growth curve.

References

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- Oosterhuis, D.M., F.M. Bourland, N.P. Tugwell, and M.J. Cochran. 1996. Terminology and concepts related to the COTMAN crop monitoring system. Univ. of Ark. Agric. Exp. Sta. Special Report 174. Fayetteville.
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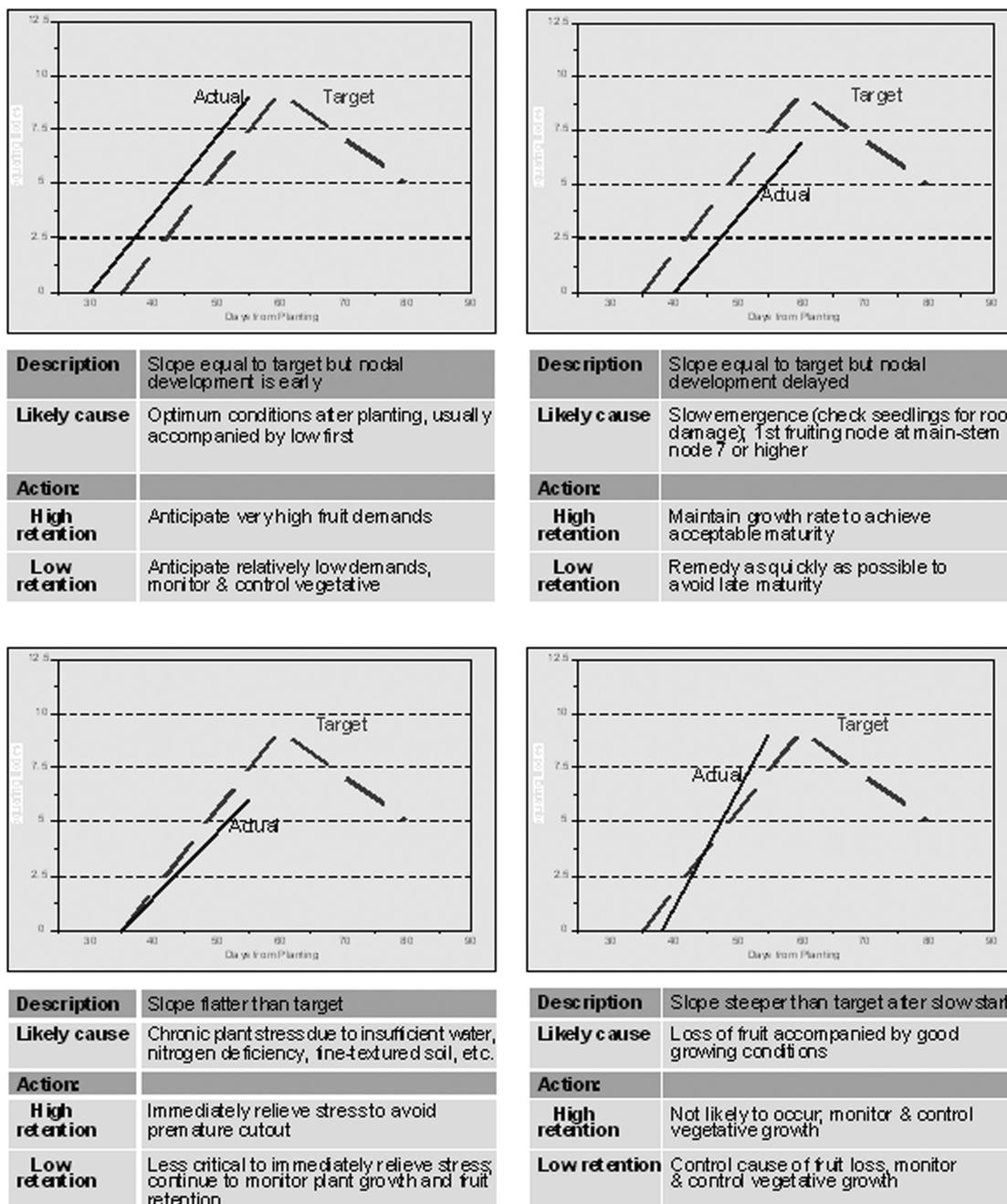


Fig. 1. Examples of Crop Growth Curves Derived from SQUAREMAN.

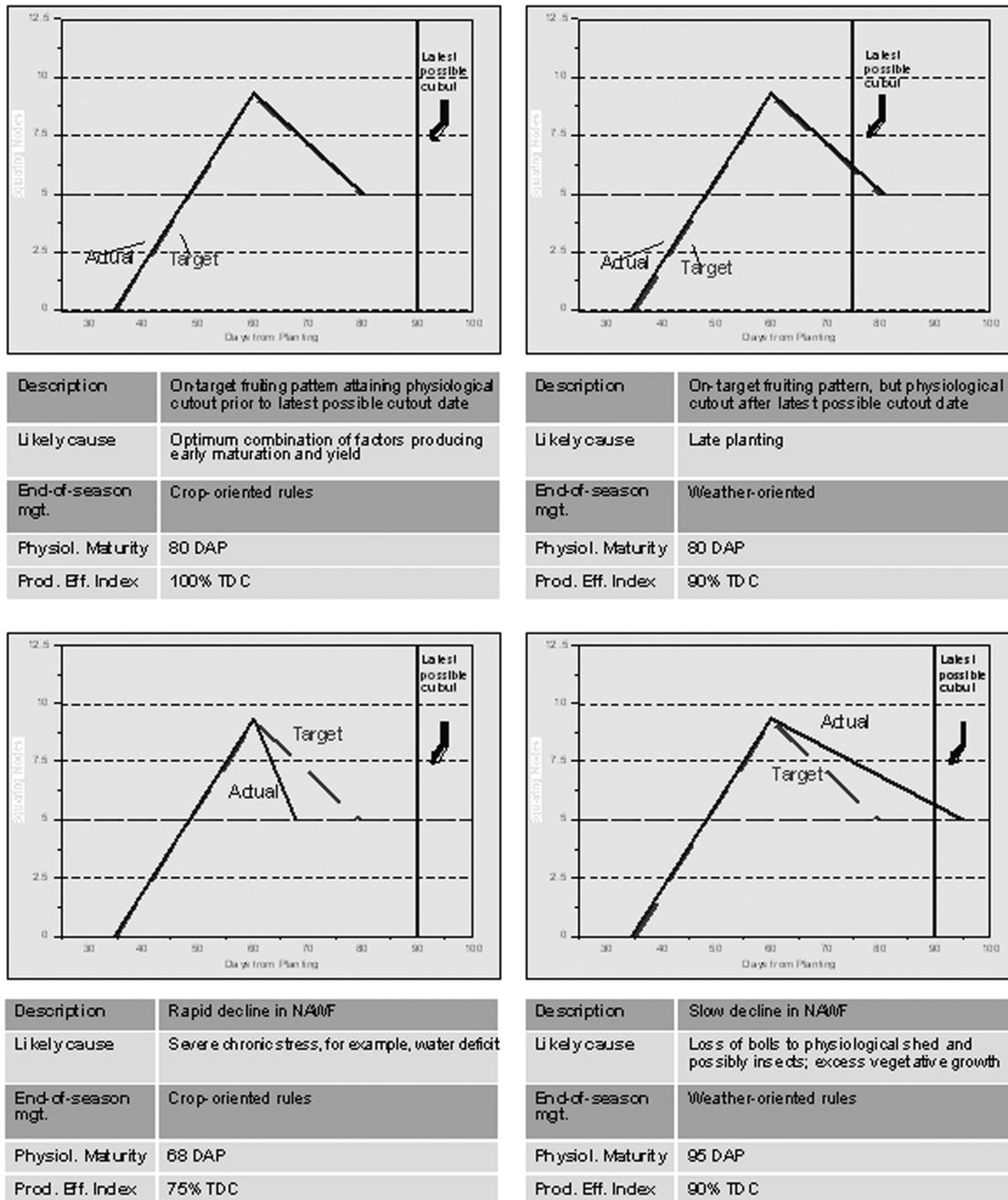


Fig. 2. Examples of BOLLMAN Curves when SQUAREMAN was On Target.

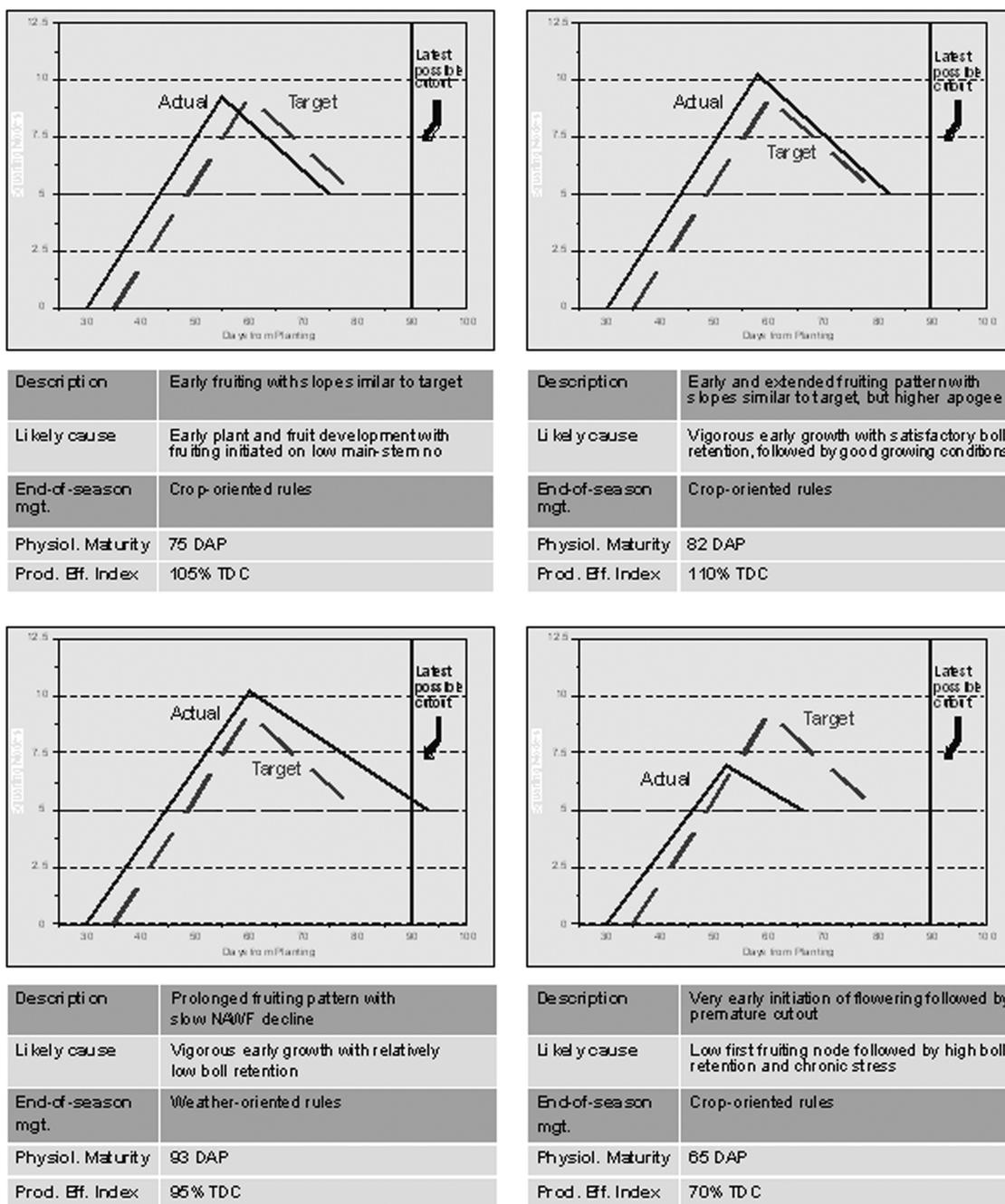


Fig. 3. Examples of BOLLMAN Curves when SQUAREMAN was Above Target.

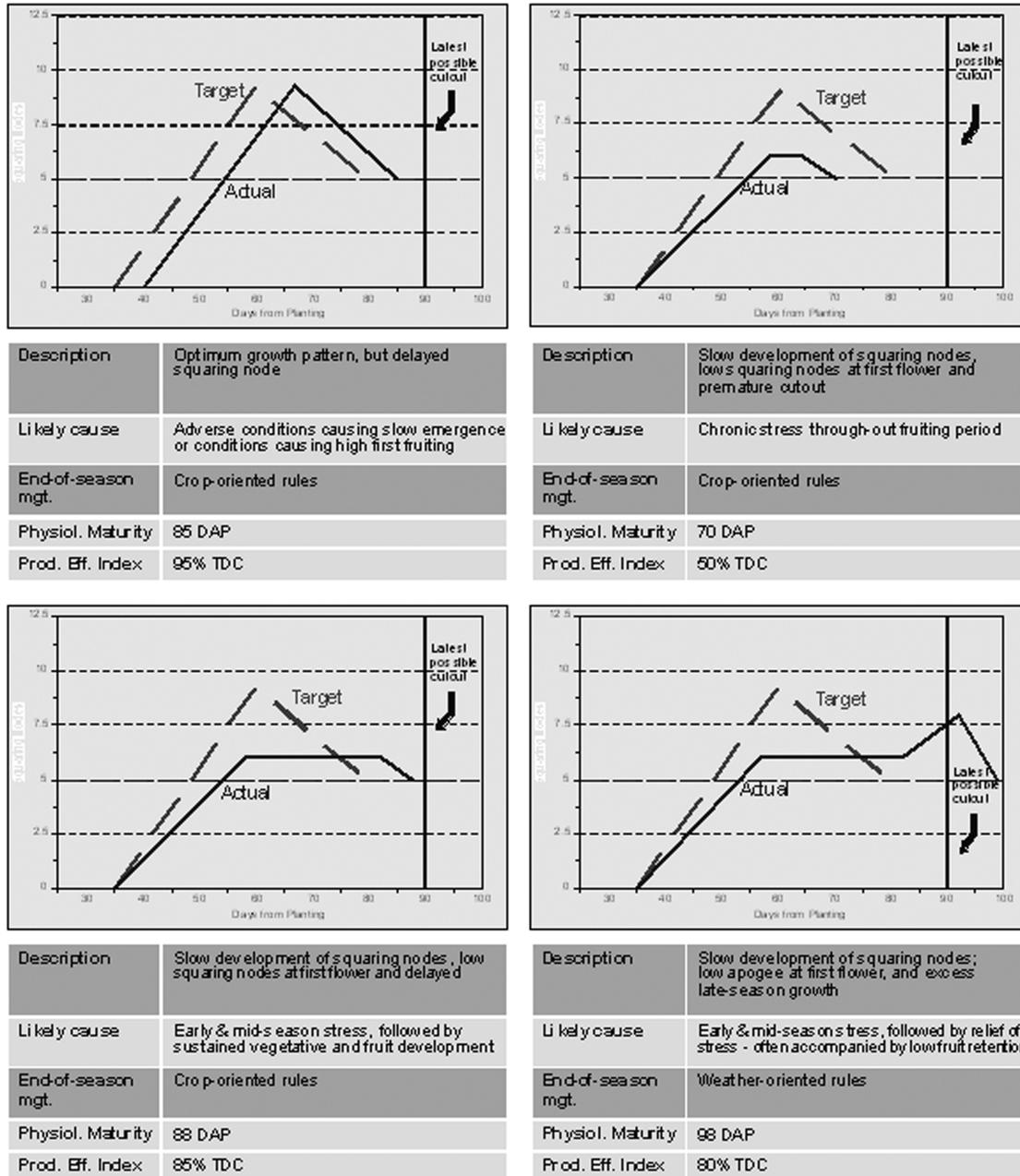


Fig. 4. Examples of BOLLMAN Curves when SQUAREMAN was Below Target.

