ESTABLISHMENT OF SQUAREMAN DECISION RULES FOR MANAGING EARLY-SEASON COTTON

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Abstract

As cotton plants approach flowering, their plant structure and fruit load have profound effects upon subsequent growth and development throughout the season. SQUAREMAN is one of two expert systems comprising COTMAN, a computer-aided cotton management system. The primary purpose of the SQUAREMAN expert system is to signal aberant crop development prior to flowering. Aberant crop development is determined by comparison of actual growth curves to a pre-determined standard (the target development curve) and by evaluation of square shed. Interpretation of growth curves is based on position of curve (three options), slope of curve (four options) and square shed (two options). One or more of eight decisions rules are triggered by combinations of these options. The decision rules and their corresponding triggers are presented.

Introduction

COTMAN is a computer-aided COTton MANagement system that is based upon the fruiting dynamics of the plant (Bourland et al., 1997a; Oosterhuis et al., 1996). The system integrates plant monitoring data, current and long-term weather records, and farm and field information to assist with efficient cotton management. COTMAN consists of two expert systems, SQUAREMAN and BOLLMAN. The primary purpose of SQUAREMAN, which uses data collected by SquareMap, is to manage the development and retention of squares prior to the initiation of flowering. SquareMap data includes once-per-season measures of plant population and first fruiting node and sequential measures of the presence/absence of first position squares and plant height (Slaymaker et al. 1995). BOLLMAN uses sequential measures of nodes-above-white-flower (NAWF) data to evaluate plant maturity after flowering and to assist with end-of-season management (Bourland et al., 1992). The following discussion will be restricted to the use of SQUAREMAN for manageing cotton prior to initiation of flowering.

Output from the SQUAREMAN program includes measurement and evaluation of:

1. Square shed by main-stem position and groups of positions; and the shed rate limit.
2. Population densities of the number of plants and first-position squares, bolls, and fruit per acre.
3. Plant structure variables including first fruiting node, number of sympodia, number of total nodes and plant height.
4. Vigor indices including height-to-node ratio, elongation rate, and plant height.
5. Crop growth curve, i.e. squaring nodes by days from planting in comparison to the target development curve (TDC).

Both SquareMap and NAWF directly measure the number of squaring nodes, i.e. the number of main-stem branches that are too young to have potentially developed a first position flower. Squaring nodes can then be plotted by days from planting to form a continuous growth development pattern for the effective fruiting period of the crop. Plant development can then be compared to a pre-determined TDC (Bourland et al., 1997b).

Eight decision rules have been established to assist with interpretation of growth curves generated by SQUAREMAN. The purpose of this paper is to enumerate the rules and summarize the triggers associated with them.

Bases for Triggering Decision Rules

SQUAREMAN utilizes SquareMap data to primarily address two crop management questions:

1. Is plant development progressing at the optimum pace?, and
2. Is square retention acceptable?

To address these questions, eight decision rules (listed below) have been incorporated into SQUAREMAN, and each is triggered by different combinations of crop development measurements and square shed.

The pace of crop development is determined by sequential measurements of *squaring nodes*. Prior to flowering, the number of squaring nodes corresponds to the number of sympodia (fruiting branches) that develop from the main stem. In SQUAREMAN, squaring nodes are plotted against days from planting, and compared to the shape and ascent of the TDC. Squaring nodes in relation to days from planting provides an indication of the sequence of nodal development compared to this standard.. Use of heat units rather than days from planting would likely provide a more accurate model of crop development, but would give little insight to the temporal development of the plant.

In relation to the pace of crop development, the decision rules are then triggered by *position* and *slope* of the curve relative to TDC. Rate of crop growth can also be evaluated by several vigor indices (Silvertooth et al., 1996; Bourland et al., 1998), but these are not used to trigger the SQUAREMAN decision rules.

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In addition to the *position* and *slope* of the curve, the third factor used to trigger the decision rules is square retention. SQUAREMAN expresses square retention as the percentage of first-position squares that are shed. The decision rules are then triggered by either a high (≥ 15%) or low (<15%) rate of *square shed*. Although not directly associated with the decision rules, square shed can also be compared to the shed rate limit within the SQUAREMAN program (Mi et al., 1998).

Generalized Interpretations of Trigger Options

Position relative to target (3 options)

Left of target: Early plant development e.g. associated with fast emergence and/or rapid development of plant structure, often accompanied by a low first fruiting node.

Near target: Development at a pace for optimum combination of earliness and yield.

Right of target: Delayed plant development such as associated with high plant density or cool temperatures accompanied by a high first fruiting node, *or* slow development of plant structure such as associated with low seedling vigor.

Slopes of growth curve (4 options)

Slope flatter than target: Plant growth is stressed. Intensity of stress is indicated by flatness of curve.

Slope similar to target: Development at optimum pace.

Slope steeper than target: Plant development progressing at a rapid pace. Excessive vegetative growth is likely.

Slope not determined: The situation when only one sample date is available.

Square shed (2 options)

High: User should determine the cause of shed square and be aware that loss of squares may incite excessive vegetative growth.

Low: User should be prepared to meet high demands for water and nutrients by the developing fruit load.

Application of the Decision Rules

Each of the 24 combinations (3 positions by 4 slopes by 2 shed options) of the three SQUAREMAN triggers may trigger one or more of the eight decision rules.

Rule 1: *Square shed prior to flowering is predominantly associated with insect damage. The square slicing technique may be used to determine whether square shed is insect or physiologically induced. Examine how close square shed rate is to the Shed Rate Limit.*
Trigger: Square shed = high; Position = all; Slope = all.
Use: Rule 1 is triggered whenever square shed ≥ 15% and instructs user to determine cause of shed.

Rule 2: *If good squaring node development and fruit retention continues, anticipate a possible high demand for nutrients and water.*
Trigger: Square shed = low; Position = all; Slope = 1-sample or target.
Use: Rule 2 is triggered by high fruit load relative to nodal development. If demands of this developmental pace are not met, undue plant stress and fruit loss may occur.

Rule 3: *Excessive vegetative growth may be present. Examine the plant vigor index and consult CES guidelines and the COTMAN User's Manual to determine if an application of mepiquat chloride is appropriate.*
Trigger: Square shed = high; Position = all; Slope = 1-sample/target/steep
Square shed = low; Position = all; Slope = steep
Use: Rule 3 is triggered by high square shed (except with a flat slope) or by the combination of low square shed and steep slope. Either case suggests that the vegetative development of the plant may be high relative to fruit development. A vigor index should be used to determine if control of vegetative growth is needed.

Rule 4: *Nitrogen may be excessive. Consider delaying early nitrogen and irrigation applications.*
Trigger: Square shed = high; Position = all; Slope = steep.
Use: Rule 4 recognizes an extreme case of conditions triggered by Rule 3. Immediate attention should be given to fields that exhibit both high square shed and steep growth curve slope so that vegetative growth can be controlled.

Rule 5: *Slow squaring node development indicates plant stress*. Check for water stress and monitor crop fertilizer needs (including soil and petiole fertility status). A growth enhancing plant growth regulator may help to retain fruit.*
** Plant stress may be due to increasing fruit load relative vegetative growth or to a number of biotic (e.g. aphids, thrips, nematodes, sublethal seedling disease) and abiotic (e.g. deficient or excessive water, inadequate fertility, cool temperatures, low sunlight, fine-textured soil, hardpan, herbicide injury, or mechanical root pruning) factors.*
Trigger: Square shed = all; Position = all; Slope = flat.
Use: A flat slope, regardless of square shed or position, indicates that plants are stressed. Likely causes of plant stress are enumerated. Steepening of the slope should occur when the stress is relieved. Plants may compensate for the flattened slope without loss of yield, but maturity will be delayed.

Rule 6: *Rapid squaring node development accompanied by high square retention is unusual, but may occur with excellent growing condition. Check squares for adequate number of developing ovules.*
Trigger: Square shed = low; Position = all; Slope = steep.
Use: Typically, high fruit load slows squaring node development. The unusual conditions that triggers Rule 6 may be transient, but excessive vegetative growth and delayed maturity will occur if the slope does not subsequently flatten.

Rule 7: *Late initiation of squaring nodes may be due to delayed emergence and slow early growth, or development of first squares at a high (e.g. >7) main-stem node (often associated with high plant densities).*
Trigger: Square shed = all; Position = right; Slope = 1-sample/target/steep.
Use: A position right of the TDC indicates a late initiation of squaring nodes, except when the curve started to the left of TDC and moved to the right with an accompanying flat slope. Caution should be taken to avoid additional delays in crop development and maturity.

Rule 8: *Early initiation of squaring nodes may be due to accelerated emergence, fast early growth, and/or development of first squares at a relatively low (e.g. <6) main-stem node.*
Trigger: Square shed = all; Position = left; Slope = 1-sample/target/flat.
Use: A position left of the TDC indicates an early initiation of squaring nodes, except when the curve started to the right of TDC and moved to the left with an accompanying steep slope. Crop demands for nutrients and water may occur sooner than normally expected, particularly with high fruit loads.

Summary

The SQUAREMAN decision rules provide an indication of crop development and may signal potential problems. Users should also consider other information (e.g. weather, insects, soil factors, field experience) as well as other SQUAREMAN outputs (e.g. measures of first fruiting node, estimates of the number of plants/acre, first-position fruit/acre, square shed by plant position). Integration of this information should help the user to determine the appropriate action to take to maintain optimum pace of crop development.

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