MONITORING COTTON'S GROWTH

INTRODUCTION

The present situation shows that international average lint price indexes for the last three seasons were bellow 60 US cents/pound.

Meanwhile, approximately 55% of cotton production worldwide benefits with direct economic support programs or price subsidies.

This state of things, makes necessary to weigh critically all the factors that affect final yield and crop profitability, with the goal of a sustainable and more efficient production, particularly, in those countries without protective or subsidy policies.

It is very important, within this task, to try to reduce all random factors in the production system, cotton is an extensive crop, which, for its own nature and costs, must be managed intensively.

In Argentina, there is a generalized idea about cotton management focused on weed and insect control, but this is not the same with phenology monitoring. This is not seen yet such a useful tool as the rest in the growers' mind.

In the last seasons, growers could make use of new technologies, such as genetically modified varieties (Bt, RR, BR or BXN) and new products like broad leaves selective over-the-top herbicides or biological pesticides of high specificity and efficacy and low environment impact. These technologies spread rapidly due to market globalization and solved many problems improving yield expectations.

Nevertheless, consequent benefits, in the case of Argentina, could not be reached and therefore these advances were not sufficient to change the critical trend in which the industry is immersed; the final crop acreage reduced dramatically in the last three years, directly related to the lint prices fall, in the world markets.

It is obvious that most battles are not only struggled in the battleground, lint prices drop and the asymmetries that present competitiveness arouses, as a consequence of distorting effect of subsidies. These aspects cannot be managed in the fields, but everything that could be done for the sake of productivity is valid and must be incorporated as a practice, while the economic discussions go on in the forums that correspond to seek for a more just status of things.

MONITORING GROWTH

"Cotton plant is an excellent teacher, if you can translate its language". When agronomists and farmers can learn this "language", they get the most valuable tool, a very useful input, to obtain a sustainable and more efficient production, and specially, more predictable.

Cotton management concept involves different aspects such as weed and insect control, plant growth monitoring, use of PGR's and harvest aids. In this circumstance focus will be directed to the measuring techniques required for the success of the crop according its growth stages.

In the last years, knowledge about cotton plant growing and development, and its physiology and phenology, has advanced to a fine-tuning state, and so, field situation can be finely interpreted and this can lead to successful final results.

However, this knowledge and its field practices, are not massively available and in most cases they are not part of common crop culture. If we are able of inserting them in the actual input menu in Argentina, for sure a synergism of all factors and improvement of global results could be obtained, integrating them in a better final result, higher yields and better quality.

In this paper, the most relevant or easiest indexes will be mentioned, only for time and space reasons, we exclude other existing, also important

Days - Degree

An easy way to estimate the crop progress along the growing season is through the use of "day-degrees". Due to the relation between cotton growing and heat accumulation, "day-degrees" are an expression of available energy for growth, and they permit an estimation of length and earliness of each crop stage, and therefore enable growers to make better decisions.

Day degrees can calculate as following:

(Max temperature-15.5º C) + (Min temperature – 15.5ºC)/2

 # Base temperature considered is 15.5ºC

In the vegetative stage, plant age can be estimated through number of nodes, considering that node development is a function of heat accumulation (day-degrees accumulation).

Each node develops at an almost constant accumulation of between 40 to 50 day degrees.

DAYS- DEGREE CHART

	Days - degree	
Stage	**maximum**	**minimum**
Sowing to Emergence	60	50
Emergence to First Square	475	425
Emergence to First Flower	875	825
Emergence to First Open Boll	1750	1700
Emergence to 60% Open Bolls	2230	2180

These are he basics required for an understanding and adjustment of local production windows and varietal performance, according each particular season length.

Height to Node Ratio

Growth curves allow a precise estimate of crop evolution comparing field situation to the standards. These curves are applicable, in most cases, taking always into account specific variations.

When monitoring in the field it is advisable to check four different places within the field and no less than five plants in each place, considering height and number of nodes. The recommended frequency for registration of data is at least once a week.

The cotiledonar node is considered as 0 node and subsequent nodes along the stem are counted from 0 node to the top; height, which is a good expression of growth vigor, is measured also from 0 node to the top.

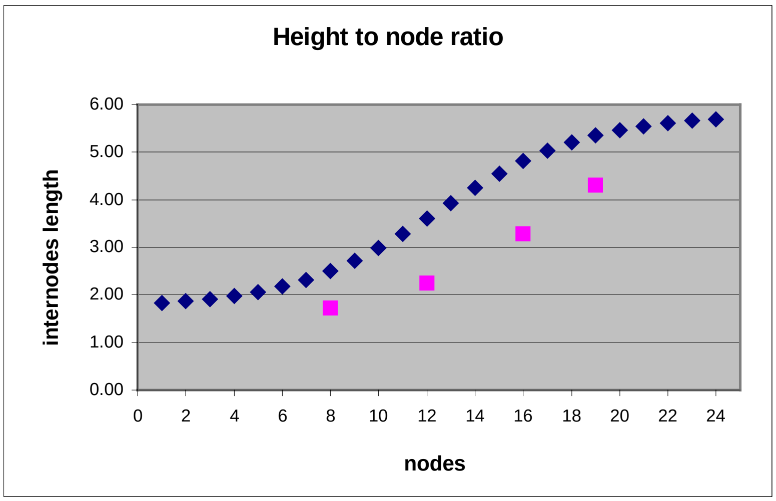
With the average from the field data, a field curve can be made and compared to the optimal situation (standard curve).

Early in the season, number of nodes is a function of day degrees, until approximately the fifteenth node.

To evaluate if height is correct according to the plant age, height can be expressed as a function of the age; that is the height to node ratio (or the internode length average). This is *the relation between height average and number of node average, as taken in the field. This figure is usually less than 2.5 cm until approximately eighth node.*

The height to node ratio is very sensible to temperature. If the temperature is below the mean, before the seventh node, the potential crop yield is not likely to be affected, because the leaves associated with boll loading are not yet developed. In the next stages, the crop production structure is defined and here the height to node ratio values should be critical. This "sensitive" zone is situated within the seventh to eighteenth nodes (or first to twelfth fruiting branches) which are carbohydrates source.

The changes in the pace of growth can be seen comparing field values with the standard, which reflects optimum growing conditions without stress situations.



$$Y = 0.686 + 1.5906 / (1 + e^{(- (x - 12.489) / 3.053)})$$

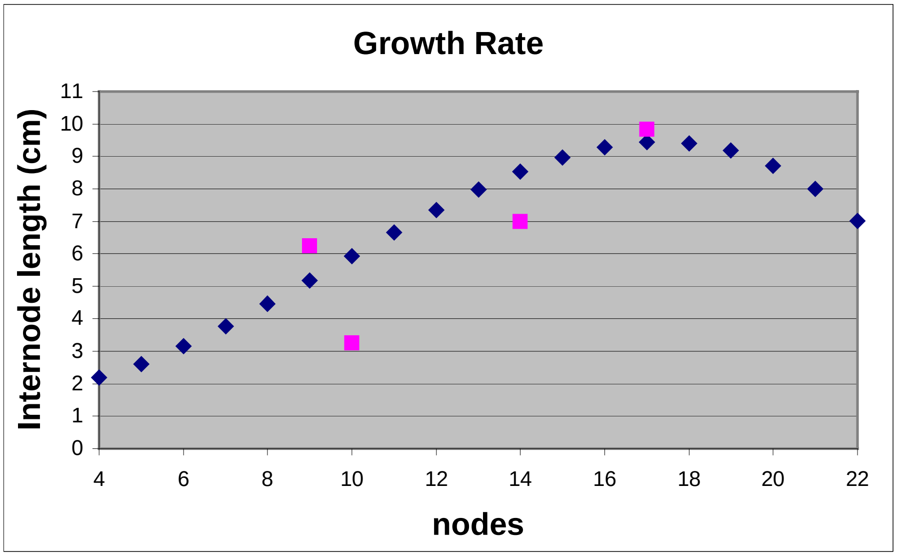
(Source Kerby & Hake, 1994)

Growth rate

Another useful index to weigh crop evolution is Growth Rate. When field data, considering height and node number, is picked in a regular base (7 to 10 days intervals), the change in the figures between subsequent evaluations give a valuable instant information about the growth rhythm.

To know this we have to calculate the differences between present and previous values of height, and in the same way with the node numbers, then we work out the rate between height and node number differences. The result is a figure that represents the average length of newly made nodes. This value must be graphed in the Y-axis of the reference curve, referred to the exact middle point between both nodes monitored (present and previous) in the X-axis. It is desirable that the real value obtained is equal or very close to optimal situation.

The growth rate declines after flowering, due to various factors, like boll setting, and loading, diseases, fertility, irrigation, management, pests. But we have to consider this is also a natural plant process to give way to yield definition, despite all those factors. At this moment, HN R and GR cease to be sensitive indexes to monitor crop progress.



$Y = 0.83 - 0.15 X + 0.046 X^2 - 0.0016 X^3$

(Source Kerby & Hake, 1994)

Nodes Above White Flower (NAWF)

During vegetative growth, cotton plant can develop a new node each 40-50 day degrees; when fruiting positions start to compete with stems for carbohydrates the node production rate decreases. This begins at about node fifteenth. At this moment squares turn into flowers at a regular rate, generally, a 3 day interval between first position flowers of successive branches can be expected.

To determine NAWF, we consider the node associated with first position open flower in the first fruiting branch as node 0 and count successive nodes to the top, considering the last to be counted the one associated with a leaf of at least 2,5 cm of diameter.

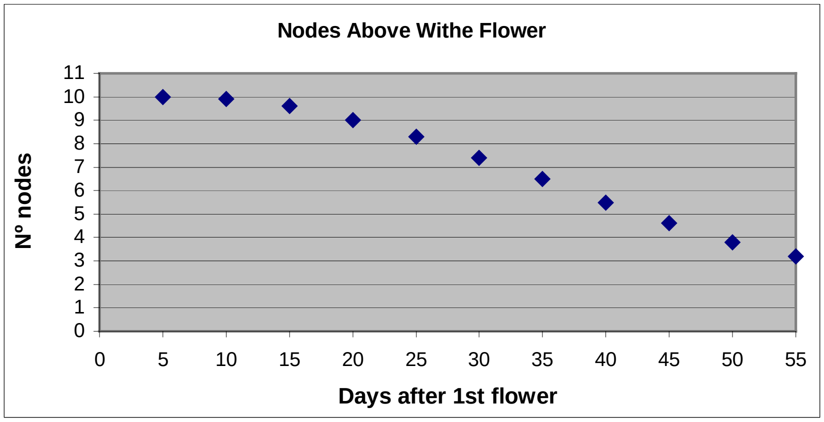
In this stage the fruiting development increases the carbohydrates demand over the vegetative growth; the NAWF gives the difference between each new node rate and an idea of the movement of the first position flower through the main stem. The NAWF values obtained when the first blooms appear or even when first position flower gets close to the top are still good indexes to estimate the balance between vegetative growth and development.

The first flower in non stressed crop is commonly associated with 8 to 9 NAWF. If the value is less than 8 there are evidences of limiting circumstances, most times related with water status, soil compaction layers, salt , diseases or nematodes.

In optimum environments the NAWF initial value decreases normally at a rate of one node each 8.3 days. The crop cut-out occurs at about 5 nodes above the white flower. It is suggested that insect protection must extend until two weeks after crop reaches 4 nodes above white flower, at least.

With 5 nodes above the white flower, 95% of all harvestable first position bolls are considered to be at flower stage.

The common crop practices that can affect this index, we can mention early boll setting, irrigation schedule (or water availability), nitrogen rates, and PGR use.



$$Y = 9.7532 + 0.0887 - 0.0077X^2 + 0.00007109X^3$$

(Source Kerby et al, 1987)

Nodes Above Cracking Boll (NACB)

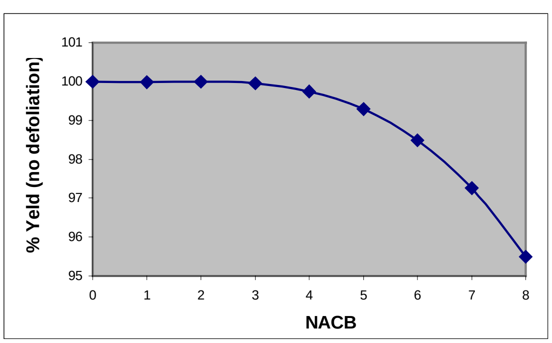
Boll maturity can be evaluated according to node position in the main stem and within the branch.

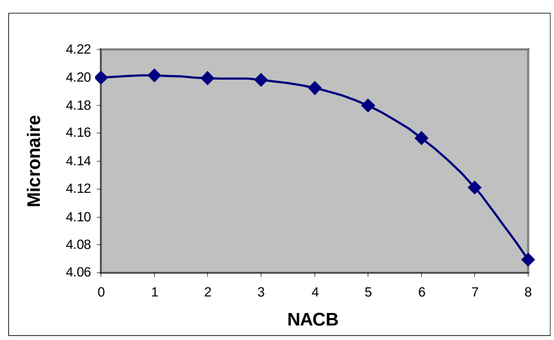
Newly set bolls locate in the upper portion of the plant in the 90% of the case. Taking into account this condition a technique called Nodes Above Cracked Boll was developed, and its main practical use is to estimate the correct moment to defoliate.

To get NACB value in the field we have to locate plants with a cracking boll in first position (we consider a cracking boll one that splits open when pressed in the hand) and count from the associate node, considered as node 0, to the top till the one that has the last boll with a harvestable size. It is recommended to monitor the field scouting 10 plants in at least 4 different locations in the paddock.

When we get an average of 4 NACB in a field, the crop should be safely defoliated, without yield or micronaire losses risks. This threshold is safe enough, though defoliation can also be decided at 5 NACB; having a loss of 1% or less, according to research.

Nevertheless, it is not advisable to use this method in fields where main stem has lost dominance due to pests or herbicide damage, and most of the plants are in the state of "crazy top". Here one should determine defoliation moment following conventional methods.





$$Y = 100 - 0.06X + 0.061X^2 - 0.0155X^3$$

$$Y = 4.20 - 0.0025X + 0.00204X^2 - 0.000471X^3$$

(Source, Kerby et al, 1996).

CONCLUSIONS

In a few words, to weigh the value of Crop Growth Monitoring and its indexes in cotton production, we can affirm that its use and validation makes it possible to:

- *Interpret each of one of the phenologycal crop phases and their momentarily demands.*
- *Project crop growth trends and be able to predict them.*
- *Fine-tune the field operations management and timing.*
- *Minimize random factors to the least in the production (more predictability)*
- *Increase sustainability of the whole production system.*

FINAL WORDS

Agriculture is a highly hazardous activity, whose unpredictability has an important impact on final results.

The environmental conditions influence and modify the crop. Market weather, which the grower cannot control, also condition the results.

To learn through experience is invariably a very expensive way. Everything that can be done to measure and diminish the risk, and meanwhile, to enable the farmer to understand timely what the situation is, how to change it or take advantage of; transforms in a useful tool and an insurance against uncertainty.

Growth monitoring techniques, used regularly and consistently, allow to increase production efficacy within the season and also to predict sustainability of the whole process throughout the campaigns.

Unfortunately, knowledge, agriculture extentionism, do not have the same marketing effort as other agriculture inputs. When we talk, (and make use of) the so called Genetically Engineered Organisms, we should probably think of an Engineered Management of Production and how to communicate it, specially in those countries where nowadays, price situation place them in such a difficult position that the only expectation is how to continue till next season.

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