# PREDICTION OF COTTON YIELD DEPENDING ON SOWING DATE AND PERIOD OF BOLLWORMS CONTROL

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***Abstract***

The present study was carried out at Sharkeia governorate, during cotton growing seasons of 2001 and 2003, to investigate the relation between both sowing dates and insecticidal protection periods for controlling bollworms, and their effect on cotton yield. Five experimental fields representing five sowing dates, starting from March 10 to April 30 (with 10 days intervals), were selected for this study. Seven periods of insecticidal protection applications (25, 31, 37, 43, 49, 55 and 61 days) were used per each sowing date. Five replicate areas, of 200 $m^2$ each, were selected to estimate cotton yield for each combination between sowing dates and protection periods.

Results indicated that obtained yields and other fruit structures were function of sowing dates (delay resulted in negative relation) and provided protection period (positive). Relationships between protection period (days) and physiological time (as accumulated heat units) with cotton yields and fruit structures over different sowing dates at end points were significantly positive. Predicted cotton yield, at the end of each protection period, could be obtained from the following equation: "Yield= 2177.76 – 136.7 date + 34.188 time", with P value for date = 0.0001 and for time = 0.0001, and Model R2 = 0.9342.

## INTRODUCTION

Cotton, *Gossypium barbadense,* is considered one of the important economic crops in Egypt. During its growing season quite few pests attack cotton. Bollworms, *Pectinophora gossypiella* (Saunders), *Earias insulana* (Boisd.) and *Helicoverpa armigera* (Hüb.), could be fairly considered as the most important and harmful insect pest attack of squares and green cotton bolls.

Planting date is a vital factor for obtaining high yield of Cotton. In Egypt cotton is planted over long period of time (i.e. March to early May), as a result fruiting structures (which is the target for bollworms infestation) do not develop at the same time. Efforts have been devoted to illustrate the effect of delay on cotton production and yield characters (Henneberry and Naranjo, 1998). Plants stand at different stages of growth and decreased by delaying sowing date. The earlier maturity cultivars possessed the shortest boll maturation periods while the later maturity cultivars possessed the longest. The earlier maturity cultivars also produce greater percentage

of their total lint yields at the lower main stem nodes (Sawires, 1976, Hussein *et al.,* 1983, Abou-Zeid *et al.,* 1989, Eissa *et al.,* 1989 and Craig and Robert, 2005).

Heat-unit accumulations have been used to estimate the time of occurrence of early-season cotton fruiting forms in relation to *P. gossypiella* moth overwintering emergence (Sevacherian *et al.,* 1977, Fry, 1983, Chu and Henneberry, 1992 and Beasley and Adams, 1996). Degree day models are common method to monitor crop progress and predict phenology of crops (Idso *et al.,* 1978, Mi *et al*., 1998, Makram *et al.,* 2001, Logan and Gwathmey, 2002, Wanjura *et al.,* 2002 and Viator *et al.,* 2005).

The purpose of this study was to predict cotton yield in relation to the interaction between planting date (date) and the period of insecticidal protection (time) against bollworms.

## MATERIALS AND METHODS

The present study was carried out at Sharkeia governorate during the cotton growing summer seasons of 2001 and 2003. Cotton variety Giza 85 was cultivated in the two seasons. Five experimental fields representing five sowing dates, starting from March 10 to April 30 (with 10 days intervals), were selected for this study. Each field was at least eight Feddan of one homogeneous sowing date and received recommended conventional agricultural practices. Insecticides used were the recommended by the Egyptian Ministry of Agriculture. Seven periods of insecticidal protection applications were used per each sowing date with the main target of maintaining the percent of boll's infestation at the range of 3-5% by the end of each protection periods. The seven protection periods were 25, 31, 37, 43, 49, 55 and 61 days.

Five replicate areas (500 $m^2$/ replicate) were allocated in each field for each combination between the 5 sawing dates and the 7 protection period (a total of 175 replicate areas). Twenty plants replicated five times(500$m^2$ each) were selected randomly every 6 days from each sowing date, to record fruiting structures (i.e. number of branches and total number of green bolls).

Susceptible green cotton bolls (SGCB) were identified as the green bolls of 15-30 days of age. Beginning of control procedures against bollworms was identified as the date for detection of 3±1 SGCB/ plant. Ending of control procedures against bollworms was identified as the date which control procedures was stopped. Accumulation of susceptible green cotton bolls percentages (ASGCBP) were calculated from SGCB per plant over the developing season.

Five replicate areas, of 200 $m^2$ each, were selected to estimate cotton yield for each combination between sowing dates and protection periods. Obtained data for the

two seasons were pooled together and used in the regression analysis. Monitored parameters were regressed against sowing dates and periods of protection as partial regression (Proc. Reg. in SAS- SAS institute, 1988). Sowing dates were assigned as 1 to 5 and protection periods as 25, 31, 37, 43, 49, 55 and 61 days.

Daily maximum and minimum temperatures for the two seasons were obtained from agricultural research center (ARC) at Abukaber meteorological station for Sharkia Governorate. Heat units at the two seasons were calculated according to Seaver *et al.,* 1990 (degree days calculated with base 30/12.78 ºC).

## RESULTS AND DISCUSSION

**Monitored cotton fruit structures in relation to days and heat units:**

Obtained results of this study over different sowing dates during cotton seasons of 2001 and 2003 are presented in Table 1. Over sowing dates, plant age from sowing date to begin protection procedures (the start point) against cotton bollworms ranged between 88.5 and 110days. Aafter 61 days of the control procedures (the end point), plant age ranged between 149.5 –171.0 days.

Table 1. Monitored cotton fruit structures for different sowing dates in relation to days and heat units at start and end points of control procedures against bollworms during 2001 and 2003 cotton seasons.

| Stage | Sowing dates | Plant age (days) | AHU | FBr | GB | SGB | ASGB % |
|---|---|---|---|---|---|---|---|
| Start point of protection | First | 110 | 1234 | 13.3 | 11.7 | 3.3 | 4.3 |
| | Second | 104 | 1236 | 12.3 | 10.1 | 3.0 | 3.9 |
| | Third | 98.5 | 1230 | 12.5 | 10.3 | 3.2 | 4.2 |
| | Fourth | 93.5 | 1238 | 12.1 | 9.3 | 3.1 | 4.4 |
| | Fifth | 88.5 | 1223 | 10.9 | 8.4 | 3.2 | 2.9 |
| End point (after 61 days of protection) | First | 171 | 2172 | 16.5 | 32.2 | 4.2 | 82.9 |
| | Second | 165 | 2189 | 16.5 | 31.2 | 4.8 | 79.6 |
| | Third | 159.5 | 2180 | 17.7 | 31.3 | 5.4 | 80.5 |
| | Fourth | 154.5 | 2185 | 16.2 | 29.4 | 5.3 | 76.3 |
| | Fifth | 149.5 | 2163 | 16 | 29.1 | 5.2 | 78.8 |

AHU (accumulated heat units), FBr (fruit branches),

GB (green bolls), SGB (susceptible green bolls) ASGB (accumulated susceptible green bolls).

Accumulated heat units fluctuated between 1223 and 2189 units. Cotton fruit branches ranged between 10.9 and 17.7 branches/plant at the start and end points,

respectively. Number of green cotton bolls ranged between 8.4 and 32.2 bolls/plant at the start and end points, respectively. Number of susceptible green cotton bolls ranged between 3.0 and 5.4 bolls/plant for the same previous points. Accumulation of susceptible green cotton bolls percentage ranged between 2.9-4.4% at the start point and 76.3-82.9% at the end point (Table 1).

Table 2. Mean count of cotton fruit branches per plant over protection periods at different sowing dates through 2001 and 2003 growing seasons.

| Sowing date | Protection period (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 25 | 31 | 37 | 43 | 49 | 55 | 61 |
| First | 15.6 | 15.7 | 15.7 | 15.7 | 15.8 | 16 | 16.5 |
| Second | 16 | 16.1 | 16 | 16 | 16.2 | 16.2 | 16.5 |
| Third | 15.2 | 15.5 | 15.9 | 16.3 | 16.8 | 17.3 | 17.7 |
| Fourth | 14.8 | 15 | 15.2 | 15.4 | 15.7 | 16 | 16.2 |
| Fifth | 14.1 | 14.7 | 15.1 | 15.6 | 15.7 | 15.9 | 16 |

**Partial regression equation**: Branches = 14.694 – 0.179 date + 0.039 time

P vale for date = 0.0021, P value for time = 0.0001, Model $R^2$ = 0.6087.

**Cotton fruit branches per plant:**

Cotton fruit branches per plant for different sowing dates over the two growing cotton seasons are presented in Table 2. Number of fruit branches ranged between 14.1-17.7 branch/plant. Lowest number of fruit branches was at the end point of the fifth sowing date with 25 days of protection. While the largest one was attained at the third date with 61 days of protection. Partial regression coefficient cleared that both factors of sowing date and protection period affected obtained values (Partial regression equation: Branches = 14.694 – 0.179 date + 0.039 time). This means that delay in sowing date had a negative effect while protection period had a positive one on number of fruit branches /plant.

**Green cotton bolls per plant:**

The numbers of green cotton bolls per plant, during every protection periods at each sowing date, are indicated in Table 3. Number of green cotton bolls ranged between 18.6-32.2 bolls/plant. Lowest number was at the fifth sowing date at the end point of 25 days of protection. The largest at the first one for at end point of 61days of protection. Partial regression equation is Green bolls = 16.8373 – 0.88 date + 0.283 time (P value for date = 0.0001, P value for time = 0.0001, Model $R^2$ = .9557). This means that delay in sowing date had a negative effect while protection period had a positive effect, on number of cotton bolls / plant.

Table 3. Mean count of green cotton bolls per plant over different sowing dates and protection periods through 2001 and 2003 growing seasons.

| Sowing date | Protection period (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 25 | 31 | 37 | 43 | 49 | 55 | 61 |
| First | 23.2 | 25.3 | 27.2 | 28.8 | 30.1 | 31.3 | 32.2 |
| Second | 21.8 | 23.5 | 25.5 | 27.4 | 29.1 | 30.3 | 31.2 |
| Third | 20.7 | 23.2 | 25.6 | 27.7 | 29.3 | 30.5 | 31.3 |
| Fourth | 18.7 | 21 | 23.2 | 25.3 | 27.1 | 28.5 | 29.4 |
| Fifth | 18.6 | 21.3 | 24 | 26 | 27.5 | 28.5 | 29.2 |

**Partial regression relation**: Green bolls = 16.8373 – 0.88 date + 0.283 time

P vale for date = 0.0001, P value for time = 0.0001, Model $R^2$ = 0.9557.

**Accumulation of susceptible green cotton bolls:**

Accumulation of susceptible protected green cotton bolls, at the end points, for different sowing dates, ranged between 30.2-82.9% (Table 4). The lowest percentage was at the fifth sowing date at the end point of 25 days of protection (Partial regression equation: Cumulative = 11.6607 – 2.204 date + 1.236 time), While the largest percentage was at the first sowing date at the end point of 61 days of protection. The relationship between the different points and ASGB reflected the same trend.

Table 4. Mean accumulation percentage of susceptible green cotton bolls over protection periods at different sowing dates through 2001 and 2003 growing seasons**.**

| Sowing dates | Protection period (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 25 | 31 | 37 | 43 | 49 | 55 | 61 |
| First | 39.9 | 49.4 | 57.6 | 64.8 | 71.3 | 77.5 | 82.9 |
| Second | 35.4 | 44.8 | 53.6 | 61.5 | 67.9 | 73.8 | 79.6 |
| Third | 35.8 | 44.1 | 51.7 | 58.8 | 66.1 | 73.4 | 80.5 |
| Fourth | 33.5 | 41 | 48 | 54.9 | 62.1 | 69.3 | 76.3 |
| Fifth | 30.2 | 38.3 | 46.2 | 54.3 | 62.8 | 71.4 | 78.8 |

**Partial regression equation**: Cumulative = 11.6607 – 2.204 date + 1.236 time

P vale for date = 0.0001, P value for time = 0.0001, Model $R^2$ = 0.9911.

**Estimated yields:**

Cotton yield differed over different end point of protection periods and sowing dates (Table 5). The lowest yield (2377.6 Kg/ha) was at the end point of the fifth sowing date with 25 days of protection. The largest yield (4351.9 kg/h) was at end point of the first sowing date with 61 days of protection, which was corresponded to the protection of 82.9% of the accumulation susceptible green cotton bolls (ASGB) / plant.

Table 5. Obtained yields (Kg/ha) over protection periods at different sowing dates through growing cotton seasons of 2001 and 2003.

| Sowing date | Protection period (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 25 | 31 | 37 | 43 | 49 | 55 | 61 |
| First | 2570 | 2866.9 | 3163.9 | 3460.9 | 3757.9 | 4054.9 | 4351.9 |
| Second | 2705.1 | 2929.8 | 3154.4 | 3379.1 | 3603.7 | 3828.4 | 4053 |
| Third | 2774.6 | 2946 | 3117.3 | 3288.7 | 3460.1 | 3631.4 | 3802.8 |
| Fourth | 2684.5 | 2851.7 | 3018.9 | 3186.1 | 3353.4 | 3520.6 | 3687.8 |
| Fifth | 2377.6 | 2543 | 2708.4 | 2873.9 | 3039.3 | 3204.7 | 3370.1 |
| Percent different | 7.5 | 11.3 | 14.4 | 17.0 | 19.1 | 21.0 | 22.6 |

**Partial regression equation**: Yield= 2177.76 – 136.7 date + 34.188 time

P vale for date = 0.0001, P value for time = 0.0001, Model $R^2$ = 0.9342. Percent different= the margin between the earliest and latest sowing date

Fruit branches at the start point ranged between 10.9 and 13.3 branch/plant and increased slowly through 61days to 16.0 – 17.7 branch/plant. The difference between start and end point was about four branches/ plant over sowing dates. This illustrate that each cotton plant produced the most number of its fruit branches at the start point of protection period. On the otherhand, the average numbers of green cotton bolls were 9.9 bolls/ plant at start point and 30.6 bolls/ plant at the end point. The difference was about twenty bolls/ plant produced during the protection period and sowing dates. The longest protection period (61days), in the 5 sowing dates, resulted in gaining the highest cotton yields (3370.1 – 4351.9 kg/ ha.).

Hussein *et al*. (1983) and Craig and Robert (2005) reported that plants stand at different stages of growth and decreased by delaying sowing date. The earlier maturity cultivars possessed the shortest boll maturation periods while the later maturity cultivars possessed the longest. The earlier maturity cultivars also produced a greater percentage of their total lint yields at lower main stem nodes. Also, many investigators showed that heat-unit accumulations have been used to estimate the time of occurrence of early-season cotton fruiting forms in relation to *P. gossypiella*

moth over wintering emergence (Fry 1983, Brawon *et al*., 1990, Beasley & Adams 1996, CHU & Henneberry 1992 and Sevacherian et al., 1977).

**Conclusion**:

This study proved that delaying planting date had a significant negative effect on the number of cotton fruit branches and green bolls. On the otherhand, longer protection period has the reveres effect. Obtained yield was affected by the same manner as other phenological characters, but the margin between the earliest and latest sowing date was as high as 22.6%. This indicates that sowing date had more meaningful effect on yield regardless the effect on other plant phenology.

The yield regressed on sowing dates and protection periods, is represented in the following partial regression equation:

**"Yield= 2177.76 – 136.7 date + 34.188 time"**

With P value for date = 0.0001 and for time = 0.0001, and Model $R^2$ = 0.9342.

From this equation it could be concluded that obtained yield was a function of sowing date (negative) and protection period (positive). Predicted cotton yield, at the end of each protection period, could be obtained from the previous equation.

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# العلاقة بين تواريخ زراعة القطن وفترات مكافحة ديدان اللوز وأثرها على التنبؤ بالمحصول

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تراكيب القطن الثمرية و محصوله لهما علاقة بتواريخ زراعته (التى تمتد من أول مارس الى آخر ابريل) ، وفترات المكافحة لديدان اللوز القرنفلية (بكتينوفورا جوسيبيلا ( ساوندرز))، دودة اللوز الأمريكية (هليكوفيربا أرميجرا(هوب.)) ودودة اللوز الشوكية (إرياس إنسيولانا (بويسد.)) تحت الظروف المصرية. فقد لوحظت زيادة للمحصول بزيادة فترة المكافحة من الحد الأدنى( ٢٥ يوما) إلى الحد الأقصى( ٦١ يوما) بفترة بينية ٦ أيام خلال تواريخ الزراعة المختلفة. الحد الأقصى والحد الأدنى من المحصول (الألياف والبذور) تراوحت ما بين ٤٣٥١.٩ و ٢٣٧٧.٦ كجم/ هكتار (فى ميعادى الزراعة المبكر(أول مارس) والمتأخر(آخر أبريل) لفترات مكافحة ٦١ و ٢٥ يوما ، على التوالي). هذه العلاقة تتمثل بالمعادلة : المحصول = ٢١٧٧.٧٦ – ١٣٦.٧ ميعاد الزراعة + ٣٤.١٨٨ فترات المكافحة (مواعيد الزراعة من ١ – ٥ وفترات المكافحة من ٢٥ – ٦١ يوم). هذه الزيادة كانت كرد فعل لزيادة فترة حماية لوز القطن الأخضر الحساس للإصابة خلال موسم النمو. أقصى إنتاجية تتفق مع حماية نحو ٨٣ ٪ من النسبة المئوية المتراكمة للوز الأخضر الحساس للإصابة خلال موسم النمو.فى مواعيد الزراعة المختلفة. أطول فترة مكافحة أعطت أعلى عدد من الفروع الثمرية واللوز الأخضر والإنتاج كجم/هيكتار والعكس كان فى أقل فترة. العلاقة بين فترة المكافحة (أيام) و الوقت الفسيولوجي (كوحدات حرارية متراكمة ) وتراكيب القطن الثمرية ومحصوله فى مواعيد الزراعة المختلفة علاقة معنوية موجبة.