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MONITORING PLANT GROWTH AND YIELD PRODUCTION IN SOME EGYPTIAN COTTON CULTIVARS USING PLANT MAP DATA

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Abstract

Management of cotton crop production environments requires the quantification of the effects of the environment on plant growth and yield. Plant mapping is a powerful technique for analyzing the fruiting patterns and for estimating potential yield of cotton crop. This paper presents a crop monitoring system based on plant map data to assist in the management of inputs for cotton production, using four Egyptian cotton cultivars (G. 75, G. 77, G. 80 and G. 83) besides different treatments on Giza 80 cultivar during 1996, 1997 and 1998 growing seasons.

Results obtained revealed that all the cultivars under study had the same behavior during different stages of plant growth, and they reached the cutout time approximately at the same stage of growth.

Pix and hill spacing treatments on G. 80 cultivar plants revealed a trend to change the behavior of plants (as mapped), in different stages of growth. Applying Pix at the optimum time and of the optimum dose (250 ml^{-1} / fed at squaring + 250 ml^{-1} / fed at beginning of flowering) or using 30 cm between hills, had a good effect on the vigour of plants.

Results also, cleared (by using plant map data) that the lower and middle zones of plant had the highest values of yield per plant with preference to the first and second fruiting positions.

INTRODUCTION

The average length of the cotton production season in Egypt is approximately 180 days from emergence until harvest. Although accumulated heat units are sufficient to produce early matured and a high yielding crop, many other factors such as water stress or other wrong treatments may modify the length of the season and the productivity of cotton plants.

Vegetative growth rates are near maximum values at the time of first bloom (Kerby *et al.* 1986). Fields vary in quantity of vegetative development at the time of early bloom. Many variables influence the balance between vegetative and reproductive growth. Accumulation of dry weight (g / m^2) in fruit for 8 weeks from the time plants had 10 nodes divided by the change in leaf area, accounted from 90 percent of the variation in vegetative growth noted across cultivars, years, water management and pest pressure differences (Kerby *et al.* 1993). Thus the carrying capacity or upper yield potential is determined by quantity of vegetative growth during this critical period. Reproductive growth rates are dependent on many factors including cool temperature, variety, water stress, salinity, soil compaction, diseases, insects, plant growth regulators, nutrient deficiency, the application time of harvest-aid and fruit retention materials (Loffory *et al.*, 1983; York 1983; Kerby, 1985; Bernhardt *et al.*, 1986 Kerby *et al.*, 1986; Lutrick *et al.*, 1986; Sabbe and Zelinski, 1990 and Supak *et al.*, 1993).

A major benefit from plant monitoring is the ability to quantify the balance between vegetative and reproductive growth (Kerby *et al.*, 1993).

Management strategies directed to produce an early maturing crop provide a practical escape from risks such as high temperatures, water stress and damage by boll worms (Landivar *et al.*, 1993).

The objective of this paper is to present a crop monitoring system based on plant mapping to assist in the management of plant-cotton production. This, makes it possible to customize cultural management during the growing season (Kerby *et al.*, 1993). The technique is really extension of the visual observation that producers have been masking for year regarding "flowering out of the top" being an indication of crop maturity and cut out (Waddle, 1982 and Oostherhuis *et al.*, 1993).

MATERIALS AND METHODS

Plant Mapping Procedure:

The plant mapping monitoring procedure consisted of collecting plant-mapping samples at four key stages of plant development:

1. Early bloom stage: (7 - 14 days after the appearance of the first bloom).
2. Peak of blooming stage: collected during the third or fourth week of flowering.
3. Early open boll stage: (10 - 15 days after the appearance of the first open boll).
4. Harvest time stage: taken at harvest time.

The cumulative distribution of green and open bolls for branch 1 up to any branch (k) is calculated as suggested by (Landivar *et al.*, 1993) as follows:

$$\frac{\sum_{i-l}^{k} Green_i + Open_i}{\sum_{i-l}^{n} Green_i + Open_i} \times 100$$

Where: n is the number of the uppermost branch with green or open bolls, and green $_i$ and open $_i$ are the number of bolls in the ith reproductive branch.

The cumulative distribution of open bolls alone is calculated as suggested by (Landivar *et al.*, 1993) as follows:

$$\frac{\sum_{i-l}^{k} Open_i}{\sum_{i-l}^{n} Green_i + Open_i} \times 100$$

A minimum of 20 plants were mapped from four selected sites. Care was taken to select sites with plant populations equal to the average population of the field being measured.

The plant mapping procedure suggested here requires recording the type of structure present at the first two fruiting positions and the rest ones (considered as third position) of each reproductive branch as well as the measurements of plant structure when it reaches cut-out (after 4 - 5 weeks of flowering), percent share of open bolls in yield / plant and average boll weight by different fruiting positions and zones per plant.

Concerning this study, samples were taken, first, to compare four different cultivars, at their optimum locations i.e. Giza 75 cultivar at Gemmeiza Exp. St., Giza 77 cultivar at Sakha Exp. St., Giza 80 cultivar at Sids Exp. St. and Giza 83 cultivar at Mallawi Exp. St. in 1996 season and secondly, to compare different treatments observations on Giza 80 cotton cultivar plants in Sids Exp. Station, in 1997 and 1998 seasons. Pix treatments (250 ml^{-1} / fed at squaring + 250 ml^{-1} / fed at beginning of flowering) and hill spacing treatment (30 cm, hill spacing), compared with control (No pix + 20 cm, hill spacing) were chosen as an example for plant mapping.

The plant map analysis, as means, is used to summarize and analyze the data.

RESULTS AND DISCUSSION

Management strategies for cotton production:

Production of an early maturing crop is an objective common to many areas of Egypt. The most important consideration for successful cotton production is the selection of the cultivar. The cultivar selected should be capable of maximizing the utilization of resources through the production season (Landivar *et al.*, 1993).

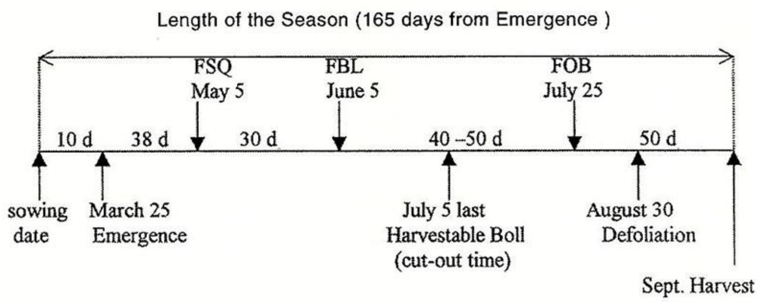

Figure 1. Length of the growing season for cultivar Giza 80 at sids in 1997 season.

[Indicating the date of first square (FSQ), first bloom (FBL), First open boll (FOB), as well as date of pollination of the fruiting position with the last harvestable boll i.e., cut-out time, defoliation time and harvest date].

Figure (1), shows dates of phenological events for cultivar Giza 80 grown at Sids Experiment Station. The crop was planted on March 15, 1997 and stand establishment was obtained by March 20 - 25. Thirty-eight to forty days later most plants had initiated the first squares. Flowers were observed during the first week of June. Under dry-land conditions, cotton plants produce most of their harvestable bolls in four to five weeks of flowering. This date coincides with the time in which the last flower on the plants are 4 - 5 nodes below the terminal, (the time of cut-out).

In selecting a cultivar for Upper Egypt region environment, it may be desirable to choose a cultivar having the potential to cut-out after the target date. Then, the actual cut-out date can be manipulated by the use of management practices.

Cut-out is affected by the growth habit of the cultivar and by management practices. The fast fruiting habit of early maturing cultivars results in a high demand for carbohydrates for reproductive organs at a time when the canopy and other vegetative organs are still expanding. This often results in crop with incomplete canopy cover and reduced rates of photothynthesis per unit of land area. For these reasons early maturing cultivars tend to cut-out and mature earlier (Landivar *et al.*, 1988).

The first open bolls were observed during the third week of July. The phenology of cultivar Giza 80 allowed for the fill utilization of the growing season and harvesting of crop during the first week of September. The use of growth regulators such as Pix or PGR. IV can be used to adjust plant growth as needed to produce the crop within the desired production.

Table 1. The comparison between varieties of final plant mapping of some Egyptian cultivars (1996).

Varieties / Fruiting organs	Giza 75	Giza 77	Giza 80	Giza 83
S (square)	----	1	1	1
X (aborted)	7	4	9	11
G (green boll)	13	4	8	10
O (open boll)	26	29	23	23
F (flower)	1	1	----	----
Fruit. Branches above yellow flower.	4	5	4	5

Table (1) depicts observations obtained at the final plant mapping (at harvest time) of different cultivars understudy. It can be observed that all the varieties had the superior number of open bolls and they reached the cut-out time - approximately - in the same stage of growth (4 - 5 fruiting branches above yellow flower). The results for the other three stages are shown in figures 2, 4, and 5.

Table (2) establishes the average number of green bolls, open bolls and aborted positions at harvest time for each cultivar. These values were reported by fruiting branch location on the cotton plant. Open bolls were found in greater number on the lower five fruiting branches (zone 1) and followed by the middle five fruiting branches (zone 2). This pattern was observed for all varieties under study.

Table (3) reports the presence of open bolls on fruiting branches positions 1, 2 and 3. All varieties followed the same trend, where the highest number of open bolls was observed on the 1st position followed by the 2nd one, whereas the lowest number was found on the 3rd position.

Table 2. Average number of green bolls (G), open bolls (O) and aborted position (X) per branch per cultivar, (1996), (at harvest time).

Varieties		Giza 75			Giza 77			Giza 80			Giza 83		
Fruiting branch		G	O	X	G	O	X	G	O	X	G	O	X
Zone 1	1	-	2	1	-	3	-	-	2	1	-	2	1
	2	-	2	1	-	3	-	-	2	1	-	3	-
	3	-	2	1	-	3	-	-	1	2	-	3	-
	4	-	2	1	-	2	1	-	2	1	1	1	1
	5	-	3	-	-	3	-	-	3	-	-	1	2
Zone 2	6	1	2	-	-	3	-	-	2	1	1	2	-
	7	-	2	1	-	2	1	-	2	1	-	1	1
	8	1	2	-	-	2	1	-	2	1	1	2	-
	9	-	1	1	-	2	-	-	2	-	1	1	1
	10	1	2	-	-	2	-	1	1	1	1	1	1
Zone 3	11	1	1	1	-	1	1	1	1	-	1	1	-
	12	1	2	-	1	1	-	1	1	-	1	1	-
	13	1	1	-	-	1	-	1	1	-	1	1	-
	14	1	1	-	-	1	-	1	1	-	-	1	1
	15	1	1	-	1	-	-	2	-	-	1	1	-
	16	2	-	-	1	-	-	1	-	-	-	1	1
	17	1	-	-	1	-	-	-	-	-	-	-	1
	18	1	-	-	-	-	-	-	-	-	1	-	1
	19	1	-	-	-	-	-	-	-	-	-	-	-
	20	-	-	-	-	-	-	-	-	-	-	-	-
Total		13	26	7	4	29	4	8	23	9	10	23	11

Table 3. Number of open bolls on fruiting branches per positions (1996) at harvest time.

Varieties		Giza 75			Giza 77			Giza 80			Giza 83		
Fruiting branch position		1	2	3	1	2	3	1	2	3	1	2	3
(Lower)	1 - 5	4	3	4	5	4	5	5	3	2	5	3	2
(Middle)	6 - 10	5	4	-	5	4	2	5	3	1	4	3	-
(Upper)	11^{+}	5	1	-	3	1	-	4	-	-	6	-	-
Total		14	8	4	13	9	7	14	6	3	15	6	2

Monitoring plant growth and yield potential:

The procedure discussed required collecting plant mapping samples at the following four key stages of plant development:

1. Early bloom stage:

The first plant-mapping sample (7 to 14 days after the appearance of the first bloom) was collected to verify the efficacy of the early insect control and to estimate potential yield. Plants with more than 75 and 50 % retention of first and second position structures (squares, blooms and bolls), respectively, are rated as having above average yield potential (Landivar *et al.*, 1993). Based on the information provided, farm managers should make a final application of growth regulators and should carefully study the needs for further applications of nutrients.

Figure (2) is an example of plant map data for four cultivars i.e. Giza 75, Giza 77, Giza 80 and Giza 83 collected during the 1996 growing season. Although the level of fruit retention was above 80 % for all cultivars, it is obvious that Giza 77 has a higher yield potential. This means that G. 77 plants are rated as having above average yield potential.

Figure (3) illustrates fruit retention for different treatments on Giza 80 cultivar plant during 1998 season, it is clear that Pix treatment (250 ml^{-1} / fed at squaring + 250 ml^{-1} / f at beginning of flowering) and hill spacing treatment (30 cm, apart), exceeded the control treatment (No. Pix + 20 cm, hill spacing) in fruit retention.

2. Peak of blooming stage:

The second plant-mapping sample, was collected during the third or fourth week of flowering.

The distribution and range of the data can be used to determine the crop maturity, insecticide treatments, the time for defoliant application and the potential yield of the plants (Landivar *et al.*, 1993).

In this stage of growth, samples to determine the number and distribution of green bolls / plant were collected, which may provide the most important information to crop managers.

Figure (2) shows that Giza 77 cultivar plants had the highest fruit retention during this critical stage of plant growth, and followed by the rest of cultivars.

Figure (3) shows that both treatments of Pix or 30 cms hill spacing raised the values of fruit retention above the control at this stage of growth.

3. Early open boll stage:

The third plant mapping sampling was performed 10 to 15 days after the appearance of the first open boll, to accurately estimate the optimum time to apply chemical defoliants and to evaluate the potential risk of hastening the application of harvest-aid chemicals.

The comparisons between cultivars (Figure 2) show that Giza 77 cultivar plants maintained the highest values of fruit retention at early open boll stage of growth and these values converted into the high distribution of green and open bolls / plant or the distribution of open bolls / plant, (as shown in figures 4 and 5).

Figure 3 shows, that Pix or 30 cm hill spacing treatments exceeded the control treatment in fruit retention and this trend resulted into high percent of green and open bolls / plant, specially below the target branch (fruiting branch no. 12).

Figure (6) shows that 90 % of the boll load (green and open bolls) on the plant are located below branch 12 (target branch). The remaining 10 % of the bolls are located above branch 12 and are normally made up of small green bolls which give yield with poor quality. Then, using the data displayed in figure (7) the percentage of open bolls up to the target branch can be found.

Figure (7) shows that(for Giza 80 cultivar), approximately 60 % of the bolls up to branch 12 are opened in control plant, while in both Pix and hill spacing treatments, it reached the highest values of open bolls / plant on lower fruiting branches than the control treatment, (Figures 6 and 7). Similar results obtained by Landivar *et al.*, 1993.

4. Harvest time stage:

A final plant mapping sampling was taken at harvest time to assess the final distribution of contributing to final yield.

The comparison between varieties in Figures (2 and 8) show that Giza 77 cultivar plants had the highest fruit retention during the different stages of growth. While Giza 80 cultivar plants had the lowest values.

Figures (3 and 9) show that fruit retention for different treatments on Giza 80 cultivar plants in stages of mapping. No clear differences could be observed between

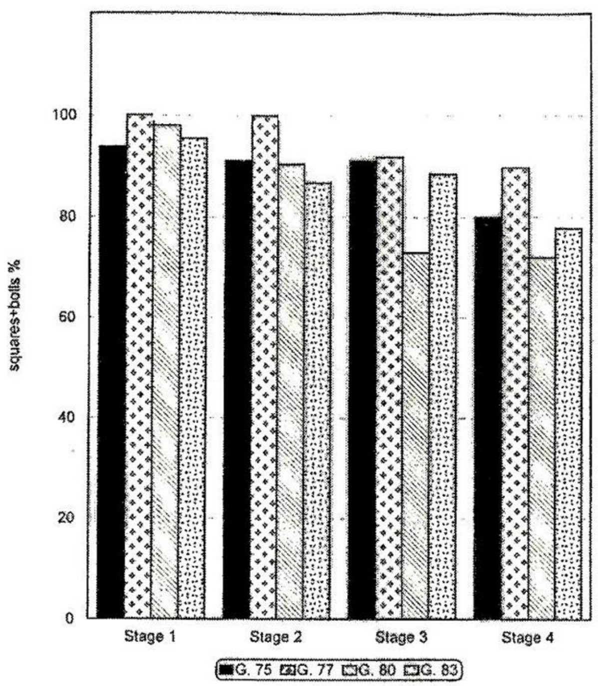

Figure 2. Squares and bolls retention % for different cultivars at different stages in 1996 season.

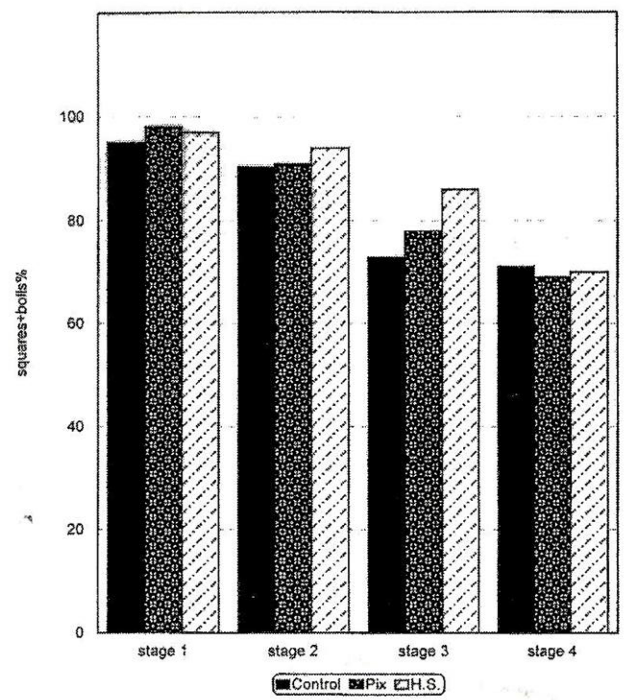

Figure 3. Squares and bolls retention % for different stages of G.80 cultivar as affected by treatments in 1997/1998 seasons.

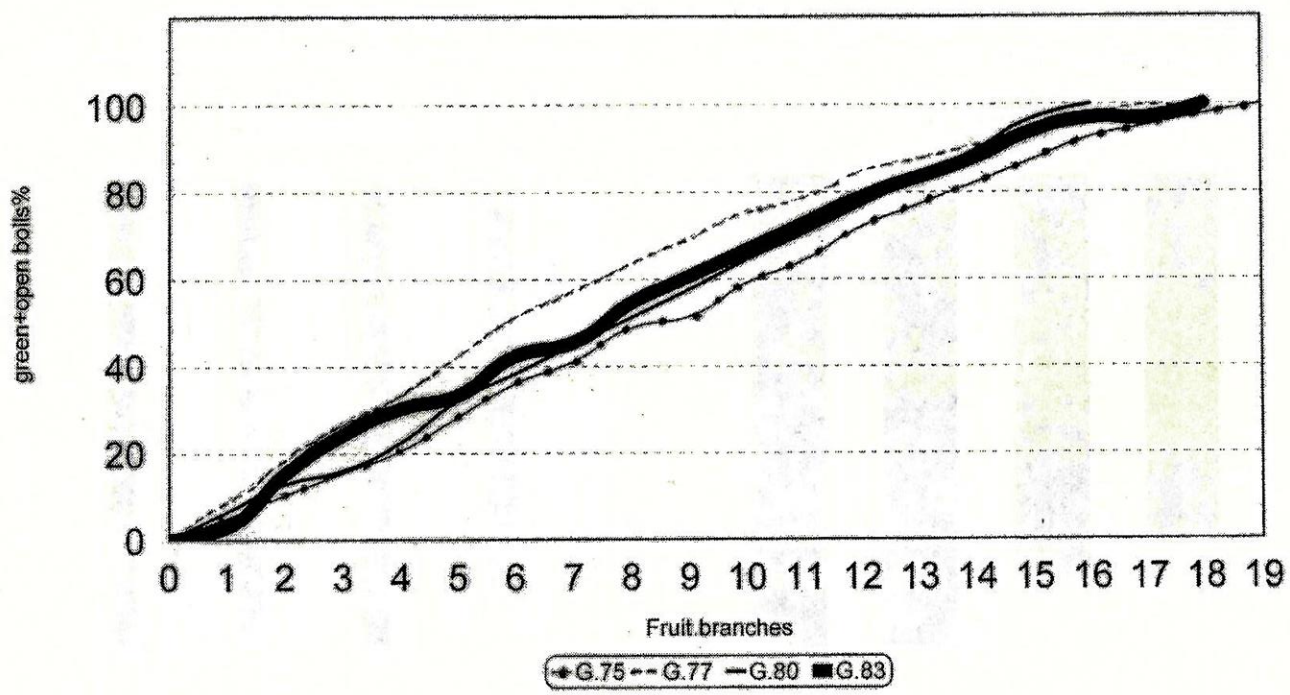

Figure 4. cumulative distribution of green and open bolls by reproductive branches (at early open boll stage) for different cultivars in 1996 season.

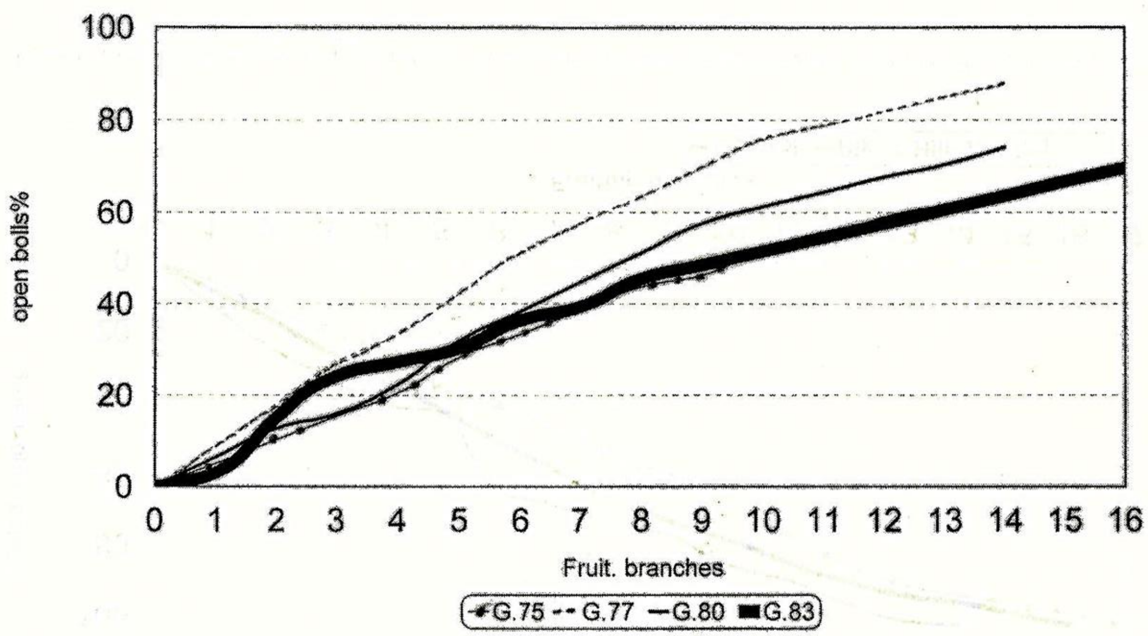

Figure 5. cumulative distribution of green and open bolls by reproductive branches (just before harvest time) for different cultivars in 1996 season.

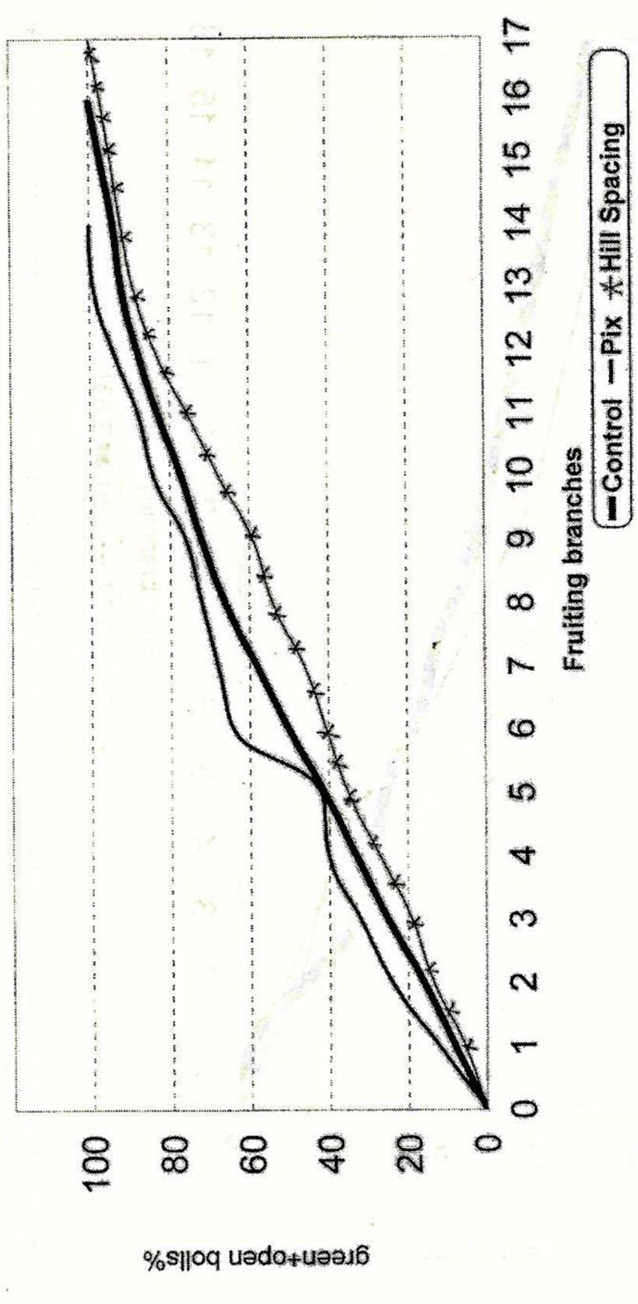

Figure 6. cumulative distribution of green and open bolls by reproductive branches of Giza 80 cultivar (as affected by Pix and hill spacing treatments) in 1997/1998 seasons.

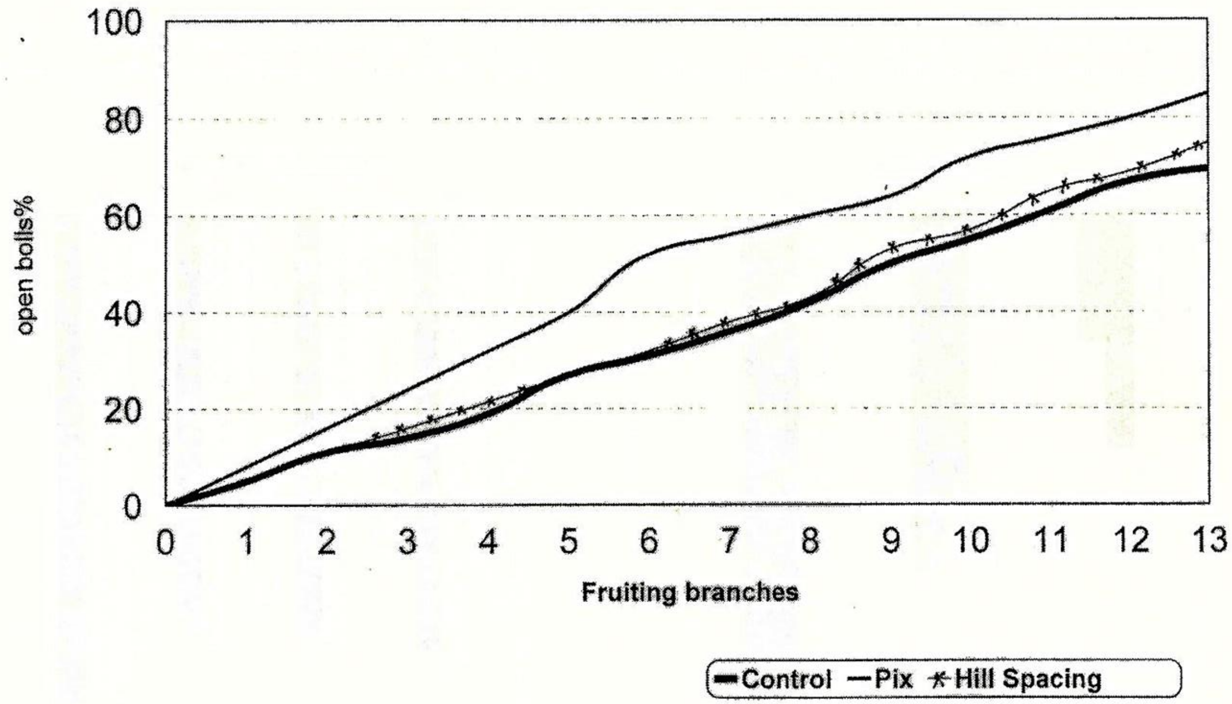

Figure 7. cumulative distribution of open bolls by reproductive branches of Giza 80 cultivar (as affected by Pix and hill spacing treatments in 1997/1998 seasons).

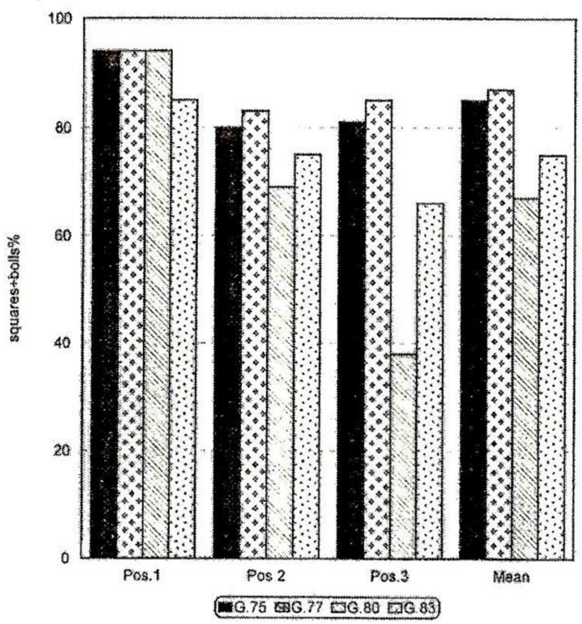

Figure 8. Reproductive structures % by position (at harvest time stage) for different cultivars in 1996 season.

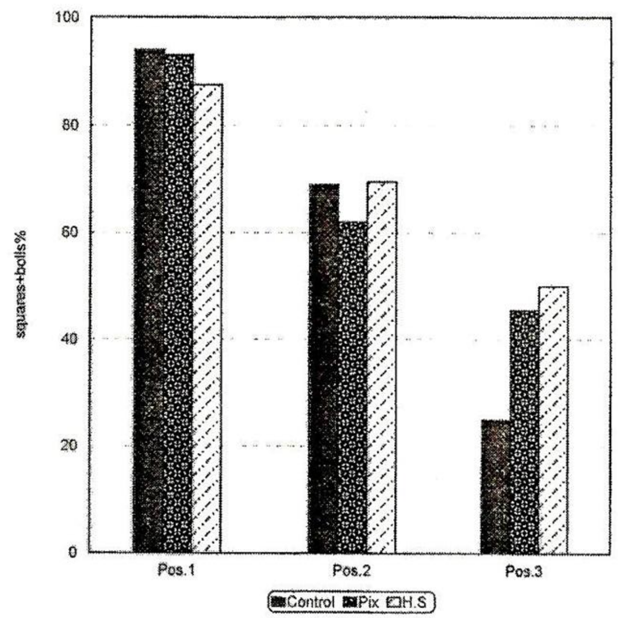

Figure 9. Reproductive structures % by position (at harvest time stage) of G,80 cultivar as affected by treatments in 1997/1998.

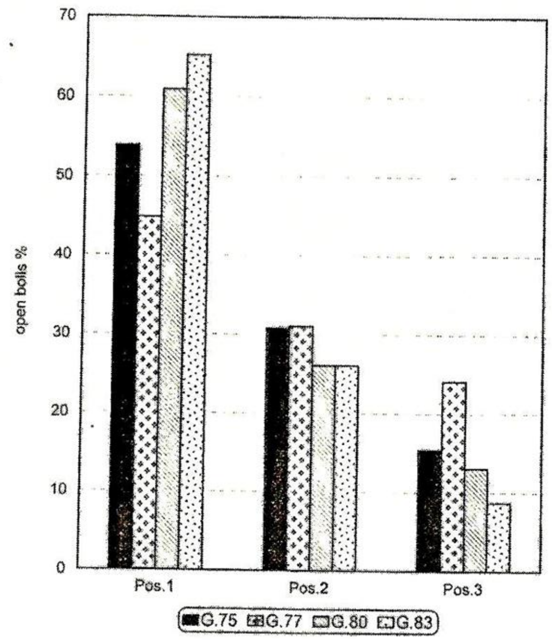

Figure 10. Open bolls share % by positions (at harvest time) for different cultivars in 1996 season.

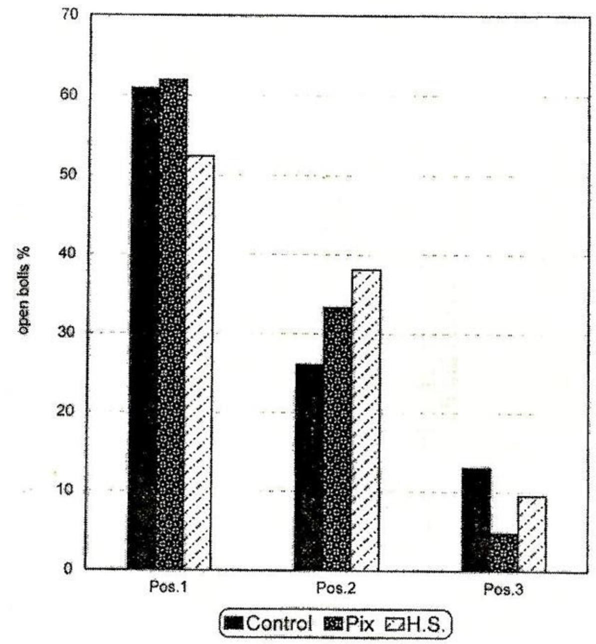

Figure 11. Open bolls share % by positions (at harvest time) of G.80 cultivar as affected by treatments in 1997/1998 seasons

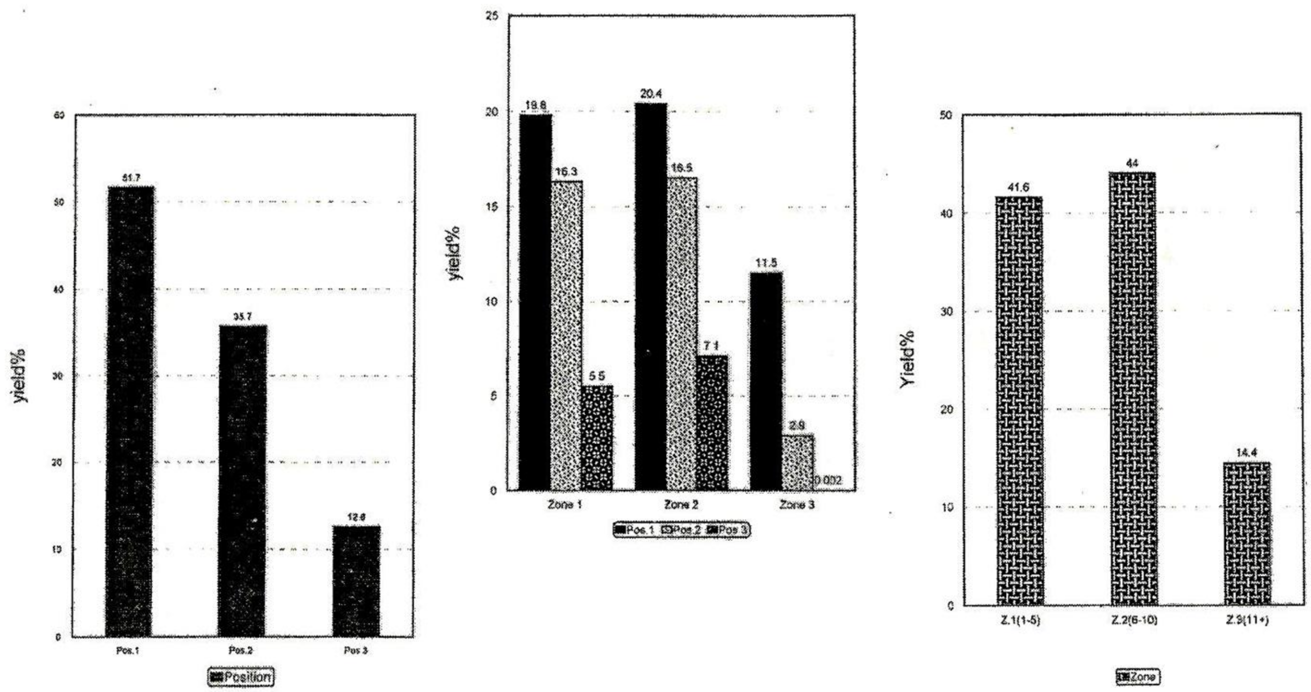

Figure 12. Seed cotton yield distribution % by zones and positions for G.80 cultivar in 1998 season.

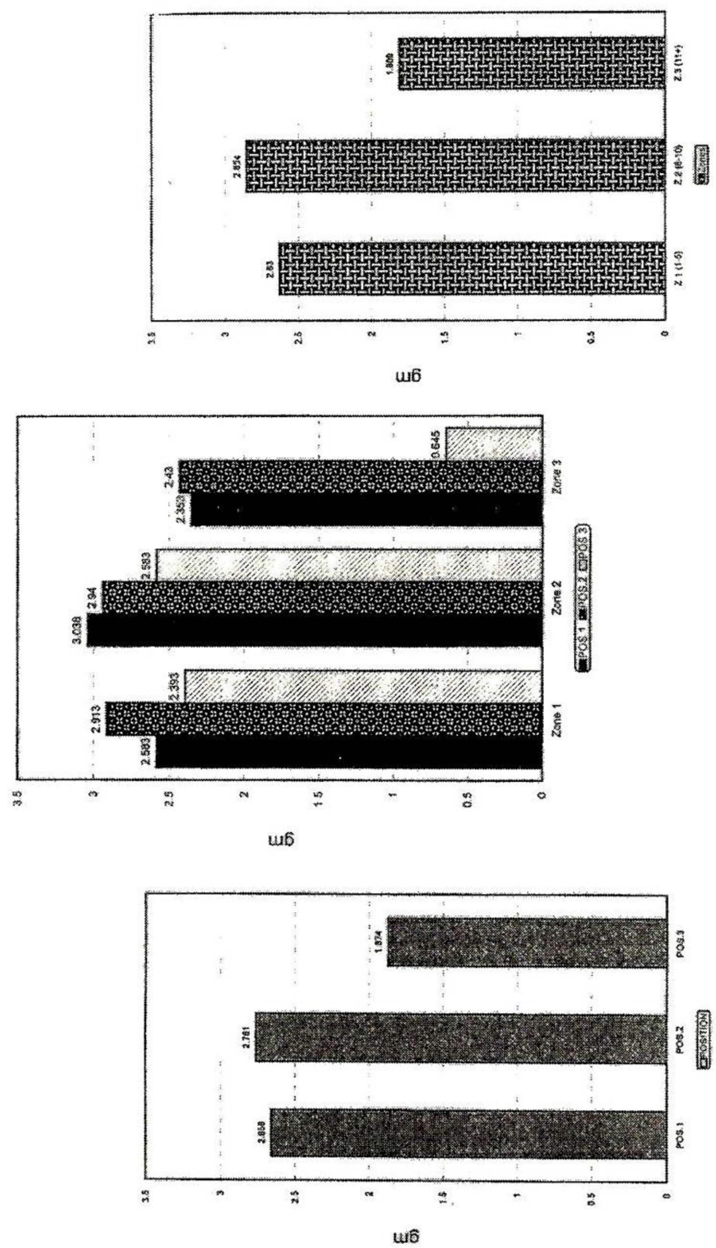

Figure 13. Average boll weight for G.80 cultivar under each zone and position in 1998 season.

the studied treatments at the fourth stage of growth, it is obvious that spraying of pix at the optimum time or using the optimum hill spacing tended to raise the values of fruit retention above the control, specially on the third position. Similar observations have been reported by Kerby *et al.*, 1986.

Figure (10) shows the open bolls share by position for different varieties. It is clear from data obtained that all the varieties under study had the high values of open bolls on the first position with preference to Giza 83 cultivar (65 %). Giza 77 cultivar plants had the highest value on the second (31 %) and third position (24 %).

Figure (11) illustrates the open bolls share by position for different treatments on Giza 80 cultivar plants. It is clear that Pix and hill spacing treatments were exceeded the control treatment (by about 7.2 and 12 % respectively) in open bolls share by position only on the second position. Kerby *et al.*, 1986 obtained similar results for Pix treatment.

Concerning the yield / plant, Figure (12) clears that zone 1 and zone 2 held the highest percentage of yield / plant (41.6 and 44 % respectively) with preference to the first and second fruiting position (51.7 and 35.7 % respectively). These results are in-agreement with those obtained by Oosterhuis *et al.*, 1993.

Figure (13) shows that average boll weight was heavier in the second zone (2.854 gm) compared with the first (2.63 gm) and third zone (1.809 gm) and it seems that first and second fruiting position had the high values (2.658 and 2.761 gm respectively). Jenkins *et al.*, 1990, reported that the most valuable reproductive branches are located in the middle of the plant.

CONCLUSION

Plant map data can be used to quantify plant growth status and potential yield. The procedure presented in this paper recommends obtaining four plant mapping samples at key stages of plant development. The data can be used to guide management practices such as early insect control and plant nutrition as well as to determine the need for the application of growth regulators and harvest-aid chemicals. This conclusion is confirmed by the results obtained by Hake, 1990.

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تتبع نمو نبات القطن وإنتاج المحصول فى بعض الأصناف المصرية باستخدام بيانات الخريطة النباتية

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يتحدد موسم إنتاج القطن بمصر بحوالى ١٨٠ يوماً من بدء الإنبات وحتى الجنى. وتعتبر المعاملات المبكرة بموسم النمو ذات نجاح ملحوظ لدفع وزيادة النضج والإنتاج. وتتضمن هذه المعاملات التحكم المبكر للآفات، استخدام منظمات النمو المختلفة، استعمال بعض الكيماويات التى تساعد على تفتح اللوز. ويأتى اختيار الصنف كأهم عامل لإنتاج قطنى ناجح. ويجب أن يمر اختبار الصنف على قابلية الصنف على الربط فى وقت يتعاظم فيه الاستفادة من كل المدخرات الغذائية خلال موسم النمو. كما أن إدارة البيئة التى ينمو بها نبات القطن يتطلب الإلمام بتأثير البيئة على نمو النبات وعلى المحصول. والخريطة النباتية تحلل النماذج الثمرية وذلك لتقدير حمل نباتات القطن للمحصول. وهذا البحث يقدم نظام تتبع نباتى للقطن يعتمد على بيانات الخريطة النباتية يساعد فى رفع كفاءة إدارة وإنتاج القطن، مستخدماً أربعة أصناف مصرية (جيزة ٧٥، جيزة ٧٧، جيزة ٨٠، جيزة ٨٣) بجانب بعض المعاملات على نباتات صنف القطن جيزة ٨٠ خلال مواسم ١٩٩٦، ١٩٩٧، ١٩٩٨ .

وقد أظهرت النتائج أن الأصناف تحت الدراسة قد سلكت سلوكاً متشابهاً أثناء مراحل النمو النباتية المختلفة، ووصلت لمرحلة الربط تقريباً عند مرحلة معينة من النمو.

ولقد أظهرت معاملة نباتات الصنف جيزة ٨٠ بالبكس (٢٥٠ ملليجرام عند ظهور البراعم + ٢٥٠ ملليجرام/فدان عند بداية التزهير) ومعاملة مسافة الزراعة (٣٠ سم بين الجور) تغيراً فى سلوك النباتات بمختلف مراحل النمو، وأن هذه المعاملات كان لها تأثيراً طيباً على قوة النباتات.

ولقد أظهرت النتائج أيضاً (باستخدام بيانات الخريطة النباتية) أن المناطق السفلى والمتوسطة من النبات تملك النسب العالية من المحصول مع الأفضلية لمحصول الموقعين الأول والثانى الثمريين.