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# Effect of Some Cultural Practices And Heat Units on Physiological Response of Cotton in Upper Egypt

**Farag, Abeer.A.[2] Shalaby, E.M.[1]; Galal, A. H.[1]; Hamoda, S.A.[2]**

[1]Agronomy Dept., Fac Agric., Assiut Univ., Assiut, Egypt
[2]Agronomy Dept., Cotton Research Institute, Agric Res Center, Giza, Egypt

## Abstract:

Six field experiments were conducted at Shandweel Agricultural Station, Sohag Governorate in Upper Egypt during the two growing seasons 2010 and 2011, three in each to study the physiological response of Egyptian cotton cultivar Giza 90 to planting date, hill spacing and NPK fertilizers. Three sowing dates were grown in every season, i.e. on 1st March, April and May).The experimental design for each sowing date was a split plot with four replications. Main plots included the hill spacing 15, 20 and 25 cm between hills and the sub plots included NPK fertilizers 75%, 100% and 125% from the recommended doses of NPK. The combined analysis between sowing dates for each season was done. Simple correlation coefficient was computed between cotton traits and carbohydrates. The obtained results revealed that sowing date affected significantly for all the characters studied due to the variation in total amount of heat units and total soluble carbohydrates in each date. Early planting increased number of fruiting branches per plant, carbohydrates in stem seedling, number of open bolls per plant, boll weight and seed cotton yield/fed., while decreased plant height and first fruiting node. Increasing hill spacing increased number of fruiting branches per plant, carbohydrates, number of open bolls per plant, boll weight and seed cotton yield/fed., while decreased plant height and first fruiting node, Increasing NPK rates to 125% increased growth, carbohydrates, yield and its components. Early planting on 1st march and hill spacing of 25cm between hills gave the highest values for growth, carbohydrates and yield. The hill spacing of 25 cm between hills and 125% NPK fertilizers gave the highest values for plant height, carbohydrates , boll weight, number of bolls /plant and seed cotton yield/fed. Early planting on 1st March and 125% NPK fertilizers gave the highest values for carbohydrates , boll weight, number of bolls/plant and seed cotton yield/fed. Early planting on 1st March, hill spacing of 25cm between hills and 125% NPK fertilizers gave the highest values for carbohydrates , boll weight, number of bolls plants and seed

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cotton yield/fed. Negative and significant correlation was found between cotton plant height or first fruiting node and total soluble carbohydrates in the two seasons. On the other hand, number of fruiting branches per plant, number of open bolls per plant, boll weight and seed cotton yield /fed. were positively and significantly correlated with total soluble carbohydrates in Upper Egypt.

**Keywords:** Planting date, Hill spacing, NPK fertilizer, Temperature, Heat units, Carbohydrate, Growth Yield and yield components.

**Introduction:**

Crop growth and yield are controlled by environmental factors such as light, CO2, temperature, water, nutrients, etc. interacting with the genetically determined physiological and biochemical systems of the plant.

Agricultural production strategy must be based on optimizing plant function in relation to environment to give high productivity with long-term stability. Temperature plays a dominate role in controlling metabolism , consequently growth and developmental rates of cotton plants. Reddy *et al.* (1996) indicated that high night temperatures are detrimental for yield of cotton and cause yield variability due to their effects on respiration and the carbon balance of the plant where more carbohydrates are lost by the high respiratoration rates at the expense of cotton plant growth.

Oosterhuis,(2002) reported that high day and night temperatures may be even more detrimental to the yield of cotton. El-Sayed and El-Menshawi (2005) found that the relatively lower temperature prevailed during seedling and vegetative stages may contribute so much in increasing the amount of metabolites synthesized by plants which led to the formation of first fruiting branches at lower node. Loka and Oosterhuis (2010) found that high night temperatures are considered to be one of the main environmental factors contributing to lowered yields in cotton and this has been attributed to a negative effect on respiration and carbohydrate accumulation. In general, high night temperatures increased respiration, which resulted in a reduction of leaf ATP levels and leaf carbohydrate content. Elayan, *et al*. (2006) found that the correlations between number of opened bolls/plant or boll weight or seed cotton yield/fed. were positive and significant with air temperature and hence heat units.

Planting cotton in a suitable time leads to forming the first fruiting branch at a lower node on the stem and only an optimum height, increasing number of bolls and yield of cotton, escaping from leaf and boll-worms and aphids at the end of the season and picking early. Boquet *et al.* (2003) showed that the excessive plant height at late planting date was partly responsible for lower yield as the crop used a larger portion of its energy budget for vegetative growth and excess plant height caused lodging. Seed cotton yield/fed. was significantly decreased with delayed planting. Emara, (2006) showed that early sowing gave shorter plants and significantly increased number of open bolls/plant and seed cotton yield/fed. Hamoda (2006) found that late sown plants grew faster than early sown ones while, boll weight, number of open bolls/plant and seed cotton yield/fed., increased in early sowing date.

Here too, the global warming which exists nowadays made it clear that further studies are required on sowing dates. Plant population is one of the management practice which require attention as far as optimum yield is concerned in cotton production. The suitable plant density per feddan was resulting into higher yield, earlier maturity and reduced cost of insect and weed control. The proper spacing is one of the management practices that affect canopy light interception, maturity and vegetative dry matter of the cotton plant. Obasi and Msaakpa (2005) indicated that wider hill spacing increased number of sympodia, open bolls, boll weight and seed cotton yield while, it decreased plant height. El-Shahawy and Hamoda (2011) found that increasing hill spacing significantly increased number of sympodia /plant, number of open bolls /plant, boll weight and seed cotton yield /fed. while plant height and first sympodial position decreased.

NPK fertilizers are one of the most important elements in cotton plants. Moderate levels of NPK fertilization may produce a higher yield and quality, but higher levels may result in excessive of vegetative growth with a lower yield and quality. Efficient and balanced nutrition has proved to be a means for improving plant tolerance to various environmental stresses. Plants receive proper nutrients supply exhibit better performance and productivity under stressful conditions (Szezpaniak and Grzebisz, 2007). In this respect, Hamed (2006) found that number of fruiting branches, number of open bolls/plant and seed cotton yield/fed. significantly increased by increasing fertilizer levels up to75kg N+30kg $P_2O_5$ +48kg $K_2O$/fed. However, location of first fruiting node was not affected by NPK fertilizer treatments. Ibrahim (2008) found that plant height, number of fruiting branches/plant, number of open bolls/ plant, boll weight,

number of plants/fed. and seed cotton yield/fed. increased significantly by increasing NPK fertilizers levels up to 80 kg N +30 kg $P_2O_5$ +48 kg $K_2O$ /fed. El-Shahawy and Hamoda (2011) found that plant height, number of sympodia /plant, first sympodial position, number of open bolls /plant, boll weight, seed index and seed cotton yield/fed. increased by increasing nitrogen levels. Therefore the main objective of this investigation was to study the physiological response of Egyptian cotton cultivar Giza 90 to planting date, hill spacing and NPK fertilizers in Upper Egypt and the relation between cotton yield and carbohydrates in cotton stem seedling through the growing seasons.

**Materials and Methods**

Six field experiments were conducted at Shandweel Agricultural Station, Sohag Governorate during the two growing seasons 2010 and 2011 to study the physiological response of Egyptian cotton cultivar Giza 90 to sowing date, hill spacing and NPK fertilization in Upper Egypt. Three sowing dates were grown in every season on $1^{st}$ March, $1^{st}$ April and $1^{st}$ May. The experimental design for each sowing date was a split plot with four replications. The Main plots included the hill spacing 15, 20 and 25 cm between hills and the sub plots included NPK fertilization (75%, 100% and 125% from the recommended doses of NPK). The recommended doses, were 60, 22.5 and 24 kg/fed for N, $P_2O_5$ and $K_2O$, respectively. The experimental unit included 7 ridges (4 m long and 60 cm apart) occupying an area of 16.8 m² in each season. Cotton seeds were planted on the different sowing dates in 2010 and 2011 seasons. Hills were spaced at the tested hills within rows and seedlings were thinned at 2 plants/hill. Phosphorus fertilizer as ordinary superphosphate (15.5% $P_2O_5$) at the tested levels was incorporated during seed bed preparation. Nitrogen fertilizer in the form of ammonium nitrate (33.5 % N) at the tested levels was applied in two equal doses, immediately before the second and the third irrigations. Potassium fertilizer in the form of potassium sulfate (48% $K_2O$) at the tested levels. was side-dressed in a single dose before the second irrigation. Standard agricultural practices were followed throughout the growing seasons. At harvest, 6 guarded plants were randomly taken from the central row of each sub plot to determine plant height (cm), number of fruiting branches/plant, first fruiting node, number of open bolls/plant, boll weight (gm), seed cotton yield (kentar /fed.) was estimated as the weight of seed cotton yield (kilogram) picked from the five middle rows in sub plot collected from two picks, then converted to yield (Kentar /fed.). Representative soil samples were taken from the experimental sites before sowing in the two seasons and were prepared for analysis, according to Chapman and Pratt (1978). The results of the soil analysis are shown in Table 1.

Table 1: Soil analysis of the experimental site in the two growing seasons

| Seasons | Properties | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soil texture | pH | EC Mmhos / cm. | CaCO3 % | Total N (%) | Soluble ions (meq/100g soil (1:5)) | | | | | | |
| | | | | | | HCO3- | Cl- | So4-- | Ca++ | Mg++ | Na+ | K+ |
| **2010** | **Clay loam** | 7.5 | 0.237 | 1.20 | 0.196 | 0.30 | 0.89 | 1.02 | 0.50 | 0.27 | 1.25 | 0.16 |
| **2011** | **Clay loam** | 7.6 | 0.235 | 1.34 | 0.168 | 0.26 | 0.79 | 1.02 | 0.53 | 0.23 | 1.19 | 0.15 |

The measurements of maximum, minimum and mean air temperatures (°C) were recorded and the amounts of heat units scored were calculated as a Mean monthly through the cotton growing season (March-September) in 2010 and 2011 seasons for Shandweel Agricultural Station as shown in Table 2. Heat units were calculated according to Young *et al.* (1980) equation as follows:

HU = Mean daily min. and max. Temperatures – K (Zero point of growth = 12.8 °C)

Table 2: Mean monthly air temperatures and heat unites for Shandweel Agricultural Station, Sohag Governorate during the two growing seasons 2010 and 2011

| **Month** | **Air temperature $C^0$ season 2010** | | | | **Air temperature $C^0$ season 2011** | | | |
|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | **Mean** | Total H.U | Max. | Min. | **Mean** | **Total H.U** |
| **March** | 29.80 | 13.74 | **21.77** | 278.10 | 26.54 | 7.99 | **17.26** | **138.35** |
| **April** | 33.04 | 14.64 | **23.85** | 331.35 | 29.26 | 9.76 | **19.51** | **201.27** |
| **May** | 35.78 | 15.63 | **25.71** | 400.50 | 34.19 | 17.26 | **25.73** | **400.70** |
| **June** | 37.57 | 15.08 | **26.32** | 405.70 | 36.35 | 20.33 | **28.34** | **466.30** |
| **July** | 37.22 | 14.82 | **26.02** | 409.95 | 38.74 | 21.62 | **30.18** | **538.70** |
| **August** | 38.14 | 16.24 | **27.19** | 446.05 | 36.83 | 20.68 | **28.76** | **494.75** |
| **September** | 36.93 | 18.89 | **27.91** | 453.35 | 33.52 | 17.48 | **25.50** | **380.90** |
| **Mean** | **35.50** | **15.57** | **25.53** | **2724.55** | **33.64** | **16.46** | **25.05** | **2620.98** |

Heat units were calculated through 45 day interval from sowing for each planting date in 2010 and 2011 seasons in Shandweel Agricultural Station as shown in Table 3.

Average total soluble carbohydrates was estimated in samples representing each sub-plot in the dry matter of stem seedlings. The samples were taken after 45 days from sowing in each planting date as described by Dubois, *et al.* (1956) and Krishnaveni, *et al.* (1984).

The combined analysis between sowing dates was carried out for each year for all aforementioned characters according to Gomez and Gomez (1984). The significant means were compared by LSD at 5% level of probability level according to Waller and Duncan (1969). In addition, correlation coefficient was estimated between total soluble carbohydrates and some cotton traits.

**Results and Discussion**

Total heat units from sowing to 45 days cotton growth period in different planting dates.

Through the different planting dates in each season, the cotton plants were exposed to different air temperatures. Heat units from sowing to 45 days cotton growth period in three sowing dates during the two growing seasons were showed in Table 3.

Results in Table 3 cleared that the total heat units which were received by cotton plants from sowing to 45 days cotton growth period in the first sowing date were low than that in the others planting dates (422.9 and 200 in 2010 and 2011, respectively). The lowest heat units at the beginning of the season led to obtain the high amount of carbohydrates . In this concern, Loka and Oosterhuis (2010) found that high night temperatures increased respiration, which resulted in a reduction of leaf ATP levels and leaf carbohydrate content. According to these results the daily and seasonal thermo periodicity played an active role in governing cotton plant growth and development, which in turn governed yield and fiber quality. McMahon and Low (1972) found that the exposure of cotton plants at early stages of growth to relatively lower night temperature promotes flowering early and brings the crop to harvest in suitable time. Also, Makram *et al.* (2001) found that the exposure of cotton plants at different stages to suitable air temperature and heat units created a good balance between vegetative growth and fruiting development.

Table 3: Heat units from sowing to 45 days cotton growth period in three sowing date at Shandweel Agric., Station in Sohag Governorate during the two growing seasons 2010 and 2011

| **Sowing dates** | **Heat units from planting to 45 days above zero point during two seasons** | |
|---|---|---|
| | **2010** | **2011** |
| **First planting date on 1$^{st}$ March** | 422.90 | 200.00 |
| **Second planting date on 1$^{st}$ April** | 517.90 | 360.38 |
| **Third planting date on 1 $^{st}$May** | 598.75 | 615.15 |

From the previous results it could be concluded that the cotton plants scored low temperature units which in turn decreased respiration and consequently increased total soluble carbohydrates .

**1- Effect of sowing date, hill spacing, NPK fertilizers and their interactions on growth, yield and carbohydrates of cotton seedlings:**

The combined analysis for the three sowing dates in each season 2010 and 2011 to growth, yield and carbohydrates characters were shown in Tables 4, 5, 6, 7 and 8. Results in Table 4 revealed that planting dates, hill spacing and NPK fertilizer significantly affected plant height, number of fruiting branches /plant, location of first fruiting node, carbohydrates, number of open bolls per plant, boll weight and seed cotton yield/fed. Late planting increased plant height and first fruiting node, while decreased carbohydrates, number of fruiting branches per plant, number of open bolls per plant, boll weight and seed cotton yield/fed. The plant height tended to be increased as planting date was delayed and temperature degrees was increased. This increase could be attributed to increases in internode length not in number of fruiting branches which took the opposite trend. Carbohydrates tended to be decreased with delayed planting date. These data revealed that cool weather prevailing during seedling stage of early sown plants may be decrease the rate of respiration which in turn increased the total soluble carbohydrates. Such findings are in harmony with those obtained by El-Sayed and El-Menshawi (2005), loka and Oosterhuis (2010). The location of first fruiting node tended to be increased as planting date was delayed. The present trend could be explained on the base that total soluble carbohydrates tended to be decreased as planting date was delayed . In this respect Mc-Mahon and Low (1972) declared that cool weather but not chilling during the seedling stage of cotton growth is required. Early planting increased yield and its components. Similar results were obtained by Boquet *et al.* (2003) and Emara, (2006).

Increasing hill spacing increased number of fruiting branches per plant, carbohydrates, number of open bolls per plant, boll weight and seed cotton yield/fed., while decreased plant height as well as location of first fruiting node,(Table 4). Similar results in this respect were obtained by Obasi and Msaakpa (2005) and El-Shahawy and Hamoda (2011)

*Farag.et al.2012*

**5-Simple correlation between total soluble carbohydrates and some cotton characters in the two seasons .**

Results in Table 9 showed significant correlation between total soluble carbohydrates and some growth characters of cotton over the two growing seasons. Negative and significant correlation was found between cotton plant height as well as first fruiting node and total soluble carbohydrates in the two seasons. On the other hand, number of fruiting branches per plant, number of open bolls per plant, boll weight and seed cotton yield /fed. were positively and significantly correlated with total soluble carbohydrates.

Table 9: Simple correlation coefficient between total soluble carbohydrate and the some characters of cotton in 2010 and 2011 seasons

| Cotton properties | | (r values) | |
|---|---|---|---|
| | | 2010 season | 2011 season |
| Growth characters | Plant height at harvest (cm) | -0.782** | -0.860** |
| | Number of fruiting branches/ plant | 0.875** | 0.966** |
| | First fruiting node | -0.868** | -0.908** |
| Yield and its components | Number of open bolls / plant | 0.811** | 0.888** |
| | Boll weight (g) | 0.800** | 0.669** |
| | Seed cotton yield/fed. (kentar) | 0.887** | 0.953** |

**** indicates significant at 0.01 level of probability.**

It should be noted that this correlation emphasized the importance of analysis the total soluble carbohydrates in the stem of cotton seedling to predict early the productivity of the new strains of cotton in the season before harvesting.

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# تأثير بعض المعاملات الزراعية والحرارة المتجمعة على الاستجابة الفسيولوجية للقطن في مصر العليا

**عبيرعبد الناصر فرج[2] ، السيد محمود محمد شلبي[1] ،**
**إنعام حلمي جلال[1] ، سعيد عبد التواب فرج حمودة[2]**
[1]قسم المحاصيل – كلية الزراعه – جامعة اسيوط – اسيوط - مصر
[2]قسم بحوث المعاملات الزراعية - معهد بحوث القطن- مركز البحوث الزراعية -الجيزة- مصر

**الملخص العربي**

أجريت ستة تجارب حقلية بمحطة البحوث الزراعية بشندويل التابعة لمركز البحوث الزراعية بمحافظة سوهاج خلال الموسمين الصيفيين ٢٠١٠ و٢٠١١ بهدف دراسة الاستجابة الفسيولوجية لنبات القطن تحت تأثير الحرارة التجميعية وبعض المعاملات الزراعية و تأثير ذلك على النمو والمحصول ومكوناته لصنف القطن جيزة ٩٠ في مصر العليا حيث تم زراعة ثلاثة مواعيد في كل موسم وهى أول مارس ، أول ابريل وأول مايو وذلك في تصميم القطع المنشقة مره واحده حيث وضعت المسافة بين الجور (١٥ ، ٢٠ و ٢٥ سم بين الجور ) فى القطع الرئيسية كما وضعت معاملات التسميد من النيتروجين والفوسفور و البوتاسيوم بنسب (٧٥، ١٠٠ و ١٢٥ % ) من الموصى به في معدلات تسميد القطن والتي تم وضعها فى القطع المنشقة وتم عمل التحليل المشترك للمواعيد فى كل موسم كما تم حساب الارتباط البسيط لبعض صفات القطن مع نسبة الكربوهيدرات المتكونة فى سيقان بادرات النبات خلال المرحلة الأولى من النمو وحساب الوحدات الحرارية وكانت أهم النتائج المتحصل عليها كما يلي:

١- أشارت النتائج إلى أن: لمواعيد الزراعة تأثيرا معنويا على جميع الصفات المدروسة وذلك لتباين درجات الحرارة التجميعية ونسبة الكربوهيدرات المتكونة حيث أعطت الزراعة المبكرة اقل القيم لدرجات الحرارة المتجمعة فوق صفر النمو في مرحلة البادرات زيادة نسبة الكربوهيدرات.

٢- أظهرت النتائج أن زيادة المسافة بين الجور أدى الى زيادة معنوية لعدد الأفرع الثمريه والمحصول بالقنطار/فدان ومكوناته ونسبة الكربوهيدرات .كما أدت زيادة مستويات التسميد الى زيادة معنوية فى طول النبات، عدد الأفرع الثمريه، المحصول (قنطار/فدان) ومكوناته ونسبة الكربوهيدرات.

٣- أدى التفاعل بين الميعاد المبكر والمسافة ٢٥ سم بين الجور زيادة معنوية لصفات عدد الأفرع الثمريه و نسبة الكربوهيدرات والمحصول ومكوناته.

٤- أوضحت نتائج التفاعل بين مسافة الزراعة ٢٥ سم بين الجور وتسميد NPK ١٢٥ % زيادة معنوية لصفات نسبة الكربوهيدرات و المحصول ومكوناته موضحا الاستجابة الكبيرة للتسميد في حالة الزراعة المبكرة وذلك بالمقارنة بالزراعات المتأخرة التي تعقب الزراعة بعد محاصيل شتوية، كما أعطى الميعاد المبكر مع ٢٥ سم بين الجور وتسميد NPK ١٢٥ % أفضل نمو ومحصول للقطن الزهر/فدان ونسبة الكربوهيدرات .

٥- كما تشير نتائج الارتباط البسيط الى وجود ارتباط معنوي سالب بين نسبة الكربوهيدرات خلال المواسم وكل من صفات طول النبات وارتفاع أول فرع ثمري كما وجد ارتباط معنوي موجب بينها وبين صفات عدد الأفرع الثمريه و عدد اللوز ووزن اللوزة و المحصول فى مصر العليا كما يمكن من خلال زيادة نسبة الكربوهيدرات فى مرحلة البادرات التنبوء بالمحصول العالي في مراحل مبكرة من النمو.

و توصي نتائج هذه الدراسة بالآتي:

١- عدم التأخير في زراعة القطن و عدم المغالاة في التسميد لعدم الاستجابة الكبيرة للزراعات المتأخرة للتسميد.

٢- أن العلاقة بين نسبة الكربوهيدرات الذائبة الكلية وجميع الصفات المحصولية علاقة موجبة مما يساعد مربي النباتات من التنبؤ بالصفات المحصولية.