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Effect of nano-fertilizer (lithovit) and potassium on growth, fruiting and yield of Egyptian cotton under different planting dates

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Abstract

Two field experiments were conducted on a clay soil at El-Gemmeiza Agricultural Research Station, (Latitude: 30.79, Longitude: 31.12 Altitude: 5), El-Gharbia Governorate, Egypt in 2014 and 2015 seasons, to study the effect of nano-fertilizer (Lithovit) rates (0, 2.5, 5 and 7.5 g/l) and foliar potassium fertilizer (in the form of Potasin-P) rates (2.5, 5 and 7.5 cm3/l) under three planting dates (8 April, 8 May and 8 June) as well as their interactions on cotton growth, earliness traits, seed cotton yield and its components of the Egyptian cotton cultivar Giza 86.Cotton plants were foliar sprayed with Lithovit and Potasin-P at 45 and 60; 46 and 61 days after planting, respectively. A strip split plot design with four replicates was used in both seasons. The important results could be summarized as follow: At the first sampling date, the greatest values of leaf area per plant and leaf area index were obtained from the third planting date in both seasons. At the second sampling date in the second season, the highest values of leaf area per plant and leaf area index were obtained from the first planting date. At the third sampling date, the highest values of leaf area per plant and leaf area index were obtained from the second planting date in the first season and from the first planting date in the second season. Total dry weight per plant significantly responded to planting dates at the three sampling dates in both seasons. At the first sampling date, the third planting date (8 June) resulted in the highest values of total dry weight/plant in both seasons. Planting dates had a pronounced effect on boll setting percentage, boll shedding percentage and 1st picking percentage over the two seasons of study. Early planting date on 8 April significantly increased boll setting percentage and 1st picking percentage and significantly dccreased shedding percentage as compared with the medium planting date on 8 May and the late planting date on 8 June in both seasons. Plant height reached its maximum for the third planting date (8 June) followed by the second date (8 May) and the least resulted from early planting in the first date (8 April), while number of fruiting branches/plant reached its maximum for the first planting date (8 April) followed by the second planting date (8 May) and the least resulted from late planting (8 June). Time of planting exhibited significant differences in boll weight, number of bolls/plant, seed cotton yield / plant and seed cotton yield per feddan in both seasons, where the heaviest bolls resulted from the first planting date. Delaying planting date significantly reduced number of bolls/plant and seed cotton yield / plant. Also, delaying planting date decreased seriously the seed cotton yield per feddan in both seasons. Foliar spray of Potasin-P at the rate of 5 cm^3/l twice at 45 and 60 days after planting resulted in the highest leaf area/plant and leaf area index at the three sampling dates in the first season. In the second season, foliar spray of Potasin-P at the rate of 7.5 cm^3/l resulted in the highest leaf area/plant and leaf area index at the three sampling dates. Significant differences were obtained in total dry weight/plant due to the three rates of Potasin-P at the three sampling dates in both season. Foliar spray of Potasin-P at the rate of 5 cm^3/l resulted in the highest total dry weight/plant at the three sampling dates in the first season. In the second season, the superiority was found in favor of high rate (7.5 cm^3/l) of Potasin-P at the three sampling dates. The high rate (7.5 cm^3/l) of Potasin-P significantly increased bolls/plant boll setting percentage and 1st picking percentage and significantly decreased boll shedding percentagr as compared with the other rates in both seasons. Seed cotton yield/fed was significantly affected by Potasin-P rates in both seasons, where applying Potasin-P at the high rate (7.5 cm^3/l) out-yielded significantly the medium rate (5 cm^3/l) and the low rate (2.5 cm^3/l). Number of open bolls/plant and boll weight were significantly affected by Potasin-P rates in both seasons where applying Potasin-P as foliar spraying twice at the high rate (7.5 cm^3/l) produced the highest number of open bolls /plant and the heaviest bolls. Increasing Lithavit rates from zero (untreated) to 7.5 g/1 significantly increased plant height at harvest and number of fruiting branches/plant in both seasons. Leaf area/plant and leaf area index significantly responded to the tested rates at 79, 100 and 121 days from planting in both seasons, in favour of the high rate (7.5 g/l) of CO_2 fertilizer. Applying CO_2 fertilizer as foliar spray at the four rates had a pronounced effect in increasing boll setting percentage and 1st picking percentage and reducing boll shedding percentage in both season, especially when CO_2 fertilizer was applied at the high rate (7.5 g/l). Significant distinctions were detected amongst the four rates of CO_2 nano fertilizer (in the form of Lithovit) twice as for number of open bolls/plant, boll weight, seed cotton yield/plant and seed cotton yield/feddan in both seasons, in favor of applying CO_2 fertilizer (in the form of Lithovit) as foliar spraying at the high rate of 7.5 g/l two times at 45 and 60 days after planting followed in ranking by the medium rate (5 g/l), the low rate (2.5 g/l) and untreated plants (without Lithovit). The first order interactions gave positive effects on these traits. The results of the second order interaction between planting dates, Potasin-P levels and CO_2 fertilizer rates showed that this interaction gave significant effect on most of these traits, where the highest values of these traits produced from plants sown early on 8 April and received the high level of Potasin-P (5cm^3/l) in combination with the high rate (7.5 g/l) of CO_2 fertilizer (in the form of Lithovit). It is a divisible to sown cotton early on 8 April and applying the high rate of Potasin-P (5cm^3/l) twice at 46 and 61 days after planting in combination with the high rate (7.5 g/l) of CO_2 fertilizer (in the form of Lithovit) twice (at 45 and 60 days after planting to induce favorable plant conditions and on reduce environmental stress effect and in turn gave significant effect on cotton productivity.

Keywords: nano-fertilizer, potassium fertilizer, CO_2 fertilizer, Egyptian cotton,

Introduction

For a long time, cotton has been the major crop in Egypt. But cotton now is suffering from numerous abiotic and biotic stresses. Every effort which contribute to economic production of the crop should support cotton's position. The present study was designed to answer two specific questions:

1- First question was (is it possible to increase cotton growth and productivity under the high concentration of CO_2)?. Where, Atmospheric CO_2 has increased by 37% during the past two centuries to its present rate of 380 mmol mol^{-1}, and it is predicted that CO_2 could be in the range of 510–760 mmol mol^{-1} by the middle or later part of this century(**Singh *et al.*, 2007**). Nanotechnology opens a large scope of novel application in the fields of biotechnology and agricultural industries, because nanoparticles have unique physicochemical properties, i.e. high surface area, high reactivity, tunable pore size and particle morphology **(Siddiqui *et al.*, 2015)**. Lithovit is naturally occurring CO_2 fertilizer which will be used at four rates to answer the first question.

2- The second question was (the possibility of using potassium fertilization to reduce the environmental stress effect)?. Potassium in the form of Potasin-P will be used at three levels to answer the second question.

The aim of this research was to determine the response of cotton to potassium fertilizer (in the form of Potasin-P) supply at the three levels and CO_2nano-fertilizer (in the form of Lithovit) at the four rates with regard to cotton growth, fruiting attributes, seed cotton yield and yield components under three planting dates under the environmental conditions of El-Gharbia Governorate.

Materials and Methods

Two field experiments were conducted on a clay soil at El-Gemmeiza Agricultural Research Station, El-Gharbia Governorate, Egypt in 2014 and 2015 seasons, to study the effect of nano-fertilizer (Lithovit) rates (0, 2.5, 5 and 7.5 g/l) and foliar Potasin-P rates (2.5, 5 and 7.5 cm3/l) under three planting dates (8 April, 8 May and 8 June) on leaves chemical composition of the Egyptian cotton, cultivar Giza 86. The preceding crop was Egyptian clover (Trifoliumalexandrinum L.,) “berseem” in both seasons. Representative soil samples were taken from the experimental soil sites before sowing in both seasons and prepared for analysis to determine chemical properties according to Jackson (1973) as shown in Table (1).

Table 1: Chemical propertiesof the experimental soil sites in the two seasons.

Properties	Season		Properties	Season	
	2014	2015		2014	2015
pH	8.1	7.8	CationsMeq/l		
EC mmhos/ cm.	0.23	0.26	Ca^{++}	1.17	1.33
Organic matter %	1.59	1.29	Mg^{++}	0.7	0.84
Total N (mg/100g)	55.65	45.15	Na^{+}	3.18	3.40
Available N (ppm)	28.1	21.3	K^{+}	0.14	0.10
Available P (ppm)	11.8	10.7	Anions Meq/l		
Exchangeable K (ppm)	354	312			
Available Fe (ppm)	11.8	10.6	CO_3^{--}	-	-
Available Mn (ppm)	3.1	3.8	HCO_3^{-}	0.87	0.90
Available Zn (ppm)	1.3	1.1	Cl^{-}	2.22	2.41
Available Cu (ppm)	3.5	3.22	SO_4^{-}	2.10	2.36

The different constituents of Lithovit were illustrated in Table 2.

Table 2: Main characteristics of Lithovit® used in the study

Component (%)	Value	Component (%)	Value
Calcium carbonate	79.19	Sulphate	0.33
Nitrogen	0.06	Iron	1.31
Phosphate	0.01	Zinc	0.005
Potassium oxide	0.21	Manganese	0.014
Magnesiumcarbonate	4.62	Copper	0.002
Selisium dioxide	11.41	Clay	0.79

A strip split plot design with four replicates was used in both seasons. The horizontal plots were assigned to planting dates, the vertical plots to PotasinP rates and sub-plots to nano-fertilizer (Lithovit) rates. The plot size was 14 m^2 (4 m x 3.5 m). Each plot included 5 ridges 70 cm apart. Phosphorus fertilizer was applied during soil preparation in the form of calcium super phosphate (15.5 % P2O5) at a rate of 22.5 kg P2O5 /fed. Sowing took place on the studied dates. Seeds of Giza 86 cultivar were sown in hills 25 cm apart with two plants /hill after thinning. All plots were fertilized at a rate of 45 kg N / fed in the form of ammonium nitrate (33.5 % N) in two equal doses, the first dose was added after thinning (before the first irrigation), while the second dose was applied before the second irrigation. Potassium fertilizer (in the form of Potasin-P) was applied as foliar spray at the tested rates. Solutions of Potasin-P (30% K2O+5% P2O5) and Lithovit with the mentioned concentrations were used as foliar spray on cotton plants twice at 46 and 61; 45 and 60 days after planting, respectively. The other cultural practices were carried out as recommended for conventional cotton seeding in the local production district.

Data in Table (3) of air temperature was obtained from the Department of Meteorology, Agricultural Research Center using the data collected from each season. The data covered the period from the start of planting to picking. Average of air temperatures (°C) through the growing seasons were recorded in order to calculate heat units (HU) according to **Sutherland (2012)** equation as follows:

Degree-day Heat unit (HU) = mean daily temperature – Base Temp.

(Base Temp. = constant =zero growth =12.6°C)

where: Maximum Daily Air Temp is capped at crop's Upper Temperature Threshold. When the maximum daily air temperature is above a crop’s upper temperature threshold, the maximum daily air temperature is set to the upper temperature threshold. When the degree-day value is negative, the degree-day value is set to zero.

Table 3: Minimum, maximum and mean values of air temperature as means of ten-day intervals and the accumulated heat units through 2014 and 2015 seasons.

Intervals	2014 season				2015 season			
	Air temperature (°C) °			Total Heat units	Air temperature (°C)			Total Heat units
	Min.	Max.	Mean		Min.	Max.	Mean	
8/4-17/4	13.16	29.23	21.195	85.95	10.19	24.82	17.505	49.05
18/4-27/4	15.08	32.49	23.785	111.85	11,75	29.90	20.825	82.25
28/4-7/5	18.34	34.63	26.485	138.85	13.74	32.59	23.165	105.65
8/5-17/5	15.66	31.25	23.455	108.55	16.24	32.72	24.480	118.80
18/5-27/5	17.68	33.87	25.778	131.78	19.63	38.42	29.025	164.25
28/5-6/6	19.34	36.43	27.885	152.85	17.30	32.70	25.000	124.00
7/6-16/6	19.71	35.53	27.620	150.20	19.10	35.75	27.425	148.25
17/6-26/6	19.68	37.53	28.605	160.05	19.35	35.90	27.625	150.25
27/6-6/7	20.93	39.41	30.170	175.70	19.79	35.95	27.870	152.70
7/7-16/7	21.18	39.17	30.175	175.75	20.63	37.34	28.985	163.85
17/7-26/7	20.91	36.68	28.795	161.95	21.63	39.29	30.460	178.60
27/7-5/8	21.70	38.42	30.060	174.60	23.46	40.41	31.935	193.35
6/8-15/8	22.03	38.22	30.125	175.25	24.94	41.07	33.005	204.05
16/8-25/8	22.31	39.15	30.730	181.30	23.46	39.06	31.260	186.60
26/8-4/9	21.15	37.64	29.395	167.95	21.64	37.56	29.60	170.00
5/9-14/9	20.95	34.99	27.970	153.70	21.81	38.81	30.31	177.10
15/9-24/9	20.30	35.54	27.920	153.20	22.71	37.19	29.95	173.50
25/9-4/10	18.98	33.21	26.095	134.95	22.13	35.13	28.63	160.30
5/10-14/10	17.53	31.89	24.710	121.10	19.60	32.79	26.195	135.95
15/10-24/10	16.71	30.05	23.380	107.80	19.49	32.51	26.00	134.00

Studied characters:

A. Growth traits:

Six guarded plants randomly taken from each plot at 79, 100 and 121 days from sowing. Roots of sample plants were removed at the cotyledonary nodes, then the different plant fractions were washed and oven dried to a constant weight at70 °C and their dry weights were obtained and the following growth traits and analysis were calculated: -

A-1. Leaf area (LA), the disk method was used according to **Johnson (1967).** The cross sectional area of the punch used was 0.015386 dm^2

$$\text{LA LA/ plant} = \frac{\text{Le} \quad \text{Leaves dry weight / plant x disk area}}{\text{Di} \quad \text{Disc dry weight}} \quad (dm^2)$$

A-2. Leaf area index (LAI): It is defined as total area of land occupied by one plant. It was computed according to the following formula (**Watson, 1952**):

$$\mathbf{LAI} = \frac{\text{L} \quad \text{LA per plant}}{\text{P} \quad \text{Plant ground area}}$$

A-3. Total dry weight (g/ plant).
A-4. Plant height at harvest (cm).
A-5. Number of fruiting branches/ plant.
A-6. Boll setting percentage, calculated from the following equation according to **Richmond and Radwan (1962)**: -

$$\text{Boll setting percentage} = \frac{\text{Total number of bolls set per plant}}{\text{Total number of flowers per plant}} \times 100$$

A-7. Boll shedding percentage, calculated from the following equation according to **Richmond and Radwan (1962)**: -

Boll shedding percentage = 100 **-** boll setting %

A-8**.** First picking percentage,measured according to **Richmond and Radwan,1962:**

$$\text{As} : \frac{1^{st}\ \text{picking}}{(1^{st} + 2^{nd})\ \text{pickings}} \times 100$$

C. Seed cotton yield and its components:

At harvest, data taken from five random representative guarded hills from the second ridge of each plot to determine the following yield components:

C-1. Number of open bolls per plant: it was calculated by counting the open bolls on the above ten representative plants before the first and the second pickings.

C-2. Average boll weight in grams:it was estimated as follow:

$$\text{Average boll weight (gm)} = \frac{\text{Seed cotton yield per plant (g)} \quad \text{gm}}{\text{No. of harvested open bolls per plant} \quad \text{nt}}$$

C-3. Seed cotton yield in grams per plant was estimated from the above ten representative plants.
C-4. Seed cotton yield (kentar/fed):

Seed cotton yield from the three inner ridges of each sub- plot in kilograms was recorded and transformed to kentars per feddan (one kentar = 157.5 kg).

The statistical analysis of the obtained data in the two seasons was done and performed according to **Le Clerg *et al.* (1966)** using M State-C microcomputer program for strip split plot design, and the treatments means were compared using LSD at 0.05 rate of probability (**Waller and Duncan, 1969**).

Results and Discussion

A. Growth traits:

A.1. As affected by planting dates:

With regard to the effect of planting date on leaf area per plant and leaf area index, the data in Tables 4 and 5 show that at the first sampling date, the greatest values of leaf area per plant and leaf area index were obtained from the third planting date in both seasons. At the second sampling date in the second season, the highest values of leaf area per plant and leaf area index were obtained from the first planting date. At the third sampling date, the highest values of leaf area per plant and leaf area index were obtained from the second planting date in the first season and from the first planting date in the second season. The increase in leaf area per plant produced by delaying planting date may be resulted from the increase in both leaf number and size. In this concern**, El – Ashmouny (2014)** found that planting cotton at 15 April had significant increase on leaf area / plant compared to other planting dates (30 April or 15 May).

Abdel – Al *et al.* (2015) found that early sowing (15 April) significantly increased dry weight of leaves / plant.

Total dry weight per plant significantly responded to planting dates at the three sampling dates in both seasons (Table 10). At the first sampling date, the third planting date (8 June) resulted in the highest values of total dry weight/plant in both seasons. The increase in the dry weight per plant at 79 days from planting in both seasons due to the third planting date may be due to:

1-Temperature, where cotton plant needs relatively high temperature in the first stages of growth which devoted mainly to vegetative growth.
2-Plants of late planting on 8 May or 8 June received the highest heat units as compared with plants of early planting on 8 April (Table 3).

The increase in the dry weight per plant at 121 days from planting due to the second date in both seasons may be due to :

1-Plants of late planting on 8 May received the highest heat units as compared with plants of early planting on 8 April (Table 3).
2-The delay in sowing from April to June reduced the heat use efficiency and resulted less dry matter accumulation.

In this regard, **El-Ashmouny (2014)** found that planting cotton at 15 April had significant increase on total dry weight / plant compared to other planting dates (30 April or 15 May).

Table 12 shows that plant height reached its maximum for the third planting date (8 June) followed by the second date (8 May) and the least resulted from early planting in the first date (8 April), while number of fruiting branches/plant reached its maximum for the first planting date (8 April) followed by the second planting date (8 May) and the least resulted from late planting (8 June).The significant increase in plant height at harvest due to late plantingcould be attributed to (1) the increase of internode length, (2) late planting resulted in rapid vegetative growth compared with early planting which exposed relatively to low air temperature.

A.2. As affected by Potasin-P rates:

Data in Tables 4 and 5 indicated that foliar spray of Potasin-P gave a significant effect on leaf area/plant and leaf area index at the three sampling dates in both seasons. Foliar spray of Potasin-P at the rate of 5 cm^3/l twice at 45 and 60 days after planting resulted in the highest leaf area/plant and leaf area index at the three sampling dates in the first season. In the second season, foliar spray of Potasin-P at the rate of 7.5 cm^3/l resulted in the highest leaf area/plant and leaf area index at the three sampling dates. The positive effect of foliar spraying of Potasin-P twice at the medium rate (5 cm^3/l) in the first season and at the high rate (7.5 cm^3/l) in the second season may be due to that the PK content in Potasin-P increased leaf area/plant. In this concern, **Reddy and Zhao (2005)** found that leaf area did not differ among K treatments at 30 days after emergence, but the differences in leaf area could be clearly observed with the development of K deficiencies. The plants grown in 40, 20, 5 and 0% K treatments had 12, 16, 36 and 43% smaller leaf area, respectively, compared with the control plants of full K supply. Total biomass did not differ among K treatments at 30 DAE, but was significantly affected by K treatments at 85 DAE.

Significant differences were obtained in total dry weight/plant due to the three rates of Potasin-P at the three sampling dates in both season (Table 10). Foliar spray of Potasin-P at the rate of 5 cm^3/l resulted in the highest total dry weight/plant at the three sampling dates in the first season. In the second season, the superiority was found in favor of high rate (7.5 cm^3/l) of Potasin-P at the three sampling dates. The significant increase in dry matter accumulation due foliar spray of Potasin-P twice using the medium rate (5 cm^3/l) in the first season and the high rate (7.5 cm^3/l) in the second season is mainly due to :-

The positive effect in increasing leaf area and leaf area index as shown in Tables 4 and 5 reflects on significant increase in total dry weight/plant due to the production of assimilates by the leaves (source) due to sufficient leaf area of this rate and consequently the total dry weight/plant.

The decreases in photosynthesis by K deficiency become more distinct when plants are exposed to elevated atmospheric concentrations of CO_2 and O_3 (**Barnes *et al.*, 1995**), indicating an enhanced K requirement of plants growing under CO_2-enriched atmosphere.

Data in Table12 indicated that,increasing Potasin-P rate from 2.5 g/l to 5.0g/l or 7.5 g/1 significantly increased plant height at harvest and number of fruiting branches/plant in both seasonsowing to the increase in number of fruiting branches/plant which reflected the increase in number of main stem internodes/plant. This result is in line with that of **Emara (2012).**

B.3. As affected by CO_2nanofertilizer rates (in the form of Lithovit):

Leaf area/plant and leaf area index significantly responded to the tested rates at 79, 100 and 121 days from planting in both seasons(Tables 4 and 5), in favour of the high rate (7.5 g/l) of CO_2 fertilizer. This result is mainly due to that the high rate is considered as a proper rate for good growth and thereby pushed cotton plants to have a profitable growth expressed as greater leaf area/plant during the three sampling dates. Also, the role of Lithovit at this rate in promoting photosynthesis and assimilates accumulation and consequently more increase in leaves number and weight. Lithovit at high rate had higher N content in leaf which is essential for building up protoplasm and protein as well as induce cell division, which resulted in an increase in cell number and cell size with an overall increase in leaf area. **Reddy and Zhao (2005)** found that plants grown in elevated [CO_2] had significantly greater leaf area than plants in ambient [CO_2] at 30 and 85 days after emergence.

The total dry weight/plant increase due to the high rate of Lithovit (7.5 g/l) was mainly attributed to :

The positive effect in increasing leaf area and leaf area index as shown in Tables 4 and 5 reflects on significant increase in total dry weight/plant due to the production of assimilates by the leaves (source) due to sufficient leaf area of this rate and consequently the total dry weight/plant.

Lithovit fed cotton plant leaves with CO_2 gas from inside the leaves at a much higher rate than in the air, thus enhancing the basic process of photosynthesis and plant growth.

The major source of plant nutrition is the fixation of atmospheric CO_2 into simple sugar using the energy of the sun. CO_2 enters through the stomata. O_2 is a product of photosynthesis and atmospheric component that also moves through the stomata. It is used in cellular respiration to release energy from the chemical bonds in the sugar to support growth and maintenance in the plant. However, CO_2 and light energy are not sufficient for the synthesis of all the molecules a plant needs. In this regard, **Kimball and Mauney (1993)** found that cotton grown under 550 µL CO_2 L^{-1} had a 35% higher biomass than plants grown under 350 µL CO_2 L^{-1} under free - air CO_2 enrichment conditions. **Prior *et al.* (1994)** observed that increasing CO_2 increased root length and dry weight densities of cotton. Cotton is the most important candidate for such a response.

Lithovit fed cotton plant leaves with CO_2 gas from inside the leaves at a much higher rate than in the air, thus enhancing the basic process of photosynthesis and plant growth.

The high leaf nitrogen, phosphorus and potassium concentration due to this rate of CO_2 fertilizer reflects on enhancing the basic process of photosynthesis and plant growth, where N as a constituent of all amino acids and proteins (and thus all enzymes), nitrogen serves a central role in cellular metabolism. Additionally, as a component of nucleotides and nucleic acids (deoxyribonucleic acid (DNA) and ribonucleic acid (RNA)), nitrogen is critical for the transcription, translation and replication of genetic information. Normal plant growth cannot be achieved without P. It is a constituent of nucleus acids, phospholipids, the coenzymes DNA and NADP, and most importantly ATP. It activates coenzymes for amino acid production used in protein synthesis; it decomposes carbohydrates produced in photosynthesis, glycolysis, respiration, and fatty acid synthesis. It enhances early growth, stimulates blooming, enhances bud set, aids in seed formation, hastens maturity (**Tucker, 1999**).It has a significant role in energy transfer via the pyrophosphate bond in ATP, and the attachment of phosphate groups to many different sugars provides metabolic energy in photosynthesis and respiration. Unlike N and P, K does not form any vital organic compounds in the plant. However, the presence of K is vital for plant growth because K is an enzyme activator that promotes metabolism. The role of K in photosynthesis is complex. The activation of Enzymes by K and its involvement in adenosine triphosphate (ATP) production is probably more important in regulating the rate of photosynthesis than is the rate of K in stomatal activity. When the sun's energy is used to combine CO_2 and water to form sugars, the initial high – energy product is ATP. The ATP is then used as the energy source for many other chemical reactions. The electrical charge balance at the site of ATP production is maintained with K ions. When plants are K deficient, the rate of photosynthesis and rate of ATP production are reduced and all of the processes dependent on ATP are showed down. Conversely, plant respiration increases which also contributes to slower growth and development (**Dibb, 1998**).

In addition, each nutrient of the micro and macro-nutrients constituents of Lithovit each nutrient assists with different plant functions that allow the plants to grow and reproduce as follow:-

Chlorine (chloride) takes part in the capture and storage of light energy through its involvement in photophosphorylation reactions in photosynthesis. It is not present in the plant as a true metabolite but as a mobile anion. Chloride takes part in osmotic processes, cofactor of light reactions of photosynthesis. Chloride is required for the water-splitting protein complex of photosystem II, it stimulates the activity of the vacuolar proton-pumping ATPase, and it can function in osmoregulation, especially in stomatal guard cells

Mn functions as an activator of an enzyme that is involved in the evolution of oxygen in photosynthesis. It is a component of several enzyme systems. It also functions as part of oxidation-reduction reactions and electron transport systems. It is a structural component of certain metalloproteins. Only one system, albeit a very important one, require Mn. This is the splitting of water by photolysis in photosystem II.

Ironis involved in N fixation, photosynthesis, electron transfer, respiratory enzyme systems as a part of cytochrome and in other enzyme systems.

Zinc is a metal component of several enzyme systems that function as electron transfer mechanisms and in protein synthesis and degradation. Zinc is necessary for chlorophyll synthesis and carbohydrate formation.

Calcium (Ca) is a constituent of cell wall and is involved in production of new growing points and root tips. It provides elasticity and expansion of cell walls, which keeps growing points from becoming rigid and brittle. It acts as a base for neutralizing organic acids generated during the growing process and aids in carbohydrate translocation and nitrogen absorption. It might be considered the bricks in plants assembly, without which cell manufacture and development would not occur (**Tucker, 1999**).

Magnesium (Mg) is a constituent of the chlorophyll molecule, which is the driving force of photosynthesis. It is also essential for metabolism of carbohydrate (sugars). It is an enzyme activator in the synthesis of nucleic acids (DNA and RNA). It regulates uptake of the other essential elements, serves as carrier of phosphate compounds through the plant, facilitates the translocation of carbohydrates (sugars and starches) and enhances the production of oils and fats (**Tucker, 1999**).

Sulfur (S) is an essential component in the synthesis of amino acids required to manufacture proteins. Sulfur is required for production of chlorophyll and utilization of phosphorus and other essential nutrients. Crops that have high nitrogen requirements must have adequate sulfur to optimize nitrogen utilization (**Tucker, 1999**).

Copper major functions are in photosynthesis, reproductive development. It increases sugar content. Water is the medium by which Cu^{+2} penetrates the leaf surface, so applications made later in the day, when free water will persist for several hours, are more effective. Lithovit readily dissolves to release Cu^{+2} ion, the most plant available form of Cu and this will correct any Cu deficiency. Because Cu is essential for chloroplast functions, deficiency normally promotes chlorosis in young growth. Consequently, Cu deficiency is most likely to be observed in high pH soils (**Hull, 2002**). Since Cu is required for the photosynthesis generation of reducing power necessary for CO_2 fixation, an inadequate Cu supply will reduce carbohydrate rate and vegetative growth rates. Photosynthesis involves the reduction of carbon dioxide (CO_2) while respiration is the oxidation of carbohydrates back to CO_2, Cu is an essential participant in this process.

Increasing Lithavit rates from zero(untreated) to 7.5 g/1 significantly increased plant height at harvest and number of fruiting branches/plant in both seasons (Table 12)owing to the increase in number of fruiting branches/plant which reflected the increase in number of main stem internodes/plant. In this regard, **Reddy and Zhao (2005)** found that plants grown under 720 $\mu L\ CO_2\ L^{-1}$ were slightly taller than those grown under 360 $\mu L\ CO_2\ L^{-1}$. Plants grown in elevated [CO_2] had significantly greater leaf area than plants in ambient [CO_2] at 30 and 85 days after emergence.

A.4. As affected by the second order interaction:

Concerning the second order interaction of planting date x Potasin-P rate x CO_2 fertilizer rate, it had a significant effect on leaf area and leaf area index at 79 and 121 days after planting only in the second season (Tables 7, 8, 9 and 10). Delaying planting date to 8 June when combined with the high rate of both

Potasin-P and CO_2 fertilizer application gave the highest values at 79 days from planting in the second season. The highest values at 121 days from planting in the second season resulted from plants at the first planting date which received the high rate of both Potasin-P and CO_2 fertilizer application. Significant effect was found on total dry weight/plant at 121 days after planting only in the first season(Tables 10 and 11), where plants at the first planting date which received the medium rate of Potasin-P and the high rate of CO_2 fertilizer application gave the highest value. This interaction had a significant effect on plant height and number of fruiting branches/plant in both seasons(Tables 12, 13, 14 and 15), where the taller plants were obtained from plants sown late on 8 Jaune and received the high rate of both Potasin-P and CO_2 fertilizer. Number of fruiting branches/plant reached its maximum from plants sown on early on 8 April and received the high rate of both Potasin-P and CO_2 fertilizer.

B. Earliness traits:

B.1. As affected by planting dates:

Planting dates had a pronounced effect on boll setting percentage, boll shedding percentage and 1st picking percentage over the two seasons of study (Table 15). Early planting date on 8 April significantly increased boll setting percentage and 1st picking percentage and significantly dccreased shedding percentage as compared with the medium planting date on 8 May and the late planting date on 8 June in both seasons.**Wright *et al.* (2015)** reported that there are several reasons to set a crop of cotton as quickly as possible and avoid relying on a late or top crop. These reasons include the following:

- A cotton plant has a greater number of blooms during the initial weeks of flowering than later in the fruiting period.
- A cotton plant sets a higher percent of blooms during the first weeks of flowering. When taken together, these two factors result in a potential of 88% of the crop being made in the first three weeks of flowering.
- Bolls set during the first 3 weeks of fruiting usually are the largest and contain the highest quality fiber. Late set bolls are frequently smaller and many contain finer and less mature fiber.
- A delay in setting fruit encourages plants to grow taller. This may lead to lodging and makes pest control more difficult.
- Pest populations tend to increase as the seasons progresses. Protecting squares and young bolls late in the growing seasons is more difficult (and expensive) than protecting an early crop.
- Later cotton requires more irrigation water and pesticides to protect against various insects.

Also, **Wright *et al.* (2015)** reported that cotton sheds fruit for a variety of reasons. Some of the more important causes for abscission that have been identified are: -

* Reduced photosynthate supply: Photosynthates are sugars produced through photosynthesis and used in plant growth (leaves, squares, bolls, etc.) the amount of sugars in a plant may be reduced or if the demand for the sugars increases. The demand increases with the presense of immature bolls, rank plant growth, and high day and night temperatures.

* Light: sunlight is required by cotton plant to produced photosynthate. Full sunlight is required for maximum photosynthesis. Furthermore, the higher temperatures of the summer increase the need for sugars, which increase the amount of shed. Even with full sunlight, rank growth cotton may experience considerable self – induced fruit shed. This is because in this type of cotton, once fruit gets to the bloom or small boll stage, the leaves feeding sugar to these fruit (the leaf at the base of the fruit or one adjacent to it) are already shaded by new foliage growth at a higher rate in the canopy. Less of these fruit causes the cotton to put more sugars into leaves, stems, nods, etc., thus perpetuating the problem.

In addition, excessive temperatures (42 – 44^oC) day temperature and 28- 31^oC night temperatures) cause heavy shedding of young flower buds and bolls (**Makhdum *et al*., 2002**).Similar results were obtained by other researchers included **El -Ashmouny (2014).**

The significant increase in 1st picking percentage due to early planting was expected, since early planting plants gave their first flower as well as open boll on earlier date than those of middle or late planting dates. In addition, early planting reduced shedding percentage and lowered first fruiting branch node (Table 67). Similar results were obtained by other researchers included **El -Ashmouny (2014).**

B.2. As affected by Potasin-P rates:

The high rate (7.5 cm^3/l) of Potasin-P significantly increased boll setting percentage and 1st picking percentage and significantly decreased boll shedding percentage as compared with the other rates in both seasons (Table 15).

B.3. As affected by CO_2 fertilizer rates (in the form of Lithovit):

Applying CO_2 fertilizer as foliar spray at the four rates had a pronounced effect in increasing boll setting percentage and 1st picking percentage and reducing boll shedding percentage in both season (Table 15), especially when CO_2 fertilizer was applied at the high rate (7.5 g/l).The positive effect of foliar spray of CO_2 fertilizer at the high rate two times was mainly refers to reduced shedding percentage due to this rate. The ability of cotton to set bolls over a long time period makes it highly responsive to increases in CO_2. (**Hake *et al.*, 1991**).The favorable effect of the high rate in reducing boll shedding percentage is mainly due to: -

* the micronutrients in Lithoit increased photosynthate supply: Photosynthates are sugars produced through photosynthesis and used in plant growth (leaves, squares, bolls, etc.) and consequently gave adequate demand for the new bolls.
* the significant increase in number of fruiting branches/plant (Table 12).

B.4. As affected by thesecond order interaction:

This interaction gave significant effect on first picking % percentage in both seasonsand boll setting percentage and boll shedding percentage in the second season only (Table 15, 16, 17 and 18), in favor of plants sown early on 8 April and received the high rate of both Potasin-P and CO_2 fertilizer.

C. Seed cotton yield/fed and its components: -

C.1. As affected by planting dates:

Time of planting exhibited significant differences in boll weight, number of bolls/plant, seed cotton yield / plant and seed cotton yield per feddan in both seasons (Table 19), where the heaviest bolls resulted from the first planting date. Delaying planting date significantly reduced number of bolls/plant and seed cotton yield / plant. Also, delaying planting date decreased seriously the seed cotton yield per feddan in both seasons. The significant increase in number of open bolls per plant from the early planting date is mainly attributed to the higher temperature which early planting plants exposed when their bolls were maturing. The positive effect of the high rate of Potasin-P as for yield/plant is mainly refers to:

1-The significant increase in number of open bolls/plant
2-The heavier bolls.

The significant increase in seed cotton yield per feddan of early planting as compared with late planting dates is mainly due to the following reasons: -
1)- the significant increase in plant growth attributes i.e. leaf area, leaf area index and total dry weight (Tables 4, 5 and 10).

3)-early planting produced highest number of open bolls and seed cotton yield per plant.

In addition to this, **Wright *et al*. (2015)** reported that there are several reasons to set a crop of cotton as quickly as possible and avoid relying on a late or top crop. These reasons include the following:

- A cotton plant has a greater number of blooms during the initial weeks of flowering than later in the fruiting period.
- A cotton plant sets a higher percent of blooms during the first weeks of flowering. When taken together, these two factors result in a potential of 88% of the crop being made in the first three weeks of flowering.
- Bolls set during the first 3 weeks of fruiting usually are the largest and contain the highest quality fiber. Late set bolls are frequently smaller and many contain finer and less mature fiber.
- A delay in setting fruit encourages plants to grow taller. This may lead to lodging and makes pest control more difficult.
- Pest populations tend to increase as the seasons progresses. Protecting squares and young bolls late in the growing seasons is more difficult (and expensive) than protecting an early crop.
- Later cotton requires more irrigation water and pesticides to protect against various insects.

C.2. As affected by Potasin-P rates:

Seed cotton yield/fed was significantly affected by Potasin-P rates in both seasons (Table 19), where applying Potasin-P at the high rate (7.5 cm^3/l) out-yielded significantly the medium rate (5 cm^3/l) and the low rate (2.5 cm^3/l).

Number of open bolls/plant and boll weight were significantly affected by Potasin-P rates in both seasons ((Table 19), where applying Potasin-P as foliar spraying twice at the high rate (7.5 cm^3/l) produced the highest number of open bolls /plant and the heaviest bolls.

C.3. As affected by CO_2 fertilizer rates (in the form of Lithovit):

Significant distinctions were detected amongst the four rates of CO_2nano fertilizer (in the form of Lithovit) twice as for number of open bolls/plant, boll weight, seed cotton yield/plant and seed cotton yield/feddan in both seasons(Table 19), in favor of applying CO_2 fertilizer (in the form of Lithovit) as foliar spraying at the high rate of 7.5 g/l two times at 45 and 60 days after planting followed in ranking by the medium rate (5 g/l), the low rate (2.5 g/l) and untreated plants (without Lithovit).The positive effect due to applying CO_2 fertilizer (in the form of Lithovit) as foliar spraying twice at 45 and 60 days after planting especially at the high rate 7.5 g/l was mainly refers to its positive effect on earliness attributes. The positive effect of early planting for yield/plant is mainly refers to:

1) The significant increase in number of open bolls/plant
2) The heavier bolls.

Similar results were obtained by other researchers included **El -Shazly and El-Masri (2003).**

C.4. As affected by thesecond order interaction:

Planting date x Potasin-P rate x CO_2 fertilizer rate interaction had significant effect on boll weight, seed cotton yield/plant and seed cotton yield/fed, in both seasons (Table 19, 20, 21 and 22), where the heaviest bolls and yield were obtained from plants which sown early on 8 April and received the high rate of both Potasin-P and CO_2 fertilizer (7.5g/l).

Table 4: Effect of planting date, Potasin-P rate and Lithovit rate as well as their interactions on leaf area (dm^2/plant) at 79, 100 and 121 days old in 2014 and 2015 seasons.

Treatments	Leaf area (dm^2/plant) at					
	79 days old		100 days old		121 days old	
	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season
A-planting date						
8 April	26.59	28.87	33.10	36.25	37.74	40.20
8 May	28.19	30.46	33.58	34.30	39.50	37.41
8 June	30.46	32.53	33.69	34.25	35.99	36.56
LSD 0.05	**0.82**	**0.41**	**NS**	**0.47**	**0.53**	**0.40**
B-Potasin-P rate						
2.5 cm^3 /l	27.45	29.28	32.81	33.16	36.96	36.58
5.0 cm^3 /l	29.27	31.05	34.17	35.69	38.47	38.70
7.5 cm^3 /l	28.52	31.54	33.39	35.94	37.80	38.88
LSD 0.05	**0.45**	**0.61**	**0.63**	**0.26**	**0.56**	**0.57**
C-Lithovit rate						
without	25.63	27.95	29.26	30.79	33.22	33.03
2.5 g/l	26.48	28.91	31.90	33.43	36.25	36.45
5.0 g/l	27.98	30.13	33.99	35.26	38.31	38.77
7.5 g/l	33.56	35.49	38.68	40.25	43.19	43.97
LSD 0.05	**0.54**	**0.55**	**0.64**	**0.46**	**0.54**	**0.42**
Interactions						
A x B	NS	NS	NS	NS	NS	NS
A X C	**	NS	**	**	**	**
B X C	**	**	NS	**	*	**
A X B X C	NS	*	NS	NS	NS	**

Table 5: Effect of planting date, Potasin-P rate and Lithovit rate as well as their interactions on leaf area index at 79, 100 and 121 days old in 2014 and 2015 seasons.

Treatments	Leaf area index at					
	79 days old		100 days old		121 days old	
	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season
A-planting date						
8 April	3.04	3.30	3.78	4.14	4.31	4.59
8 May	3.22	3.48	3.84	3.92	4.51	4.28
8 June	3.48	3.72	3.85	3.92	4.11	4.19
LSD 0.05	**0.09**	**0.05**	**NS**	**0.05**	**0.06**	**0.05**
B-Potasin-P rate						
2.5 cm^3 /l	3.14	3.35	3.75	3.79	4.22	4.18
5.0 cm^3 /l	3.35	3.55	3.91	4.08	4.40	4.42
7.5 cm^3 /l	3.26	3.60	3.82	4.11	4.32	4.44
LSD 0.05	**0.05**	**0.07**	**0.07**	**0.03**	**0.06**	**0.07**
C-Lithovit rate						
without	2.93	3.19	3.35	3.52	3.80	3.77
2.5 g/l	3.03	3.30	3.65	3.82	4.14	4.17
5.0 g/l	3.20	3.44	3.89	4.03	4.38	4.43
7.5 g/l	3.84	4.06	4.42	4.60	4.94	5.03
LSD 0.05	**0.06**	**0.06**	**0.07**	**0.05**	**0.06**	**0.05**
Interactions						
A x B	NS	NS	NS	NS	NS	NS
A X C	**	NS	**	**	**	**
B X C	**	**	NS	**	*	**
A X B X C	NS	*	NS	NS	NS	**

Table 6: Means of leaf area (dm^2 /plant) at 79 and 121 days old as affected by the secondorder interaction, planting date (a) xPotasin-P rate (b) x Lithovit rate (c) in 2015 season.

Treatments		Leaf area (dm^2 /plant) at 79 days old			
		2015 season			
		Lithovit (g/l)			
Planting date	**Potasin-P (cm^3/l)**	**0.0**	**2.5**	**5.0**	**7.5**
8 April	**2.5**	25.96	26.06	26.83	30.52
	5.0	26.66	27.30	29.35	34.44
	7.5	26.88	27.81	29.90	34.78
8 May	**2.5**	27.88	28.80	28.24	33.38
	5.0	27.72	28.48	30.90	36.08
	7.5	27.99	28.86	30.47	36.70
8 June	**2.5**	29.31	30.12	31.00	33.23
	5.0	29.48	31.40	32.25	38.51
	7.5	29.67	31.37	32.27	41.75
LSD 0.05		**1.65**			

Table 7: Means of leaf area (dm^2 /plant) at 121 days old as affected by the second order interaction, planting date (a) x Potasin-P rate (b) x Lithovit rate (c) in 2015 season.

Treatments		Leaf area (dm^2 /plant) at 121 days old 2015 season Lithovit (g/l)			
Planting date(A)	**Potasin-P rate(B)**	**0.0**	**2.5**	**5.0**	**7.5**
8 April	**2.5**	32.75	34.90	39.90	47.74
	5.0	33.79	37.84	43.01	48.68
	7.5	33.00	38.08	43.45	49.26
8 May	**2.5**	33.11	35.70	35.19	41.79
	5.0	33.54	37.00	38.07	42.56
	7.5	33.95	36.80	38.30	42.88
8 June	**2.5**	31.69	34.37	34.46	37.35
	5.0	32.86	36.54	37.95	42.62
	7.5	**32.61**	**36.82**	**38.60**	**42.84**
LSD 0.05		**1.27**			

Table 8: Means of leaf area index at 79 days old as affected by the second order interaction,planting date (a) x Potasin-P rate (b) x Lithovit rate (c) in 2015 seasons.

Treatments		Leaf area index at 79 days old 2015 season Lithovit rate (g/l)			
Planting date	**Potasin-P (cm^3/l)**	**0.0**	**2.5**	**5.0**	**7.5**
8 April	**2.5**	2.97	2.98	3.07	3.49
	5.0	3.05	3.12	3.36	3.94
	7.5	3.07	3.18	3.42	3.97
8 May	**2.5**	3.19	3.29	3.23	3.82
	5.0	3.17	3.26	3.53	4.13
	7.5	3.20	3.30	3.48	4.19
8 June	**2.5**	3.35	3.44	3.54	3.80
	5.0	3.37	3.59	3.69	4.40
	7.5	3.39	3.58	3.69	4.77
LSD 0.05		**0.19**			

Table 9: Means of leaf area index at 121 days old as affected by the second orderinteraction, planting date (a) x Potasin-P rate (b) x Lithovit rate (c) in 2015 season.

Treatments		Leaf area index at 121 days old 2015 season Lithovit rate (g/l)			
Planting date	Potasin-P (cm^3/l)	0.0	2.5	5.0	7.5
8 April	2.5	3.74	3.99	4.56	5.46
	5.0	3.86	4.32	4.92	5.56
	7.5	3.77	4.35	4.97	5.63
8 May	2.5	3.79	4.08	4.03	4.78
	5.0	3.83	4.23	4.35	4.87
	7.5	3.88	4.21	4.38	4.90
8 June	2.5	3.62	3.93	3.94	4.27
	5.0	3.75	4.18	4.34	4.87
	7.5	3.73	4.21	4.41	4.90
LSD 0.05		0.15			

Table 10: Effect of planting date, Potasin-P rate and Lithovit rate as well as their interactions on total dry weight (g/plant) at 79, 100 and 121 days old in 2014 and 2015 seasons.

Treatments	Total dry weight (g/plant) at					
	79 days old		100 days old		121 days old	
	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season
A-planting date						
8 April	44.76	43.92	93.94	78.23	169.87	145.18
8 May	77.18	73.83	129.56	120.30	194.29	184.53
8 June	80.32	77.83	128.26	122.63	165.09	157.19
LSD 0.05	**1.46**	**0.85**	**1.51**	**0.99**	**1.64**	**1.54**
B-Potasin-P rate						
2.5 cm^3 /l	64.64	62.04	113.15	102.36	171.50	157.30
5.0 cm^3 /l	69.79	66.56	121.06	108.71	181.04	164.37
7.5 cm^3 /l	67.82	66.98	117.55	110.09	176.71	165.22
LSD 0.05	**1.20**	**1.11**	**1.88**	**1.28**	**1.74**	**1.19**
C-Lithovit rate						
without	52.07	51.64	91.35	85.31	141.50	132.89
2.5 g/l	60.66	59.48	106.48	98.86	164.54	151.08
5.0 g/l	70.82	68.24	123.29	110.71	184.90	167.41
7.5 g/l	86.13	81.36	147.88	133.32	214.74	197.82
LSD 0.05	**1.10**	**0.77**	**1.06**	**1.27**	**1.35**	**1.37**
Interactions						
A x B	NS	*	NS	NS	NS	NS
A X C	**	**	**	**	**	**
B X C	**	**	**	**	**	**
A X B X C	NS	NS	NS	NS	*	NS

Table 11: Means of total dry weight (g/plant) at 121days old as affected by the second order interaction, planting date (a) x Potasin-P rate (b) x Lithovit rate (c) in 2014 season.

Treatments		Total dry weight (g/plant) at 121 days old			
		2014 season			
		Lithovit rate (g/l)			
Planting date	Potasin-P (cm^3/l)	0.0	2.5	5.0	7.5
8 April	2.5	130.20	153.13	175.33	201.79
	5.0	132.87	162.50	185.67	214.73
	7.5	129.82	159.06	180.70	212.62
8 May	2.5	158.59	181.02	197.16	222.73
	5.0	162.92	185.54	203.11	239.78
	7.5	154.24	185.32	202.75	238.40
8 June	2.5	135.22	146.66	165.89	190.26
	5.0	137.89	155.35	179.58	212.59
	7.5	131.78	152.26	173.88	199.73
LSD 0.05		4.06			

Table 12: Effect of planting date, Potasin-P rate and Lithovit rate as well as their interactions on plant height at harvest(cm) and number of fruiting branches per plant in 2014 and2015 seasons.

Treatments	Plant height at harvest (cm)		Number of fruiting branches/plant	
	2014 season	2015 season	2014 season	2015 season
A-planting date				
8 April	159.54	159.29	14.91	14.79
8 May	157.25	156.50	14.62	14.71
8 June	169.06	164.10	13.41	13.36
LSD 0.05	**0.58**	**0.51**	**0.23**	**0.06**
B-Potasin-P rate				
2.5 cm^3 /l	160.08	158.67	13.88	13.84
5.0 cm^3 /l	163.71	160.79	14.58	14.44
7.5 cm^3 /l	162.06	160.44	14.48	14.59
LSD 0.05	**0.52**	**0.78**	**0.19**	**0.11**
C-Lithovit rate				
without	152.03	151.33	13.24	13.29
2.5 g/l	157.56	157.11	14.04	14.09
5.0 g/l	165.33	163.89	14.55	14.51
7.5 g/l	172.89	167.53	15.43	15.25
LSD 0.05	**0.49**	**0.52**	**0.19**	**0.07**
Interactions				
A x B	**	**	*	*
A X C	**	**	**	**
B X C	**	**	*	**
A X B X C	**	**	NS	**

Table 13: Means of plant height at harvest(cm) as affected by the second order interaction, plantingdate (a) x Potasin-P rate (b) x Lithovit rate (c) in 2014 and 2015 seasons.

Treatments		Plant height at harvest (cm)							
		2014 season				2015 season			
		Lithovit (g/l)				Lithovit (g/l)			
Planting date	**Potasin-P (cm^3/l)**	**0.0**	**2.5**	**5.0**	**7.5**	**0.0**	**2.5**	**5.0**	**7.5**
8 April	**2.5**	152.50	156.50	160.00	165.00	153.00	157.00	160.25	163.00
	5.0	155.00	158.75	163.50	171.00	154.00	159.50	161.50	167.00
	7.5	148.75	156.00	160.75	166.75	150.25	157.00	161.25	167.75
8 May	**2.5**	149.75	153.25	157.25	163.25	148.75	154.00	158.75	160.75
	5.0	152.25	155.75	160.00	167.50	151.00	156.25	159.50	163.00
	7.5	149.50	154.75	158.25	165.50	150.00	153.25	158.25	164.50
8 June	**2.5**	153.50	157.00	171.50	181.50	152.00	156.00	169.25	171.25
	5.0	153.75	162.25	177.25	187.50	151.50	159.50	172.25	174.50
	7.5	153.25	163.75	179.50	188.00	151.50	161.50	174.00	176.00
LSD 0.05		**1.46**				**1.56**			

Table 14: Means of number of fruiting branches/plant as affected by the second order interaction, planting date (a) x Potasin-P rate (b) x Lithovitrate (c) in 2015 season.

Treatments		Number of fruiting branches/plant			
		2015 season			
		Lithovit (g/l)			
Planting date	**Potasin-P (cm^3/l)**	**0.0**	**2.5**	**5.0**	**7.5**
8 April	**2.5**	13.88	14.28	14.33	14.73
	5.0	13.90	14.83	15.03	15.98
	7.5	14.03	15.08	15.25	16.15
8 May	**2.5**	13.83	14.18	14.18	14.73
	5.0	13.95	14.73	14.98	15.93
	7.5	14.00	14.98	15.08	16.03
8 June	**2.5**	11.95	12.25	13.73	14.00
	5.0	11.98	13.25	13.95	14.75
	7.5	12.08	13.30	14.13	14.98
LSD 0.05		**0.22**			

Table 15: Effect of planting date, Potasin-P rate and Lithovit rate as well as their interactions on boll shedding percentage, boll setting percentage and first picking percentage in 2014 and 2015 seasons.

Treatments	Boll shedding (%)		Boll setting (%)		First picking (%)	
	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season
A-planting date						
8 April	30.56	31.51	69.44	68.49	71.12	72.74
8 May	35.08	34.06	64.92	65.94	46.83	49.77
8 June	36.98	34.67	63.02	65.33	6.00	7.74
LSD 0.05	**0.61**	**0.87**	**0.61**	**0.87**	**0.53**	**0.83**
B-Potasin-P rate						
2.5 cm^3 /l	35.77	34.80	64.23	65.20	39.24	40.25
5.0 cm^3 /l	33.93	33.12	66.07	66.88	41.30	44.05
7.5 cm^3 /l	32.91	32.32	67.09	67.68	43.42	45.95
LSD 0.05	**0.54**	**0.97**	**0.54**	**0.97**	**0.38**	**0.49**
C-Lithovit rate						
without	38.14	37.21	61.86	62.79	36.24	39.49
2.5 g/l	33.80	34.26	66.20	65.74	39.14	42.07
5.0 g/l	32.94	31.86	67.06	68.14	42.89	44.51
7.5 g/l	31.95	30.32	68.05	69.68	47.01	47.59
LSD 0.05	**1.05**	**0.76**	**1.05**	**0.76**	**0.42**	**0.39**
Interactions						
A x B	NS	*	NS	*	NS	**
A X C	NS	*	NS	*	**	**
B X C	NS	NS	NS	NS	**	**
A X B X C	NS	**	NS	**	**	**

Table 16: Means of boll setting percentage as affected by the second order interaction, planting date (a) x Potasin-P rate (b) x Lithovit rate (c) in2015 season.

Treatments		Boll setting percentage 2015 season Lithovit (g/l)			
Planting date	**Potasin-P (cm^3/l)**	**0.0**	**2.5**	**5.0**	**7.5**
8 April	**2.5**	63.20	66.49	69.49	70.14
	5.0	64.81	68.01	70.44	70.89
	7.5	65.43	68.98	71.13	72.86
8 May	**2.5**	60.81	64.62	67.46	67.90
	5.0	60.97	65.37	68.21	69.37
	7.5	62.16	65.89	68.94	69.64
8 June	**2.5**	62.09	62.98	62.23	65.02
	5.0	62.71	64.28	67.01	70.55
	7.5	62.97	65.05	68.36	70.73
LSD 0.05		**0.95**			

Table 17: Means of boll shedding percentage as affected by the second order interaction, planting date (a) x Potasin-P rate (b) x Lithovit rate (c) in 2015 season.

Treatments		Boll shedding percentage			
		2015 season			
		Lithovit (g/l)			
Planting date	Potasin-P (cm^3/l)	0.0	2.5	5.0	7.5
8 April	2.5	36.80	33.51	30.51	29.86
	5.0	35.20	31.99	29.56	29.11
	7.5	34.57	31.02	28.88	27.14
8 May	2.5	39.19	35.39	32.54	32.10
	5.0	39.04	34.63	31.79	30.63
	7.5	37.84	34.11	31.06	30.37
8 June	2.5	37.91	37.02	37.77	34.98
	5.0	37.29	35.72	32.99	29.45
	7.5	37.03	34.95	31.64	29.27
LSD 0.05		0.95			

Table 18: Means of first picking percentage as affected by the second order interaction, planting date (a) x Potasin-P rate (b) x Lithovit rate (c) in2014 and 2015 seasons.

Treatments		First picking percentage							
		2014 season				2015 season			
		Lithovit (g/l)				Lithovit (g/l)			
Planting date	Potasin-P (cm^3/l)	0.0	2.5	5.0	7.5	0.0	2.5	5.0	7.5
8 April	2.5	64.13	66.58	71.00	72.73	66.48	67.33	68.60	70.55
	5.0	64.83	69.25	73.08	78.50	71.88	73.05	75.03	78.80
	7.5	66.33	69.93	77.23	79.90	70.90	72.75	77.80	79.70
8 May	2.5	39.75	42.90	46.48	50.63	42.35	45.95	49.00	51.73
	5.0	40.88	45.23	47.53	52.80	45.05	47.75	50.98	54.78
	7.5	43.23	47.20	49.93	55.45	46.83	52.30	52.95	57.60
8 June	2.5	1.23	2.50	5.00	7.98	2.03	4.58	6.33	8.10
	5.0	2.03	3.25	6.93	11.28	3.73	5.85	9.03	12.70
	7.5	3.78	5.40	8.83	13.85	6.20	9.05	10.88	14.40
LSD 0.05		1.25				1.17			

Table 19: Effect of planting date, Potasin-P rate and Lithovit rate as well as their interactions on number of open bolls per plant, boll weight and seed cotton yield / plant in 2014 and 2015 seasons.

Treatments	Number of open bolls /plant		Boll weight (g)		Seed cotton yield/plant (g)		Seed cotton yield/feddan (kentar)	
	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season
A-planting date								
8 April	16.11	16.17	2.71	2.75	43.66	44.47	11.43	11.83
8 May	15.70	15.67	2.66	2.73	41.76	42.80	10.78	11.11
8 June	10.69	11.45	2.65	2.67	28.32	30.58	6.94	7.59
LSD 0.05	**0.25**	**0.16**	**0.02**	**0.02**	**0.32**	**0.23**	**0.08**	**0.06**
B -Potasin-P rate								
2.5 cm^3 /l	13.82	14.26	2.64	2.67	36.49	38.08	9.30	9.84
5.0 cm^3 /l	14.19	14.52	2.68	2.72	38.03	39.50	9.75	10.25
7.5 cm^3 /l	14.53	14.70	2.70	2.74	39.22	40.27	10.09	10.43
LSD 0.05	**0.20**	**0.25**	**0.01**	**0.02**	**0.29**	**0.39**	**0.08**	**0.09**
C-Lithovit rate								
without	13.59	14.12	2.53	2.58	34.39	36.42	8.68	9.41
2.5 g/l	13.70	14.08	2.67	2.70	36.59	38.02	9.43	9.84
5.0 g/l	14.33	14.51	2.72	2.76	38.99	40.05	10.04	10.45
7.5 g/l	15.05	15.17	2.77	2.81	41.68	42.64	10.71	11.01
LSD 0.05	**0.18**	**0.17**	**0.01**	**0.01**	**0.30**	**0.20**	**0.07**	**0.05**
Interactions								
A x B	NS	NS	*	NS	**	NS	**	NS
A X C	**	NS	**	**	**	*	**	**
B X C	*	**	**	**	**	**	**	**
A X B X C	NS	NS	**	**	**	**	**	**

Table 20: Means of boll weight (g) as affected by the second order interaction, planting date (a)x Potasin-P rate (b) x Lithovit rate (c) in 2014 and 2015 seasons.

Treatments		Boll weight (g)							
		2014 season				2015 season			
		Lithovit (g/l)				Lithovit (g/l)			
Planting date	Potasin-P (cm^3/l)	0.0	2.5	5.0	7.5	0.0	2.5	5.0	7.5
8 April	2.5	2.51	2.68	2.71	2.77	2.62	2.69	2.73	2.77
	5.0	2.57	2.73	2.74	2.85	2.63	2.73	2.77	2.88
	7.5	2.58	2.74	2.79	2.85	2.68	2.77	2.80	2.90
8 May	2.5	2.50	2.64	2.70	2.71	2.53	2.65	2.76	2.81
	5.0	2.51	2.68	2.72	2.74	2.58	2.75	2.80	2.83
	7.5	2.53	2.69	2.72	2.77	2.62	2.76	2.80	2.85
8 June	2.5	2.49	2.55	2.67	2.72	2.48	2.63	2.70	2.71
	5.0	2.50	2.60	2.72	2.77	2.53	2.66	2.76	2.76
	7.5	2.55	2.68	2.75	2.80	2.60	2.69	2.71	2.77
LSD 0.05		0.03				0.04			

Table 21: Means of seed cotton yield (g/plant)as affected by the second order interaction, planting date (a) x Potasin-P rate (b) x Lithovit rate (c) in 2014 and 2015 seasons.

Treatments		Seed cotton yield per plant							
		2014 season				2015 season			
		Lithovit (g/l)				Lithovit (g/l)			
Planting date	Potasin-P (cm^3/l)	0.0	2.5	5.0	7.5	0.0	2.5	5.0	7.5
8 April	2.5	39.82	41.25	42.32	44.54	40.63	42.18	43.43	46.25
	5.0	40.64	42.80	44.38	48.12	41.87	43.11	45.16	48.74
	7.5	41.72	43.43	46.10	48.75	42.18	43.75	46.87	49.47
8 May	2.5	37.96	39.69	41.26	43.28	38.91	40.48	41.88	44.69
	5.0	38.59	40.63	42.65	45.32	40.32	41.87	43.75	46.20
	7.5	39.69	41.87	44.22	45.94	40.63	42.33	45.32	47.18
8 June	2.5	23.27	24.16	28.27	32.03	26.73	28.43	30.63	32.80
	5.0	23.74	26.57	29.84	33.11	28.11	29.84	31.26	33.74
	7.5	24.06	28.90	31.88	34.06	28.43	30.16	32.19	34.69
LSD 0.05		0.89				0.60			

Table 22: Means of seed cotton yield per feddanas affected by the second order interaction, planting date (a) x Potasin-P rate (b) x Lithovit rate (c) in 2014 and 2015 seasons.

Treatments		Seed cotton yield per feddan							
		2014 season				2015 season			
		Lithovit (cm^3/l)				Lithovit (cm^3/l)			
Planting date	Potasin-P (cm^3/l)	0.0	2.5	5.0	7.5	0.0	2.5	5.0	7.5
8 April	2.5	10.18	10.68	11.07	11.64	10.72	11.11	11.57	12.27
	5.0	10.42	11.19	11.71	12.69	11.03	11.46	12.07	13.04
	7.5	10.70	11.46	12.28	13.10	11.11	11.59	12.67	13.33
8 May	2.5	9.54	10.18	10.51	11.21	10.08	10.44	10.83	11.55
	5.0	9.70	10.63	11.05	11.87	10.44	10.83	11.54	12.05
	7.5	10.09	10.85	11.58	12.15	10.52	11.00	11.83	12.18
8 June	2.5	5.71	6.19	6.98	7.78	6.68	7.08	7.68	8.12
	5.0	5.83	6.55	7.38	7.96	7.00	7.51	7.80	8.27
	7.5	5.91	7.14	7.82	7.98	7.08	7.53	8.04	8.26
LSD 0.05		0.21				0.16			

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