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SUMMARY AND CONCLUSION

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Two field experiments were carried out at El-Gemmeiza Agricultural Research Station, El-Gharbia Governorate during two successive seasons of 2014 and 2015. These experiments were conducted to study the effect of foliar CO_2 fertilizer in the form of Lithovit (nano $CaCO_3$) which produced by using nanotechnology application by using four rates (without, 2.5, 5 and 7.5 g/l) twice (at 45 and 60 days after planting) and foliar spraying with three levels of Potasin-P (2.5, 5 and 7.5 cm^3/l) twice (at 46 and 61 days after planting) under three planting dates (8^{th} April, 8^{th} May and 8^{th} June) as well as their interactions on leaves chemical composition, growth characters, earliness traits, seed quality, seed cotton yield and its components and fiber quality of the Egyptian cotton (*Gossypium barbadense* L.), cultivar Giza 86.

Each experiment contained three separate experiments represented the three planting dates *i.e.* 8^{th} April, 8^{th} May and 8^{th} June. Also, the combined analysis between the three experiments was done. The two other variables distributed in each experiment in a strip plot design with four replicates, where the horizontal plots were assigned to the foliar potassium fertilizer levels (in the form of Potasin-P) and the vertical plots contained the rates of foliar CO_2 as a nano-fertilizer (in the form of Lithovit).

Studied traits:

A. Leaf chemical composition:

A.1.Leaf N, P and K content (%).

A-2.Photosynthetic pigments *i.e.* chlorophyll a, chlorophyll b, total chlorophyll and carotenoids (mg/g dw).

A-3.Total carbohydrates and total sugars (mg/g dw).

A-4.Proline concentration (µg lucine/g d.wt.).

A-5.Determination of peroxidase and phenoloxidase enzymes activity (O.D./g fresh weight after 2 and 45 min., respectively).

B. Growth characters:

B-1. Leaf area (dm^2/plant).

B-2.Leaf area index.

B-3.Total dry weight (g/ plant).

B-4.Crop growth rate (g/m^2 /week).

B-5.Net assimilation rate (g/m^2 /week).

B-6.Relative growth rate (mg/g/day).

B-7. Plant height at harvest (cm).

B-8. Number of fruiting branches/ plant.

C-Earliness traits:

C-1. First fruiting branch node.

C-2. Days to first flower.

C-3. Days to first open boll.

C-4. Number of total flowers/plant.

C-5. Number of total bolls/plant.

C-6. Boll setting percentage.

C-7. Boll shedding percentage.

C-8. First picking percentage.

D.Seed quality

D-1. Seed index **(**weight of 100 cotton seeds in grams**)**

D-2. Seed oil percentage.

E. Seed cotton yield and its components:

E-1. Number of open bolls per plant,

E-2. Average boll weight in grams.

E-3. Seed cotton yield in grams per plant.

E-4. Lint percentage.

E-5. Seed cotton yield (kentar/fed).

F. Fiber quality:

F.1. Fiber length(mm.).

F.2. Uniformity index (%).

F.3. fiber strength (Pressley index).

F.4. Micronaire reading.

The obtained results could be summarized as follows: -

A. Leaf chemical composition:

A.1. As affected by planting dates:

Leaves N, P, K, chlorophyll a, b, total chlorophyll, carotenoids, total soluble sugars and total carbohydrate contents were significantly affected by planting dates in both seasons, in favour of early planting date (8th April) as compared to medium and late planting dates (8th May and 8th June). Delaying planting date significantly increased leaves proline content and leaf peroxidase and phenoloxidase activity which indicate the presence of heat stress on the plant.

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

Leaves N, chlorophyll a, b, total chlorophyll, carotenoids and total carbohydrates contents were significantly affected by levels of Potasin-P in both seasons, in favour of the medium level of Potasin-P (5cm^3/l). While, leaves P and K contents were significantly increased by using the high level of Potasin-P (7.5cm^3/l). The medium level of Potasin-P (5cm^3/l) significantly decreased leaf proline content and leaf peroxidase and phenoloxidase activity which indicate favorable plant conditions.

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

Leaves N, P, K, chlorophyll a, b, total chlorophyll, carotenoids, total sugars and total carbohydrates contents were significantly increased by using the high rate (7.5g/l) of CO_2 fertilizer (in the form of Lithovit) twice in both seasons. Also, this rate significantly decreased leaves proline content and leaves peroxidase and phenoloxidase activity which indicate that this rate induced favorable plant conditions and this reflect on reduce environmental stress.

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

Leaves N, P, K, chlorophyll a, b, total chlorophyll, carotenoids, total sugars and total carbohydrates contents were significantly affected by the second order interaction of planting dates x Potasin-P levels x CO_2 fertilizer rates (in the form of Lithovit) in both seasons, where the highest leaves P and K contents values were obtained from plants sown in early planting date (8^{th} April) which received the high level of Potasin-P and CO_2 fertilizer as a spray at the high rate (7.5 g/l). The highest leaves N, chlorophyll a, b, total chlorophyll, carotenoids total sugars and total carbohydrates contents were obtained from plants sown in early planting date (8^{th} April) which received the medium level of Potasin-P and CO_2 fertilizer as a spray at the high rate (7.5 g/l). Late planting (8^{th} June) without Lithovit application when sprayed with Potasin-P at the low level produced the highest leaves proline content, leaves peroxidase and phenoloxidase activity which indicate favorable plant conditions.

B. Growth characters:

B.1. As affected by planting dates:

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.

Significant differences among the three planting dates for crop growth rate at the two growth stages over the two seasons of study, in favor of the second planting date (8^{th}May) at the first growth stage. At the second growth stage the superiority was found in favor of the first planting date (8^{th} April).

Plant height reached its maximum for the third planting date (8^{th} June) followed by the second date (8^{th} May) and the least resulted from early planting in the first date (8^{th} April), while number of fruiting branches/plant reached its maximum for the first planting date (8^{th} April) followed by the second planting date (8^{th} May) and the least resulted from late planting (8^{th} June).

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

Foliar spray of Potasin-P at the level of 5 cm^3/l twice (at 46 and 61 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 level 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 levels of Potasin-P at the three sampling dates in both season. Foliar spray of Potasin-P at the level 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 level (7.5 cm^3/l) of Potasin-P at the three sampling dates.

Net assimilation rate was significantly affected by Potasin-P levels at the second growth stage in the second season, in favor of spraying Potasin-P at the low level.

Foliar spraying of Potasin-P at the level of 5 cm^3/l resulted in the highest crop growth rate at the first growth stage in the first season. In the second season, foliar spraying of Potasin-P at the level of 7.5 cm^3/l resulted in the highest crop growth rate at the first growth stage.

B.3. As affected by rates of foliar CO_2 fertilizer (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, in favor of the high rate (7.5 g/l) of CO_2 fertilizer.

Significant differences were obtained in crop growth rate due to the four CO_2 fertilizer rates (in the form of Lithovit) at the two growth stages over the two seasons of study, where the superiority was found in favor of high rate (7.5 cm^3/l) of Lithovit.

Significant differences were obtained in net assimilation rate due to the four CO_2 fertilizer rates (in the form of Lithovit) at the two growth stages over the two seasons of study, where the superiority was found in favor of the low rate (2.5 g/l) of Lithovit at the second growth stage in the first season and from the high rate of Lithovit (7.5 g/l) at the first growth stage in both seasons and at the second growth stage in the second season.

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.

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

Concerning the second order interaction of planting dates x Potasin-P levels x CO_2 fertilizer rates, it had a significant effect on leaf area and leaf area index at 79 and 121 days after planting only in the second season. Delaying planting date to 8th 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, where plants at the second planting date which received the medium level 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 at harvest in both seasons and number of fruiting branches/plant in the second season, where the taller plants were obtained from plants sown late on 8thJune and received the high level of both Potasin-P and CO_2 fertilizer. Number of fruiting branches/plant reached its maximum from plants sown on early on 8th April and received the high rate of both Potasin-P and CO_2 fertilizer.

C. Earliness traits:

C.1. As affected by planting dates:

Planting dates had pronounced effect on first fruiting branch node during the two seasons of study. The position of the first fruiting node was initiated on significantly higher node in case of late planting than early or intermediate planting dates.

Average numbers of days from planting up to the first flower and first open boll were significantly affected by planting dates in both seasons,

where early planting significantly delayed days to first flower and first open boll. However, delaying planting date significantly reduced that delay.

Early planting date on 8th April significantly increased numbers of total flowers, bolls per plant, boll setting percentage and 1st picking percentage and significantly decreased shedding percentage as compared with the medium planting date on 8th May and the late planting date on 8th June in both seasons.

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

The high level (7.5cm^3/l) of Potasin-P significantly increased numbers of total flowers, bolls/plant, boll setting percentage and 1st picking percentage and significantly decreased boll shedding percentage as compared with the other rates in both seasons.

Significant differences were found among means of days to the first flower and first open boll due to the Potasin - P levels in the second season only, where the high level (7.5cm^3/l) significantly reduced this period.

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

Significant differences were found among means of days to the first flower due to the CO_2 fertilizer rates in the second season only and among means of days to the first open boll in both seasons, in favor of the high rate of Lithovit which significantly reduced the period from planting to the first flower and first open boll. No significant differences were found among means of the first fruiting position in nodes due to the CO_2 fertilizer rates in both seasons.

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 fertilizer (in the form of Lithovit) as for numbers of total flowers and bolls/plant 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.

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

This interaction gave significant effect on number of total bolls/plant, boll setting percentage and boll shedding percentage in the second season only and on first picking % percentage in both seasons, in favor of plants sown early on 8th April and received the high rate of both Potasin-P and CO_2 fertilizer.

D. Seed quality:

D.1. As affected by planting dates:

Early planting on 8th April significantly increased seed index and seed oil percentage as compared with the intermediate and late dates.

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

Significant effect on seed index and seed oil percentage over the two seasons of study was found due to the different levels of Potasin-P. The highest seed index was obtained from applying Potasin-P at the medium rate in the first season and from the high level in the second season and the highest seed oil percentage resulted from applying Potasin-P at the high level.

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

Foliar spraying of CO_2 fertilizer twice at the high rate (7.5 g/l) significantly increased seed index and seed oil percentage in both seasons.

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

As for the second order interaction of planting date x Potasin-P rate x CO_2 fertilizer rates (in the form of Lithovit), seed index was significantly affected by this interaction in the first season only, in favor of plants sown on 8th May which received the medium rate of Potasin-P plus the high rate of Lithovit. Seed oil percentage was significantly affected by this interaction in both seasons, in favor of plants sown early on 8th April which received the medium rate of Potasin-P plus the high rate of Lithovit.

E. Seed cotton yield/fed and its components:

E.1. As affected by planting dates:

Time of planting exhibited significant differences in boll weight, number of open 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 open bolls/plant and seed cotton yield / plant. Also, delaying planting date decreased seriously the seed cotton yield per feddan in both seasons.

Lint percentage was significantly affected by planting dates in both seasons, where early planting date on 8 April and the intermediate planting date on 8 May significantly increased lint percentage, where these two dates gave the highest values in the first and second seasons, respectively.

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

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).

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 in both seasons.

Significant differences were found among means of lint percentage due to the Potasin - P rates in both seasons, where the highest lint percentage resulted from the medium rate in the first season and from the high rate in the second season, respectively.

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

Significant distinctions were detected amongst the four rates of foliar CO_2 as a nano- fertilizer (in the form of Lithovit) twice as for number of open bolls/plant, boll weight, seed cotton yield/plant, lint % 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).

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

Planting dates x Potasin-P levels x CO_2 fertilizer rates interaction had a significant effect on boll weight, seed cotton yield/plant and seed cotton yield/fed in both seasons, where the heaviest bolls and highest yield were obtained from plants which sown early on 8 April and received the high level of both Potasin-P and CO_2 fertilizer. This interaction had a significant effect on lint percentage in the second season only, where the highest lint percentage resulted from plants sown on 8 May and received the high level of both Potasin-P and CO_2 fertilizer.

F. Fiber quality

F.1. As affected by planting dates:

Planting dates had insignificant effect on fiber length and micronaire reading in both seasons and gave significant effect on uniformity index and fiber strength only in the second season, in favor of early planting date (8 April) with regard to uniformity index, where this date produced the highest uniformity index and in favor of intermediate planting date with regard to fiber strength, where this date produced the highest fiber strength.

E.2. As affected by Potasin-P levels:

The differences in fiber length and fiber strength were only significant in one season, in favor of the high level of Potasin-P (7.5 cm^3/l), where this rate produced the longest fiber length and the highest fiber strength. Uniformity index and micronaire reading were insignificantly affected by Potasin-P rates in both seasons.

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

Fiber length, uniformity index and fiber strength were significantly affected by CO_2 fertilizer rates in both seasons, where the superiority was found in favor of applying the high rate (7.5 g/l). Micronaire reading was insignificantly affected by CO_2 fertilizer rates in both seasons.

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

As for the second order interaction of planting dates x Potasin-P levels x CO_2 fertilizer rates (in the form of Lithovit), fiber length and uniformity index were significantly affected by this interaction in one season only, fiber strength was significantly affected by this interaction in both seasons and micronaire reading was insignificantly affected by this

interaction in both seasons. The taller fibers were obtained from plants sown in late planting date (8th June) which received the low rate of Potasin-P and the high rate of CO_2 fertilizer. Uniformity index reached its maximum due to plants which received the high rate of Potasin-P and the medium rate of CO_2 fertilizer in late planting date. The stronger fibers resulted from intermediate planting date (8th May) when combined with the high rate of both Potasin-P and CO_2 fertilizer in the first season and when combined with the low rate of Potasin-P without CO_2 fertilizer application in the second season.

Conclusion:

It is a divisible to sown cotton early on 8th April and applying the high level of Potasin-P (7.5cm^3/l) twice at 46 and 61 days after planting in combination with the high rate (7.5 g/l) of foliar CO_2 fertilizer in the form of Lithovit (a nano $CaCO_3$) twice (at 45 and 60 days after planting) to increase the leaves N, P, K, chlorophyll a, b, total chlorophyll, carotenoids and total carbohydrates contents and reduce leaves proline content and leaves peroxidase and phenoloxidase activity which reflect on induced favorable plant conditions and on reduce environmental stress effect and in turn gave significant increase in growth characters, flowering traits, productivity and quality under El-Gharbia Governorate conditions. Also, it could be concluded that seed cotton yield of late plantings could be increased by foliar spray with Potasin-P at the level of 7.5cm^3/l twice (at 46 and 61 days after planting) in combined with two foliar sprays with CO_2 fertilizer in the form of Lithovit (at 45 and 60 days after planting) at the rate of 7.5 g/l, where this combination is the best treatment for good growth and high productivity.