J. of Plant Production, Mansoura Univ.,Vol 12 (9):1031 - 1038, 2021

Journal of Plant Production

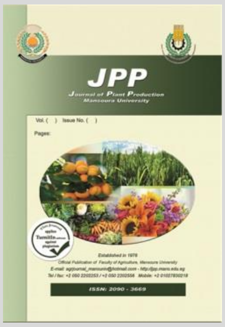
Journal homepage: www.jpp.mans.edu.eg
Available online at: www.jpp.journals.ekb.eg

Physiological Studies to Induce Flowering and Fix Boll Setting in Cotton Plant

Abdel Aal, M. H. ; A. E. El-Gabiery and M. W. M. EL-Shazly*

Cotton Physiology Department, Cotton Research Institute, Agricultural Research Center, Giza, Egypt.

Cross Mark



ABSTRACT

Two field experiments were carried out at El-Gemmeiza Agricultural Research Station, El-Gharbia Governorate, Egypt during 2019 and 2020 seasons, to find out the proper time of foliar application with Idai Top Flower(ITF)(9.50% P_2O_5 +3.50% Mo).It was applied at the rate of 2 cm^3/L once(at squaring start or at the beginning of flowering or at the peak of flowering) and twice (at squaring start and the beginning of flowering or at the beginning of flowering and the peak of flowering)compared to the control treatment The effect of these treatments on boll retention and productivity of cotton cultivar Giza 86 was also evaluated. The layout of the experiment was a randomized complete blocks design with 4 replicates in both seasons.The obtained results revealed that foliar feeding with ITF twice(at squaring start and the beginning of flowering or at the beginning of flowering and the peak of flowering) led to a significant increase in growth parameters, boll setting and earliness attributes(except boll shedding% which decreased), the open bolls number $plant^{-1}$ and yield of seed cotton $feddan^{-1}$ in both seasons as well as boll weight,seed index and lint% in the second season.The lowest values of these traits in consideration were resulted from the control treatment with a significant increase in boll shedding percentage. Application of Idai Top Flower(ITF)at a concentration of 2 cm^3/liter twice(at squaring start and the beginning of flowering)or(at the beginning of flowering and the peak of flowering)was recommended to increase cotton boll retention and productivity under conditions similar to El-Gemmeiza location.

Keywords: Seed cotton; foliar feeding; phosphorus; shedding; molybdenum.

INTRODUCTION

Phosphorus availability is affected by one or more of pH, clay contents, organic matter, alkalinity and $CaCO_3$ (Khalil, 2013). The adsorbed P by soil was difficult to release again (Huang, 1998), and becomes unavailable to the plants, where it is transformed rapidly to tricalcium phosphate (Miller and Donahue, 1992) and free P reacts with $CaCO_3$ and precipitates as Ca-P comprising non-soluble P forms (Lindsay *et al*., 1989). Both dissolved inorganic and particulate P lost through surface runoff, subsurface drainage and erosion (O'Conner, 1968) or leaching as a result of increasing the amount of water moving through the soil, increasing P concentration and saturation in solution, decreasing P buffer capacity and consequently resulted in eutrophication in receiving waters (Zöbisch *et al*., 1994). From all P, about 80% moves through diffusion towards the roots from the soil, where the average distance for diffusion between P and the root has been found to be 0.2 mm (Brady and Weil, 2008).

In alkaline soil, the $Al(OH)^{2+}$ in the clay fraction fixed P (Wild, 1953) and in arid region this category of fixation is more serious problem. Soils that have a large quantity of clay, a high Ca^{2+} activity and a large amount of highly reactive calcium saturated clay reduced the activity of P (Tisdale *et al*., 1985). Above pH 7.0 the added P precipitated by carbonates of calcium and magnesium ions, and its availability decreases. P diffuses slowly and has a high rate of fixation as Fe-P and Al-P in soil (Marcante *et al*., 2016).

Soils have propensity to retain equilibrium between solution P and adsorbed P. Fertilizer requirement is the amount needed of a nutrient (beyond that the soil supplied it) to increase growth of plant to a desired or optimum level (external nutrient requirement). Therefore, applying a compound as ITF which contains (9.50% P_2O_5 +3.50% Mo) to achieve maximum plant growth, push cotton plant to flower and to fix the boll setting and high productivity.

In the plant cells, several important compounds including the sugar phosphate intermediates of respiration and photosynthesis, and the phospholipids that make up plant membranes required phosphorus, where P is an integral component of these compounds (Taiz and Zeiger, 2010). Energy storage and energy transfer are the two essential functions of phosphorus, where adenosine di- and tri-phosphates (ADP and ATP) which used in photosynthesis and respiration reactions. P is a structural component of nucleic acids (the genes and chromosomes building blocks and the heredity essence), nucleotides, phospholipids, coenzymes, and phosphoproteins and sugar phosphates to construct cellular membranes (Marschner, 1995). In phosphorylation enzyme activity modifies by P. Also, P activates proteins, regulates metabolic processes, cell signaling and division (Dubetz and Bole, 1975).

Phosphorus application as foliar spraying enhances production (Verma *et al*., 2018), where plant P uptake is

* **Corresponding author.**
E-mail address: mahmoud5wagdy@gmail.com
DOI: 10.21608/jpp.2021.202847

relatively less efficient due to its poor solubility in soil (Hopkins, 2015). Barber (1980 and 1995) calculated that ~92.5% of P provided by diffusion compared with ~2.5% for mass flow. However, applied P is poorly available to roots of plant, where it may remain in the surface layer (Sposito, 2008). Hopkins *et al.* (2014) reported that in alkaline soils, the balance lied in favor of CO_3^{2-} accumulating in soil and preventing pH change from occurring. Therefore, for alkaline soils the management strategy is to add relatively higher fertilizer rates of P.

Unlike other micronutrients, the availability of Mo increases with increases in soil pH. In fact, availability of Mo within the soil increases one-hundred-fold for every soil pH unit increase (Gupta, 1997). In alkaline soils, molybdenum becomes more soluble and is accessible to plants mainly in its anion form as MoO^{-4} (Marschner, 1995; Mendel and Haensch, 2002). It is an essential trace element of higher plants required in very small amount as it occurs in more than 60 enzymes catalyzing diverse oxidation–reduction reactions (Sauer and Frebort, 2003). They added that this element has a crucial role in plant nitrogen metabolism. Molybdenum helps in protein synthesis and sulfur metabolism. Molybdenum has a positive effect on formation of carotenoid at its low and adequate levels. It helps in absorption and translocation of iron in plants (Marschner, 1995). Molybdenum is required for the function of a few enzymes involved in redox processes, when inserted as part of a prosthetic group known as the Mo-cofactor (Mendel and Haensch, 2002). It is involved in several enzyme systems including nitrate reductase, xanthine oxidase, aldehyde oxidase and sulphate oxidase (Nicholas, 1975). Molybdenum is also required in ascorbic acid synthesis and is implicated in making iron (Fe) physiologically available in plants, it plays a part in nitrogen metabolism as a component of enzymes such as nitrate reductase and nitrogenase. At the same time, Mo participates in the metabolism of sulfur, biosynthesis of plant hormones and catabolism of purine compounds (Kaiser *et al*., 2005). Increased molybdenum nutrition may aid in agricultural plant development and required in very small amounts and has a narrow range between deficiency and toxicity (Brent *et al*., 2005).

Abou Seeda *et al.* (2020) reported that Mo availability for uptake by plant is highly dependent upon growing environmental factors, pH and texture of soil, organic matter content in soil, water drainage and other nutrients concentration (mainly oxides such as manganese, iron, aluminum) present in the soil (Kaiser *et al*., 2005).

ITF contains (9.50% P_2O_5 +3.50% Mo). P and Mo used as a foliar application to the different plant species for induction their productivity (Malhotra *et al*., 2018 and Steiner *et al*., 2018). Applying P and Mo to cotton achieved maximum growth, induced flowering and boll setting with high productivity (Gebaly, 2013 and Ahmad *et al.*, 2020).

Thus, this study was designed to study the effect of foliar feeding with ITF (9.50% P_2O_5 +3.50% Mo) at the rate of 2 cm^3/L once and twice compared to the control treatment (sprayed with tap water) on growth, boll retention and yield of Egyptian cotton cultivar Giza 86 under conditions of El-Gemmeiza location.

MATERIALS AND METHODS

Two field experiments were carried out at El-Gmmeiza Agricultural Research Station, El-Gharbia Governorate, Egypt during the two growing seasons of 2019 and 2020 to study the effect of foliar feeding with Idai Top Flower (ITF) at the rate of 2 cm^3/L once (at squaring start or at the beginning of flowering or at the peak of flowering) and twice (at squaring start and the beginning of flowering or at the beginning of flowering and the peak of flowering) compared to the control treatment (sprayed with tap water) on boll setting and productivity of Egyptian cotton cultivar Giza 86 (*Gossypium barbadense* L.).

Active ingredients of ITF are presented in Table 1.

Table 1. Active ingredients of Idai Top Flower (ITF)

Active ingredient	%
P_2O_5	9.50
Mo	3.50

Randomized complete blocks design with 4 replicates was used in this experiment, where the following six treatments were applied:

T_1- Untreated (sprayed with tap water) as a control.
T_2- Foliar feeding with ITF once at squaring start.
T_3- Foliar feeding with ITF once at the beginning of flowering.
T_4- Foliar feeding with ITF once at the peak of flowering.
T_5- Foliar feeding with ITF twice at squaring start and the beginning of flowering.
T_6-Foliar feeding with ITF twice at the beginning and the peak of flowering.

Soil samples represented one layer from 0-30 cm depth were taken before sowing from the experimental soil site in each season to determine some soil properties using the standard methods as described by Estefan *et al*. (2013) and the data are presented in Table 2.

Table 2. Properties of the experimental soil of the two growing seasons 2019 and 2020.

Properties	season	
	2019	2020
Mechanical analysis:		
Clay %	44.2	45.1
Silt %	33.0	32.6
Sand %	22.8	22.3
Texture class	Clayey	Clayey
Chemical analysis		
pH	8.1	7.9
EC ds/m^2	0.99	0.64
Organic matter %	1.40	1.25
$CaCO_3$ (%)	1.10	1.00
Total N (mg/100g)	49.00	43.75
Available macronutrients:		
P (mg/100g)	1.28	0.96
Exchangable K (mg/100g)	31.0	21.0
Mg (mg/100g)	23	20
Available micronutrients:		
Fe (ppm)	12.4	10.7
Mn (ppm)	3.9	3.1
Zn (ppm)	1.12	1.20
Cu (ppm)	1.7	0.9
Mo (ppm)	0.07	0.05

Cotton seeds were sown on 10th April in the first season and on 14th April in the second season after one cut of Egyptian clover (*Trifolium alexandrinum* L.) “berseem”.

In both seasons, the experimental plot area was 14 m^2, (4 m length x 3.5 m width) included 5 ridges of 0.70 m in between with hills 25 cm apart with two vigor seedlings hill^{-1} at thinning time to insure 48,000 plants/fed.

Phosphorus fertilizer in the form of ordinary super phosphate (15.5% P_2O_5) was applied at the rate of 22.5 kg P_2O_5 fed^{-1} during land preparation. Nitrogen fertilizer was applied as urea (46% N) at the rate of 45 kg N fed^{-1} in two equal portions. First portion was applied after thinning before irrigation, while the second was applied after 15 days.

Potassium fertilizer in the form of Potasin-P at the rate of 1 liter fed^{-1} was applied as foliar application three times (at squaring stage, flowering start and the top of flowering).

All cultural practices *i.e.,* irrigation, control of diseases and insects, hoeing and harvest were carried out throughout the two growing seasons as recommended (CRI, ARC).

Studied characters:

I-Growth parameters: At harvesting, five guarded hills from each plot were taken at random to determine the following parameters; 1. Plant height (cm): It is measured from the cotyledonary nodes to the tip of the terminal bud and 2. Number of fruiting branches plant^{-1}.

II. Earliness attributes: From ten representative plants, the following attributes were determined according to Richmond and Radwan (1962); 1. Total flowers number plant^{-1}, 2. Total bolls number set plant^{-1}, 3. Boll retention (setting) as percentage of total bolls number set plant^{-1} to total flowers number plant^{-1}, 4. Boll shedding percentage = (100 –boll setting %) and 5. Earliness index (percentage of first picking).

III. Yield and its contributed parameters: From the above ten representative plants, the following parameters were determined; 1. Open bolls number picked plant-1, 2. Boll weight (g), 3. Lint% (Ginning percentage) as percentage of lint cotton to seed cotton after ginning, 4. Seed index (g). Yield of seed cotton fed^{-1} in the two pickings was obtained by picked and weighed seed cotton from each plot in kilograms, which was subsequently converted to kentars.

IV. Fiber quality: The following parameters were determined according to A.S.T.M., 2012 at the laboratories of the Cotton Technology Research Division, Cotton Research Institute, Agricultural Research Center, Giza, Egypt; 1- 2.5 % span length (mm), 2- Length uniformity ratio (%): It is the ratio of mean fiber length *i.e.,* 50% span length to upper half mean length *i.e.,* 2.5 % span length as percentage. Fiber upper half mean length (mm.) and length uniformity ratio (%) were determined on digital fibrograph instrument 630, 3- Fineness and fiber maturity as micronaire reading was determined on micronaire instrument 675 and 4- Fiber strength was tested by using Pressley tester and expressed as Pressley index.

Statistical analysis:

All data were subjected to the statistical analysis as prescribed by Steel *et al*. (1997) and the mean values were compared at 0.05 level of probability using LSD (Waller and Duncan, 1969).

RESULTS AND DISCUSSION

I-Growth parameters:

The effect of number and application time of ITF on height of plant at harvesting time and its fruiting branches number are shown in Table 3. Spraying ITF twice (at the beginning of flowering and the peak of flowering) produced the tallest plants (165.23 and 164.30 cm), followed by spraying once at the top of flowering (163.03 and 162.08 cm) in 2019 and 2020 seasons, respectively. The highest fruiting branches number plant^{-1} (17.08, 16.83 and 16.78 in the first season; 16.93, 16.73 and 16.63 in the second season) resulted from foliar spraying with ITF twice at squaring start and the beginning of flowering, at the beginning of flowering and the peak of flowering and once at the peak of flowering at the respective order, without significant difference. The shortest plants (154.05 and 153.00 cm) with the lowest number of fruiting branches/plant (14.63 and 14.18) were obtained from the control in both seasons, respectively.

The positive effect of using two sprays of ITF (9.50% P_2O_5 +3.50% Mo) on final plant height and its fruiting branches number may be due to one or more of the following reasons; 1-The beneficial effect of P fertilization on energy transformation, metabolic process and root growth resulting in taller plant and beneficial effects of applied Mo. 2- Increases in phosphorous availability and the maximized nitrogen absorption enhanced growth and expansion of cell (Dohary et al., 2004). 3- The enhancing effect of phosphorus on photosynthesis, transfer energy, division and enlargement of cell, formation of root, growth and water use efficiency (Malhotra et al., 2018) as well as protein synthesis, protoplasm formation, molecular structure of nucleic acids DNA and RNA, cell size, cell division and formation of meristematic tissues (Tisdale et al., 1993).

Table 3. Effect of foliar application with Idai Top Flower (ITF) on cotton growth parameters in 2019 and 2020 seasons.

Treatments	Plant height at harvest (cm)		Fruiting branches number plant^{-1}	
	2019 season	2020 season	2019 season	2020 season
T_1- Control (spraying tap water)	154.05	153.00	14.63	14.18
T_2- Spraying ITF at squaring start	162.68	161.22	16.60	16.43
T_3- Spraying ITF at the beginning of flowering.	161.00	161.00	15.73	15.55
T_4- Spraying ITF at the peak of flowering	163.03	162.08	16.78	16.63
T_5- (T_2+ T_3)	159.75	159.55	17.08	16.93
T_6- (T_3+ T_4)	165.23	164.30	16.83	16.73
LSD at 0.05	1.27	2.34	0.42	0.46

Uchida (2000) added that phosphorus plays an important role in pyridoxal formation which is necessary for chlorophyll biosynthesis and conversion carbon dioxide to sugar. 4- The positive effects of phosphorus on the availability of Mo may be play an important role on increasing the activities of many selected enzymes and carrier of phosphorus in the plant (Marschner, 1995), including nitrate reductase, xanthine dehydrogenase, aldehyde oxidase and sulfite oxidase. 5- Data in this study indicated Idai Top Flower increases sympodial branches in an acropetal pattern so, where height of plant was more, number of sympodial branches per plant was also more (Table 3). Molybdenum also participates as a co-factor of nitrogenase responsible for biological nitrogen fixation as the deficiency of this element causes a reduction of nitrogen fixation (Bambara and Ndakidemi, 2010). The role of Mo as a metal component of some enzymes that catalyze nitrogen function, nitrate assimilation and reduction was reported (Li *et al.,* 2013). Inorganic N conversion in form of nitrate to nitrite catalyzed by Mo (Mokhele et al., 2012).

Molybdoenzymes play vital role in catalyzing oxidation-reduction reactions taking place within cycles of the carbon, nitrogen, and sulfur in plants. Mo uptake takes place through transporters located within plant roots, either through phosphate-phosphorus transporters (Datta et al., 2011) or sulfate transporters (Broadley et al., 2012). Plant molybdoenzymes can be broken down to those involved in nitrogen reduction and assimilation [i.e., nitrate reduction (nitrate reductase; NR), nitrogen fixation (nitrogenase), purine catabolism (xanthine dehydrogenase/oxidase; XDH), abscisic acid (ABA) and indole-3 acetic acid (IAA) synthesis (aldehyde oxidase; AO)] and sulfur metabolism (sulfite oxidase; SO).

Alkaline soil pH (Table 2) allows Mo to adsorb readily to cations such as calcium, sodium, potassium, and magnesium. This process increases the available Mo concentrations for immediate uptake by plant and losses of Mo through leaching (Kaiser et al., 2005). The Mo absence promotes accumulation of nitrates and indicates less assimilation of nitrogen by the plants. However, nitrates reduction to ammonium (NH_4^+) is necessary to support the organic compounds and proteins synthesis in plants (Steiner et al., 2018). Application of Mo reduces the concentration of nitrate in leaves and improves the assimilation of N in plants (Resende et al., 2010).

In general, Mo concentration between 0.1 and 3.0 mg kg^{-1} is considered adequate for normal growth of plants. Deficient plants showed leaf concentrations between 0.01 and 0.1 mg kg^{-1} (Tedesco et al., 1995). Data presented in Table 2 indicated that the experimental soil is clayey in texture, alkaline in reaction and containing amounts of $CaCO_3$ ranging from 1.0 to 1.1 %. It had low salinity. The values of P ranged between 0.96-1.28 mg/100 g soil, where these values are above and less the critical level (1.2-2.7 mg/100 g soil) in the first and second seasons according to Ankerman and Large (1974). Concerning the amount of available soil Mo, it ranged between (0.05-0.07 ppm) where these values are less than the critical level range of (0.1-0.2 ppm) according to Sillanpãã (1982).

In this respect, Gebaly (2013) found that comparing with the control, spraying molybdenum (Mo) at 0.8 g L^{-1} insignificantly affected plant height and its fruiting branches number in both seasons. Ahmad et al. (2020) found that phosphorous application significantly increased height of plant and number of nodes $plant^{-1}$. Ali et al. (2020) added that phosphorous availability reduction resulted in reducing the growth and inhibits dark green leaves of cotton plant.

II-Earliness attributes:

Table 4 indicated significant differences for total bolls and flowers numbers $plant^{-1}$, boll setting, boll shedding and earliness percentages in both seasons due to ITF treatments. In the first season, spraying with ITF twice (at squaring start and the beginning of flowering) produced highest total bolls number set/plant (24.53), boll setting% (83.16%) and earliness (66.73%), followed by sprayed twice (at the beginning of flowering and the peak of flowering) where the respective values were (23.63, 78.02% and 62.68%) for total bolls number set/plant, boll setting% and earliness% with significant difference between these two treatments. Also, these two treatments significantly decreased boll shedding% and recorded the lowest boll shedding% (16.84% and 21.98%), respectively. In the second season, spraying with ITF twice (at the beginning of flowering and the peak of flowering) produced highest total bolls number set/plant (18.83), boll setting% (73.48%) and earliness % (67.21%), followed by that sprayed twice (at squaring start and the beginning of flowering) where the respective values were (17.96, 71.05% and 65.38%). Also, these two treatments significantly decreased boll shedding% and recorded the lowest boll shedding% (26.52% and 28.95%), respectively. In both seasons, the highest boll shedding% and the lowest values of total flowers number $plant^{-1}$, total bolls number set $plant^{-1}$, boll setting and earliness percentages were resulted from untreated plants (the control).

Table 4. Effect of foliar application with Idai Top Flower (ITF) on cotton earliness attributes in 2019 and 2020 seasons.

Treatments	Total flowers number $plant^{-1}$	Total bolls number set $plant^{-1}$	Boll setting %	Boll shedding %	Earliness %
			Season 2019		
T_1- Control (spraying tap water)	28.36	17.75	62.62	37.38	52.05
T_2- Spraying ITF at squaring start	28.92	20.85	72.15	27.85	58.05
T_3- Spraying ITF at the beginning of flowering.	33.73	22.15	65.73	34.27	53.53
T_4- Spraying ITF at the peak of flowering	31.95	22.85	71.54	28.46	56.93
T_5- (T_2+ T_3)	29.50	24.53	83.16	16.84	66.73
T_6- (T_3+ T_4)	30.29	23.63	78.02	21.98	62.68
LSD at 0.05	1.40	0.58	2.18	2.18	1.28
Treatments			Season 2020		
T_1- Control (spraying tap water)	23.49	14.48	61.68	38.32	57.40
T_2- Spraying ITF at squaring start	25.53	16.92	66.29	33.71	64.18
T_3- Spraying ITF at the beginning of flowering.	25.24	16.19	64.15	35.85	62.64
T_4- Spraying ITF at the peak of flowering	25.68	16.46	64.10	35.90	63.71
T_5- (T_2+ T_3)	25.28	17.96	71.05	28.95	65.38
T_6- (T_3+ T_4)	25.62	18.83	73.48	26.52	67.21
LSD at 0.05	0.39	0.37	0.55	0.55	1.52

The positive effect of spraying ITF twice (9.50% P_2O_5 +3.50% Mo) on earliness measurements is mainly due to; Its constituents of P and Mo, P helps hasten maturity (Malhotra *et al*., 2018). P and Mo may prevent leaves senescence and thus prolonged photosynthesis and carbon fixation resulting in decreasing boll shedding (Bronson *et al.,* 2001). Phosphorus diverts the plant toward the reproductive phase through its vital role in cell division, cell elongation and stimulate early flowering which was reported (Singh, 2003). Chiles and Chiles (1991) reported that the promotive effect of increased rate of phosphorus on earliness% may be detected through an alteration of the nitrogen balance of cotton plant that led to early maturity of cotton plant. An increase in sympodial branches may result in more bolls plant^{-1}, where superior fruiting branches number were noted with these two treatments, but significantly lower fruiting branches number were noted from control (Table 3). Phosphorus generally increased the availability of Mo. This increase in Mo availability may be in part to the reduced adsorption of Mo by soil when P is applied. In this respect, it was reported that phosphorus is essential for cell division, development of meristematic tissue and causing a stimulating effect on the number of floral buds and bolls per plant. Lower phosphorous availability in cotton crop affects the development of flower buds (Dohary *et al*., 2004). Gebaly (2013) reported that spraying molybdenum (Mo) at 0.8 g L^{-1} significantly increased total flowers number plant^{-1}, boll retention% and earliness% in one season only as compared with the control. Ali *et al*. (2020) reported that phosphorous availability reduction reduces flowering, imbalanced pollination and inhibits flower bud necrosis.

III-Seed cotton yield and its components:

Table 5 shows that the number and date of sprays had significant effect on open bolls number plant^{-1} in the two growing seasons. In the first season, spraying with ITF twice (at squaring start and the beginning of flowering) produced the highest open bolls number plant^{-1} (24.53), followed by that treated twice (at the beginning of flowering and the peak of flowering) (23.63) with significant difference between these two treatments. Also, these two treatments significantly increased open bolls number plant^{-1} than those in which they were sprayed once (at squaring start or at flowering initiation or at the top of flowering), which produced 20.85, 22.15 and 22.85, respectively. Foliar feeding with ITF at the rate of 2 cm^3/L once (at squaring start or at the beginning of flowering or at the peak of flowering) or twice (at squaring start and the beginning of flowering or at the beginning of flowering and the peak of flowering) significantly increased open bolls number plant^{-1} as compared with the control treatment (spraying tap water) which showed lower open bolls number plant^{-1} (17.75). In the second season, spraying ITF twice (at the beginning of flowering and the peak of flowering) showed significant increase in open bolls number plant^{-1}, boll weight, lint% and seed index. Other treatments resulted in the highest number of open bolls/plant (18.83), seed index (10.48 g), lint% (42.33%) and higher boll weight (2.84 g). However, the control treatment produced the lowest open bolls number plant^{-1} (14.48), seed index (9.20 g), lint% (39.57%) and lighter boll weight (2.34 g). Concerning seed cotton yield/feddan, the effect of number and time of ITF foliar application was significant in both seasons (Table 5). In the first season, the spraying with ITF twice (at squaring start and the beginning of flowering) significantly increased yield by 20.28, 10.36, 3.69, 6.09 and 4.38% over the control, foliar spraying with ITF at the rate of 2 cm^3/L once (at squaring start), (at the beginning of flowering), (at the peak of flowering), foliar spraying with ITF at the rate of 2 cm^3/L twice (at the beginning of flowering and the peak of flowering) at the respective order. In the second season, spraying ITF twice (at the beginning of flowering and the peak of flowering) significantly increased yield by 15.41, 6.65, 9.03, 8.57 and 3.95% over the control, foliar spraying with ITF at the rate of 2 cm^3/L once (at squaring start), (at the beginning of flowering), (at the peak of flowering), and foliar spraying with ITF at the rate of 2 cm^3/L twice (at squaring start and the beginning of flowering) at the respective order. The lowest yield was detected in the control (Table 5).

Table 5. Effect of foliar application with Idai Top Flower (ITF) on yield of seed cotton and its components in 2019 and 2020 seasons.

Treatments	Lint %	Seed index (g)	Open bolls number Plant^{-1}	Weight of boll (g)	Yield of seed cotton fed^{-1}(kentar)
			Season 2019		
T_1- Control (spraying tap water)	41.90	10.15	17.75	2.93	9.12
T_2- Spraying ITF at squaring start	41.54	10.32	20.85	2.92	9.94
T_3- Spraying ITF at the beginning of flowering.	42.16	9.96	22.15	3.07	10.58
T_4- Spraying ITF at the peak of flowering	40.89	10.41	22.85	2.97	10.34
T_5- (T_2+ T_3)	40.84	10.63	24.53	3.11	10.97
T_6- (T_3+ T_4)	41.27	10.51	23.63	3.08	10.51
LSD at 0.05	NS	NS	0.58	NS	0.33
Treatments			Season 2020		
T_1- Control (spraying tap water)	39.57	9.20	14.48	2.34	8.89
T_2- Spraying ITF at squaring start	41.38	10.18	16.92	2.70	9.62
T_3- Spraying ITF at the beginning of flowering.	40.37	9.48	16.19	2.43	9.41
T_4- Spraying ITF at the peak of flowering	40.57	9.71	16.46	2.69	9.45
T_5- (T_2+ T_3)	41.72	10.35	17.96	2.78	9.87
T_6- (T_3+ T_4)	42.33	10.48	18.83	2.84	10.26
LSD at 0.05	0.44	0.28	0.37	0.05	0.43

The positive effect of using two sprays of ITF (9.50% P_2O_5 +3.50% Mo) on yield of seed cotton and its components is mainly due to; The increase in fruiting branches results in more bolls per plant, which eventually enhance the productivity. Superior fruiting branches were noted with using these two treatments (Table 3). However, the control significantly reduced fruiting branches. Phosphorus generally increases Mo availability and this increase may be in part to the reduced of Mo adsorption by soil when P is applied. Which showed significant increase in open bolls number plant^{-1} in both seasons, the lowest boll shedding% and the highest boll setting%.

In this regard, foliar spray with P and Mo increased cotton yield through prolonged photosynthesis and carbon fixation, where these two nutrients prevent leaf senescence and photosynthesis decline (Bronson *et al*., 2001). Gebaly (2013) found that foliar spray with Mo at 0.8 g L^{-1} significantly increased open bolls number plant^{-1}, seed index and yield of seed cotton fed^{-1} in both seasons. However, lint% and boll weight insignificantly affected as compared with control. Ahmad *et al*. (2020) reported that phosphorous application significantly increased cotton yield in terms of bolls number plant^{-1}, boll weight, yield of seed cotton and ginning out turn. Spraying 150 kg phosphorus ha^{-1} is more suitable for greater cotton production. Ali *et al*. (2020) reported that phosphorous availability reduction resulted in reducing the cotton boll weight and size.

IV-Fibre quality parameters:

The effect of number and time of ITF foliar application on fiber micronaire, fiber uniformity ratio (%), fiber length (mm) and strength (Pressley units) are shown in Table 6. The number and time of sprays insignificantly affected fiber traits under study in both seasons.

Table 6. Effect of foliar application with Idai Top Flower (ITF) on cotton fiber quality in 2019 and 2020 seasons.

Treatments	Micronaire reading	Pressley index	2.5% Span length (mm)	Uniformity Index (%)
		Season 2019		
T_1- Control (spraying tap water)	4.6	10.8	34.8	86.5
T_2- Spraying ITF at squaring start	4.6	10.6	34.7	86.6
T_3- Spraying ITF at the beginning of flowering.	4.6	10.8	34.6	86.6
T_4- Spraying ITF at the peak of flowering	4.5	10.8	34.2	86.2
T_5- (T_2+ T_3)	4.6	10.9	34.4	86.2
T_6- (T_3+ T_4)	4.6	10.8	34.5	86.0
LSD at 0.05	NS	NS	NS	NS
Treatments		Season 2020		
T_1- Control (spraying tap water)	4.5	10.6	34.2	86.1
T_2- Spraying ITF at squaring start	4.6	10.6	34.1	86.4
T_3- Spraying ITF at the beginning of flowering.	4.6	10.6	34.5	86.3
T_4- Spraying ITF at the peak of flowering	4.5	10.5	34.2	86.0
T_5- (T_2+ T_3)	4.6	10.6	34.5	86.3
T_6- (T_3+ T_4)	4.4	10.6	34.4	86.5
LSD at 0.05	NS	NS	NS	NS

In this respect, Sawan *et al.* (2008) found that fiber properties did not affect by spraying plants with P_2O_5 at the three P concentrations (0.576, 1.152 and 1.728 kg of P ha^{-1}). Gebaly (2013) found that foliar application of Mo significantly increased fiber length parameters (upper half mean length and uniformity index), fiber bundle tensile strength (g/tex) and micronaire reading in both seasons. Abdel-Gayed *et al.* (2020) found that fiber traits were not affected by phosphorus application as foliar spraying twice.

CONCLUSION

It could be concluded that spraying with Idai Top Flower (ITF) at a concentration of 2 cm^3/liter two times at squaring start and the beginning of flowering or at the beginning of flowering and the peak of flowering increases the boll retention and productivity of cotton under conditions similar to El-Gemmeiza location. It was recommended.

REFERENCES

A.S.T.M. (2012): American Society for Testing and Materials. Designation, (D1447-07), (D1448-97) and (D1445-67).

Abdel-Gayed, S. Sh.; A. M. Abd El-Hafeez and M. A. A. Ibrahim (2020): Effect of Reducing Mineral Nitrogen and Phosphorus Fertilizer by Foliar Spraying of Phosphorus and Bio-Fertilization on Quality and Quantity of Cotton. J. of Soil Sci. and Agric. Eng., Mansoura Univ., 11 (1): 11- 15.

Abou Seeda M. A.; A. A. Yassen; E. A. A. Abou El-Nour and S. M. Zaghloul (2020): Importance of molybdenum and it diverse role in plant physiology: A Review Middle East J. Appl. Sci., 10(2): 228-249.

Ahmad, A.; H. Ali; Sh. Hussain; W. Hassan and R. Ahmad (2020): Supplemental application of phosphorus improves yield, quality and net returns of *Gossypium hirsutum.* Pure Appl. Biol., 9(4): 2577-2588.

Ali, H.; A. Ahmad and S. Hussain (2020): The effect of exogenous phosphorous application on growth, yield, quality and net returns of Upland cotton (*Gossipium hirsutum* L.). Appl. Ecology and Environ. Res., 18(1):769-781.

Ankerman, D. and L. Large (1974). Soil and Plant Analysis. A and L. Agriculture Laboratories. Inc., New York. USA.

Bambara, S. and P. A. Ndakidemi (2010): *Phaseolus vulgaris* response to *Rhizobium* inoculation, lime and molybdenum in selected low pH soil in Western Cape, South Africa. African J. of Agric. Res., 5(14): 1804-1811.

Barber, S.A. (1980): Soil-plant interactions in the phosphorus nutrition of plants. In The Role of Phosphorus in Agriculture, eds. Khasawneh, F.E.; E.C. Sample, and E.J. Kamprath, pp. 591–615. Madison, WI: American Society of Agronomy, Crop Science Society of America and Soil Science Society of America.

Barber, S.A. (1995): Soil Nutrient Bioavailability: A Mechanistic Approach, 2nd edition. New York: John Wiley & Sons.

Brady, N. C. and R. R. Weil (2008): The nature and properties of soils, 14th Ed. Prentice Hall, New Jersey.

Brent, N. K; L. G.Kate; N.B. Joanne; P. Thomas and D.T. Stephen (2005): The role of molybdenum in agricultural plant production. Annals of Bot., 96: 745-754.

Broadley, M., P. Brown, I. Cakmak, Z. Rengel, and F. Zhao (2012): Function of nutrients: micronutrients. In: P. Marschner, editor, Marschner's mineral nutrition of higher plants. 3rd ed. Academic Press, Waltham, MA. P.191-243.

Bronson, K. F.; A. B. Onken; J. D. Booker; R. J. Lascano; T. L. Provin and H. A. Torbert (2001): Irrigated cotton yields as affected by phosphorus fertilizer and landscape position. Commun. Soil Sci. Plant Anal., 32: 1959-1967.

Chiles, J. W. and J. L. Chiles (1991): The benefits of a starter fertilizer high in phosphate that can be sprayed on the leaves of seedling cotton. In: 8th Cotton Soil Management and Plant Nutrition Research Conference, Beltwide Cotton Conferences, National Cotton Council of America. 943.

Datta, J. K.; A. Kundu; S. D. Hossein; A. Banerjee and N. K. Mondal (2011): Studies on the impact of micronutrient (molybdenum) on germination, seedling growth and physiology of Bengal gram (*Cicer arietium*) under laboratory condition. Asian J. of Crop Sci., 3(2): 55-67.

Dohary, C. G.; I. J. Rochester and G. J. Blair (2004): Response of field grown cotton (*Gossypium hirsutum* L.) to phosphorus fertilization on alkaline soils in eastern Australia. Aust. J. Soil Res., 42: 913-920.

Dubetz, S. and J. Bole (1975): Effect of nitrogen, phosphorus, and potassium fertilizers on yield components and specific gravity of potatoes. Am. J. Pot. Res. 52(12), 399-405.

Estefan, G.; R. Sommer and J. Ryan (2013): Methods of Soil, Plant, and Water Analysis: A manual for the West Asia and North Africa region Third Edition. Beirut: ICARDA, 2013.

Gebaly, S. G. (2013): Effect of foliar application of etherel and combination of some micro-nutrients on productivity of Egyptian cotton plant. J. Plant Production, Mansoura Univ., 4 (6): 885-895.

Gupta, U.C. (1997): Soil and plant factors affecting molybdenum uptake by plants. In: U.C. Gupta, editor, Molybdenum in agriculture. 1st Ed. Cambridge Univ. Press, New York, NY. P.71- 91.

Hopkins, B. G. (2015): Phosphorus from: Handbook of Plant Nutrition by A. V. Barker and D. J. Pilbeam CRC Press.

Hopkins, B. G.; D.A. Horneck and A. E. MacGuidwin (2014): Improving phosphorus use efficiency through potato rhizosphere modifications and extension. Am. J. Potato Res., 91:161–174.

Huang, Q. N. (1998): Properties of phosphorus adsorption and desorption in red soil under a stand of Chinese fir in Fujian. J. Nanjing Forestry Uni., 22(2): 39-44.

Kaiser, B.N.; K.L. Gridley; J.N. Brady; T. Phillips and S.D. Tyerman (2005): The role of molybdenum in agriculture plant production. Ann. Bot., 96(5): 745-754.

Khalil, A. A. (2013): Significance of some soil amendments and phosphate dissolving bacteria to enhance the availability of phosphate in calcareous soil. ISRN Soil Sci., Article ID 438949, 7 pages.

Li, S. X.; Z. H. Wang and B. A. Stewart (2013): Responses of crop plants to ammonium and nitrate N. Adv. Agron., 118: 205-397.

Lindsay, W. L.; P. L. G. Vlek and S. H. Chien (1989): 'Phosphate minerals. In minerals in soil environment, 2nd ed. Eds. J B Dixon and S B Weed. pp. 1089-1130. Soil Science Society of America, Madison, WI, USA.

Malhotra, H.; V. S. Sharma and R. Pandey (2018): Phosphorus nutrition: plant growth in response to deficiency and excess. In book: Plant Nutrients and Abiotic Stress Tolerance Chapter 7: 171-190.

Marcante, N. C.; T. Muroaka; I. P. Bruno and M. A. Camacho (2016): Phosphorus uptake and use efficiency of different cotton cultivars in savannah soil (Acrisol). Acta Scientiarum. Agronomy Maringá, 38(2): 239-247.

Marschner, H. (1995): Mineral nutrition in higher plants. Wd Ltd. The Greystone Press, Antrim, Northern Ireland.

Mendel, R. R. and R. Haensch (2002): Molybdoenzymes and molybdenum cofactor in plants. J. of Exp. Bot., 53: 1689–1698.

Miller, R. W. and R. L. Donahue (1992): Soils: An introduction to soils and plant growth, Prentice Hall of India Pvt Ltd, New Delhi.

Mokhele, B.; X. Zhan; G. Yang and X. Zhang (2012): Review: Nitrogen assimilation in crop plants and its affecting factors. Can. J. Plant Sci., 92(2): 399-405.

Nicholas, D. J. D. (1975): The function of trace elements in plants. In: D. J. D. Nicholas and A R Edan (eds), Trace elements in soil–plant–animal systems. Academic Press, New York, USA. pp: 181– 198.

O'Conner, K.F. (1968): The role of agricultural land use in affecting water quality. Lincoln Pap. Water Recour., 1: 52-65.

Resende, G. M.; M. A. R. Alvarenga; J. E. Yuri and R. J. Souza (2010): Yield and postharvest quality of winter growing crisp head lettuce as affected by doses of nitrogen and molybdenum. Hortic. Bras, 28(4): 441-445.

Richmond, T. R. and S. R. H. Radwan (1962): Comparative study of seven methods of measuring earliness of crop maturity in cotton. Crop Sci., 2: 397-400.

Sauer, P. and I. Frebort (2003): Molybdenum cofactor-containing oxidoreductase family in plants. Biologia Plantarum. 46: 481–490.

Sawan, Z. M.; M. H. Mahmoud and A. H. El-Guibali (2008): Influence of potassium fertilization and foliar application of zinc and phosphorus on growth, yield components, yield and fiber properties of Egyptian cotton (*Gossypium barbadense* L.). J. of Plant Eco., 1(4): 259-270.

Sillanpãã, M. (1982): Micronutrients and nutrient status of soils: A global study. FAO Soils Bull. 48. pp. 343–409.

Singh, S. S. (2003): Soil fertility and nutrient management. Kalyani Publishers New Delhi India.

Sposito, G. (2008): The Chemistry of Soils. Oxford University Press, New York, 2nd edition.

Steel, R. G.; J. H. Torrie and D. A. Dickey (1997): Principles and Procedures of Statistics: A Biometrical Approach, 3rd ed.; McGraw Hill Book International Co.: Singapore.

Steiner, F.; T. Zoz; A. M. Zuffo; P. P. Machado; J. Zoz and A. Zoz (2018): Foliar application of molybdenum enhanced quality and yield of crisp leaf lettuce (*Lactuca sativa* L., cv. Grand Rapids). Acta Agron., 67(1): 73–78.

Taiz, L. and E. Zeiger (2010): Plant Physiology, 5th ed.; Sinauer: Sunderland, MA, USA.

Tedesco, M. J.; C. Gianello; C. A. Bissani; H. Bohnen and S. J. Volkweiss (1995): Análises de solos, plantas e outros materiais. 2nd ed. Porto Alegre: UFRGS, 174 p.

Tisdale, S. L.; W. L. Nelson and J. D. Beaton (1985): Soil Fertility and fertilizers, 4th ed. Macmillan Publication, New York.

Tisdale, S. L.; W. L. Nelson; J. D. Beaton and J. L. Havlin (1993): Soil fertility and fertilizers. 5 th ed. New York, Macmillan Publishing Co.

Uchida, R. (2000): Essential nutrients for plant growth: nutrient functions and deficiency symptoms. Plant Nutrient Management in Hawaiis soils. Approaches for tropical and Subtropical Agric., Chapter 3: 31-55.

Verma, N.; S. Chaudhary and S. Goyal (2018): Long term effects of inorganic fertilizers and organic amendments on ammonification and nitrification activity of soils under cotton wheat cropping system. Int. J. Curr. Microbiol. App. Sci., 7: 718-724.

Waller, R. A. and D. B. Duncan (1969): A bays rule for the symmetric multiple comparison problem. J. Amer. Stat. Assoc.,1485-1503.

Wild, A. (1953): The effect of exchangeable cation on the retention of phosphate by clay. J. Soil Sci., 4: 72-85.

Zöbisch, M. A.; C. Richter; B. Heiligtag and R. Schlott (1994): Nutrient losses from cropland in Central Highlands of Kenya due to surface runoff and soil erosion. Soil Till. Res., 33: 109-116.

دراسات فسيولوجية لتحفيز التزهير وتثبيت عقد اللوز فى نبات القطن

مجمد حامد عبد العال ، على السيد الجعبيرى و محمود وجدى محمد الشاذلى
قسم بحوث فسيولوجى القطن- معهد بحوث القطن- مركز البحوث الزراعية- الجيزة- جمهورية مصر العربية.

أجريت تجربتان حقليتان بمحطة البحوث الزراعية بالجميزة - محافظة الغربية - مصر خلال الموسمين الزراعيين (٢٠١٩ و ٢٠٢٠م) بهدف دراسة تاثير التغذية الورقية بايداى توب فلور بتركيز ٢سم٣ /لتر مرة واحدة (فى بداية الوسواس أو بداية التزهير أو قمة التزهير) ومرتين (فى بداية الوسواس وبداية التزهير أو فى بداية التزهير وقمة التزهير) على تحفيز التزهير وتثبيت عقد اللوز والإنتاجية لصنف القطن المصري جيزة ٨٦، مقارنة مع النباتات غير المعاملة . وتم أستخدام تصميم القطاعات الكاملة العشوائية فى أربعة مكررات. وأوضحت النتائج أن التغذية الورقية بايداى توب فلور مرتين (فى بداية الوسواس وبداية التزهير أو فى بداية التزهير وقمة التزهير) أدت الى زيادة معنوية فى النمو ، دلائل العقد والتبكير باستثناء % للتساقط والتى انخفضت ، عدد اللوز المتفتح/ النبات ، ومحصول القطن الزهر/الفدان فى الموسمين وكذلك وزن اللوزة ، معامل البذرة ، النسبة المئوية للتيلة فى الموسم الثانى وأعطت النباتات غير المعاملة اقل القيم فى هذه الصفات مع زيادة معنوية فى النسبة المئوية للتساقط . بينما لم تتأثر النعومة ومتانة التيلة وطول التيلة ودليل انتظام الطول. وخلصت الدراسة الى أن التغذية الورقية بايداى توب فلور بتركيز ٢سم٣ /لتر مرتين (فى بداية الوسواس وبداية التزهير أو فى بداية التزهير وقمة التزهير) حققت أعلى عقد وانتاجية وتوصى الدراسة بامكانية تطبيقها من قبل المزارعين لزيادة العقد والإنتاجية للقطن تحت ظروف مماثلة لمنطقة الجميزة.