Utilization of Thinned Cotton Plants through Bare-Root Transplanting Coupled with Foliar Application of Nutrients

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ABSTRACT

A two year experiment was conducted to investigate the possibility of transplanting cotton plants of the cultivars Giza 86 and Giza 88 thinned from hills grown in the permanent field. The bare-root transplants (BRT) were thinned at the age of 30 days and transplants received three different foliar applications of macro- and micro-nutrients as compared to the direct seeded plants. The BRT method with five foliar applications of macronutrients and two foliar applications of micronutrients significantly improved survival rate of seedlings and surpassed the directly sown plants in seed-cotton yield and its components. Increase in yield was 11.4% for Giza 86 and 4.9% for Giza 88. No effects for transplanting on fiber properties were observed for the cultivar Giza 88. The BRT method with seven foliar applications was suggested as a practical and affordable method for cotton transplanting compared to potted-transplanting (PT). These results have positive implications on the utilization of plants that are usually wasted by the thinning process (about 60-70%) in the direct seed sowing method, especially in areas devoted for cultivars' seed multiplication. A second application of the BRT method is identical to the PT method but rather cheaper, where nurseries (as in rice transplanting) could be grown directly in the permanent field, allowing the preceding winter crops to reach maturity, while cotton nurseries are grown on the optimum sowing date during March. Thus the main goal of the transplanting process would be achieved, namely; 70% less amount of seeds would be required for sowing annually. This implies that demand on seeds produced by the government will decline by the same rate and thus more focus on seed quality and genetic purity, rather than seed mass production, could be achieved.

Key words: Potted-transplanting, *Gossypium brabadense* L., transplanting, fiber properties.

INTRODUCTION

Cotton production in Egypt has been on the decline for the past decade. The cultivated area has fallen from 270,000 ha in 2005 to 67,000 ha in 2015, while production has dropped from 657,000 to 241,000 ton for the same period according to CAPMAS (2017). The reasons for the unprecedented reduction in growing area and production as elaborated by USDA FAS (2016), could be explained by the floundering decisions regarding local cotton pricing, delivery and imports of competing short staple cottons. Second, the profitability of wheat cultivation and the government's interest in expanding its growing area (wheat is a winter crop that can precede cotton in the crop rotation, causing the delay in growing cotton than the optimum growing date or avoiding cotton planting and growing vegetable crops instead). Finally and most seriously, is the genetic purity degradation of the extra-long and long staple cotton varieties. Because of these circumstances, each pure seed of the Egyptian cotton varieties is extremely valuable and should be utilized efficiently. Traditional cotton growing requires around 30 kg/feddan of cotton seeds, where 5-7 seeds are sown/hill, that are later on thinned to 2 plants/hill, indicating that almost 60-70% of the seeds sown are eliminated during thinning. In 2014, the Ministry of Agriculture and Land Reclamation (MALR), through its extension service, posted its protocol for cotton transplanting as a new agricultural technique in cotton. The technique employs foam trays (100 trays, 209 holes each/feddan) to germinate the seeds under greenhouse conditions. The main idea was to save on seeds (8 kg/feddan instead of 30 kg/feddan in direct sowing method, i.e. 73% saving on seeds), amount of irrigation water and pesticides, besides giving the preceding winter crops (wheat, faba bean, sugar beet and berseem clover) the chance to fetch farmers maximum profit without delays in growing cotton in the permanent field and directing the excess of seeds for oil extraction (CAAES, 2017a).

Cotton transplanting is an old practice that dates back to 1912 in Turkestan, as reported by Christidis (1962). It was adopted in regions with a short warm season and utilized the warmth of decomposing farm manure (replaced by greenhouses today) that allowed seedlings to grow in clay pots until the temperature of the permanent field was suitable enough for transplanting. This method brought about early flowering, boll maturity and increase in yield compared to the direct sowing method. The method is being deployed in many countries today utilizing polyethylene bags, paper pots or peat moss cubes. Seedlings grown by this method are later transferred to the permanent field with their roots wrapped in soil or peat moss. This method of transplanting will be referred to as "PT; potted transplanting" herein. In China, reports have

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indicated that 30% of the area devoted to cotton was grown by PT, while 20% was sown directly in the permanent field under polyethylene mulching sheets (Gillham, 1995). Bt cotton China is transplanted, via the regular transplanting method when seedlings achieve 3-4 leaves and after the soil temperature reaches 19^{o}C, into previously dug and fertilized holes (Xu and Fok, 2007). Roots of the transplanted cotton plants are usually shortened and plants grow more vigorous than direct seeded plants and increase in yield up to 35% is common. In India, farmers are encouraged to use the PT method, as to avoid negative drought effects on cotton in the permanent field; however, the method is too expensive for many farmers (Krave, 2003). In Egypt, adoption of the PT technique is also regarded expensive to farmers compared to the market price of seed-cotton (Kamel *et al*., 1991).

A second transplanting method involves sowing cotton seeds in a nursery, directly in the field, under the same conditions of the permanent field, then moving/transplanting the seedlings at the specified age to the permanent field without polyethylene mulching, with bare roots and this method will be termed hereafter "bare-root transplanting" in short "BRT". The method was described by Ghaly *et al*. (1987) with the modification of spreading a plastic sheet at a depth of 10-15cm beneath the nursery soil as a tool to prevent seedling root damage when uprooting for transplanting. The work of Bakheit (1965) is the earliest documented and most extensive on cotton transplanting using BRT and was conducted at Assiut University, Egypt. He studied the effect of seedling age at transplanting, number of transplanted seedlings/hill, root pruning and soil moisture at transplanting on seedling survival, plant phenology, yield and fiber properties of transplanted cotton compared to the directly sown seeds. His results indicated that BRT plants flowered and matured much later and were heavily affected by boll weevils than directly seeded cotton, resulting in significantly lower yield and its components. BRT yielded only 20-57% that of directly sown cotton and was thus declared infeasible. Similarly, Ghaly *et al*. (1987), Hamed (1995), Dwedar (1998) and Ismail *et al*. (2000) in Egypt, all came to the conclusion, that seed-cotton yield of direct seeded cotton was higher than transplanted cotton. In India, Krave (2003) reported that the BRT plants failed to survive after transplanting.

The aim of the present study was to investigate the effect bare-root transplanting (BRT) with the application of nutrient foliar treatments on improving the survival rate and productivity of transplants collected from thinned cotton seedlings of two Egyptian cotton cultivars.

MATERIALS AND METHODS

The experiments were executed at Abbis experimental station of the Faculty of Agriculture, Alexandria University, Egypt. The soil in the location was sandy loam, moderately alkaline (pH 8.4), with EC of 1.30 dSm^{-1} and 1.5% organic matter content. Seeds of the two cultivars Giza 86 and Giza 88, obtained from MALR, were sown on the 1st of April in 2015 and 10th of April in 2016 in a split-plot experiment with three replicates. The main plots were devoted to the cultivars, while the subplots contained the four growing methods namely;

1. DS: Direct sowing
2. BRT+0: Transplanting + 5 sprays of "Nile Flor" from Strading S.R.L., registration no. 6181 (3.1% N, 1% P_2O_5, 2% K_2O, 200 ppm Mg, 100 ppm Zn, 30 ppm Cu, 0.01% B and 6% free amino acids), at a rate of 1L/feddan after 2, 12, 24, 48 and 64 days after transplanting (DAT).
3. BRT+1: Transplanting + 5 sprays Nile Flor + 1 spray of "Micro-Pull" from Agro Science, registration no. 3336 (7% Fe, 5% Zn, 4% Mn, 3% Mg, 0.3% B, 12.7% S, in addition to amino acids), at the rate of 2g/L, after 81 DAT.
4. BRT+2: Transplanting + 5 sprays Nile Flor + 2 sprays of Micro-Pull, after 81 and 94 DAT.

Each of the 24 experimental plots was made up of four ridges, 3 meters long and 70 cm apart. Seven to ten seeds were sown in hills 25 cm apart on one side of each ridge in the plots sown directly. Thirty days after seed sowing, hills were thinned, leaving 2 plants/hill and the thinned plants were transplanted in the corresponding plots for each of the studied cultivars in presence of water. Transplanted plots were irrigated one week after transplanting and three more irrigations followed, making up a total of five irrigations, compared to six for directly sown plots. The last irrigation was on the first week of July and harvesting was performed on the second week of September for both years.

Data on plant height, number of vegetative branches, number of fruiting branches, total number of bolls/plant, number of opened bolls/plant, number of green bolls/plant, seed-cotton weight/boll (g), lint weight/boll (g), and lint weight/plant (g), was recorded on five random plants taken from the middle two ridges of each experimental plot. Seed-cotton yield in Kentar/feddan was calculated based on yield from the two guarded ridges for each experimental plot. Fiber properties of the cultivar Giza 88 across the two growing seasons including; fiber length [fiber upper half mean (U.H.M), in mm and uniformity index (U.I. %)], fiber strength [strength (Str.) in g/tex and elongation (Elg.) as a percent], micronaire reading (Mic.), short fiber (S.F.) as % <12.7 mm and maturity ratio (Mat. R. %), were determined using the High Volume Instrument (HVI). Statistical analyses was performed using SAS 9.3 software (SAS Institute, Inc., 2007) for each year separately, then a combined analysis over the two years of study was undertaken due to the uniformity of error of variance according to (Winer, 1971). Significance was declared at $P < 0.05$, and the least significant difference ($L.S.D_{0.05}$) was used for comparison of means.

RESULTS AND DISCUSSION

While the term "transplant" means; to lift and reset (a plant) in another soil or situation or to remove from one place or context and settle or introduce elsewhere (Transplant, 2017), literature on transplanting left us baffled. A number of studies reported that cotton transplanting leads to early flowering and boll opening and eventually an increase in yield on one hand, while others reported that it leads to late flowering, boll opening and tremendous loss in yield. Thus the term bare-root transplanting (BRT), originally used for trees, was suggested here to explain that transplants were thinned as opposed to the regular potted-transplanting (PT) of plants originally grown in pots, peat moss cubes, and trays or similar, before transplanting.

In a preliminary work on transplanting cotton, we came to realize that the root system of BRT plants changed morphologically after the tip of the main tap root was cut during transplanting. The root system was observed to be shallow growing and spreading horizontally as opposed to a normal tap root system of a normal cotton plant. Furthermore, plants were extremely late flowering and rarely open bolls were detected. Based on these observations that were also reported earlier by Bakheit (1965), we were convinced that in case of BRT, plants should be handled differently than directly sown plants and potted-transplants that do not experience a long recovery period after transplanting as BRT. Our observations also indicated that survival rate of BRT was estimated to be 50% (data not shown).

Results of the analysis of variance combined over the two years of study (Table 1), indicated insignificant variations among years for all studied traits except the number of fruiting branches/plant. A higher number of fruiting branches/plant (9.51) was observed in the first growing season as compared to only 8.77 branches in the second season (data not shown). The interaction between years and each of the cultivars and growing methods, in addition to the three way interaction between the three factors, was insignificant for all studied traits. On the other hand, significant differences were detected among cultivars, growing methods and their interactions for most studied traits (Table 1). Regarding the main effects of the studied factors and their interactions, they could be summarized as follows:

I) Cultivar effect:

The cultivar Giza 86 showed significantly taller plants, higher number of fruiting branches, total number of bolls, open bolls, and green bolls/plant and consequently higher seed-cotton weight, fiber weight/plant and seed-cotton yield/feddan as compared to Giza 88 (Table 2). Insignificant differences however, were observed for the number of vegetative branches/plant and boll weight between the two cultivars. These results fulfill the true characteristics of the cultivars, since Giza 88 is known to be an extra-long staple cultivar of lower yield compared to the long-staple cultivar Giza 86 (ICAC, 2010)

II) Growing method effect:

The results presented in Table (2) indicated that the growing methods had insignificant effects on the number of vegetative branches/plant and boll weight. A trend, however, for a higher number of vegetative branches from the direct seeding method (DS), as opposed to the other methods, with the least number of vegetative branches (2.58) recorded for the BRT+2 treatment. The growing method BRT+2 had a significantly higher number of fruiting branches (11.72) compared to almost eight branches/plant, for the other growing methods. The total number of bolls, green bolls and open bolls/plant, were also significantly higher for the BRT+2 growing method with an increase amounting to nearly 53% than the DS, for all three traits. Similarly, the BRT+2 growing method out-yielded the DS growing method by 56.8% for seed-cotton/plant, 56.6% for lint weight/plant and 8.26% for seed-cotton yield/feddan as shown in Table (2). Since cotton yield is a combination of boll number and size, Cothren (1999), indicated that any treatment to improve on either trait is essential for improving yield. Results from our work on both cultivars Giza 86 and Giza 88 have shown no response to the various treatments on boll weight indicating that boll number is the key trait controlling yield here. It is quite clear that the second foliar application of micronutrients at the age of 94 DAT has significantly increased the total number of bolls by 31.6% and the number of opened bolls by 21.8% for BRT+2 compared to a single spray BRT+1, as observed in Table (2). Guinn, (1982) indicated that the correction of micronutrient deficiencies can cause large yield increases per unit of cost. A mild deficiency of boron for example may cause most of the fruits to abscise without limiting plant growth. The increase in yield could thus be attributed to either an increase in number

Table 1. Mean squares and levels of significance for cotton traits as affected by cultivar (C) and growing method (GM) combined over the 2015 and 2016 years of study

S.O.V	d.f	Plant Height	Vegetative branches	Fruiting branches	Total bolls/plant	Green bolls/plant	Open bolls/plant	Boll weight	Seed-cotton/plant	Lint weight/plant	Seed-cotton yield/fed
Year (Y)	1	15.19$^{n.s.}$	0.16$^{n.s.}$	0.19**	3.80$^{n.s.}$	0.04$^{n.s.}$	0.03$^{n.s.}$	0.02$^{n.s.}$	16.32$^{n.s.}$	5.75$^{n.s.}$	0.13$^{n.s.}$
Replicate (Rep.)	2	58.08	0.07	0.01	7.64	0.03	0.05	0.07	19.19	2.14	0.02
Y x Rep.	2	0.96	0.10	0.001	4.07	0.02	0.05	0.12	32.14	3.59	0.01
Cultivar (C)	1	17252.0 8**	0.16$^{n.s.}$	0.86**	251.63**	3.16**	0.73*	0.24$^{n.s.}$	458.46**	51.43**	8.29**
Y x C	1	7.84$^{n.s.}$	0.02$^{n.s.}$	0.001$^{n.s.}$	0.35$^{n.s.}$	0.001$^{n.s.}$	0.01$^{n.s.}$	0.01$^{n.s.}$	0.06$^{n.s.}$	0.001$^{n.s.}$	0.003$^{n.s.}$
Y x Rep. x C	4	50.01	0.16	0.02	6.54	0.02	0.08	0.13	51.3	5.81	0.02
Growing Method (GM)	3	7579.54**	0.15$^{n.s.}$	0.92**	248.90**	1.78**	1.47**	0.02$^{n.s.}$	457.25**	51.14**	1.94**
Y x GM	3	5.98$^{n.s.}$	0.08$^{n.s.}$	0.01$^{n.s.}$	1.38$^{n.s.}$	0.05$^{n.s.}$	0.001$^{n.s.}$	0.10$^{n.s.}$	13.99$^{n.s.}$	1.41$^{n.s.}$	0.031$^{n.s.}$
C x GM	3	773.93**	0.27$^{n.s.}$	0.42**	17.93$^{n.s.}$	0.14$^{n.s.}$	0.27**	0.01$^{n.s.}$	128.73**	14.45**	0.44**
Y x C x GM	3	7.63$^{n.s.}$	0.18$^{n.s.}$	0.003$^{n.s.}$	2.75$^{n.s.}$	0.05$^{n.s.}$	0.004$^{n.s.}$	0.22$^{n.s.}$	31.33$^{n.s.}$	3.52$^{n.s.}$	0.02$^{n.s.}$
Error b	24	42.38	0.13	0.02	6.13	0.07	0.05	0.12	24.12	2.76	0.04

*Significant at 0.05 level of probability, **Significant at 0.01 level of probability, n.s.: Not-significant

Table 2. Means for plant height, number of vegetative and fruiting branches/plant, total number of bolls/plant, number of green and open bolls/plant, boll weight, seed-cotton weight/plant and lint weight/plant and seed-cotton yield/feddan combined over the two growing season 2015 and 2016 as affected by each of the cultivar and the growing method

Cultivar	Plant Height (cm)	No. of vegetative branches /plant	No. of fruiting branches /plant	Total no. of bolls/plant	No. of green bolls/plant	No. of open bolls/plant	Boll weight (g)	Seed-cotton weight/plant (g)	Lint weight/plant (g)	Seed-cotton yield/fed (Kentar)
Giza 86	135.76a	2.85a	9.88a	22.87a	8.72a	14.15a	2.35a	33.23a	11.14a	9.52a
Giza 88	97.84b	3.02a	8.40b	18.29b	6.04b	12.25b	2.21a	27.05b	9.07b	8.68b
Growing Method	**Plant Height (cm)**	**No. of vegetative branches /plant**	**No. of fruiting branches /plant**	**Total no. of bolls/plant**	**No. of green bolls/plant**	**No. of open bolls/plant**	**Boll weight (g)**	**Seed-cotton weight/plant (g)**	**Lint weight/plant (g)**	**Seed-cotton yield/fed (Kentar)**
DS	101.54b	3.76a	8.33b	17.87b	6.82b	11.05c	2.23a	24.72c	8.29c	8.96b
BRT+0	104.65b	2.73a	8.17b	18.33b	6.77bc	11.56c	2.33a	26.85bc	9.0bc	8.91b
BRT+1	106.64b	2.68a	8.34b	18.74b	5.49c	13.25b	2.29a	30.25b	10.13b	8.83b
BRT+2	154.37a	2.58a	11.72a	27.39a	10.45a	16.94a	2.28a	38.75a	12.98a	9.7a

Means followed by the same letter (s) within the same column for each treatment, are insignificantly different at 0.05 level of probability of squares produced or decrease in abscission of fruiting organs or both.

The positive effects of foliar application of micronutrients, has been observed in *Gossypium brabadense* L. (Eleyan *et al*., 2014) and *Gossypium hirsutum* L. (Sankaranarayanan *et al*., 2010).

III) Cultivar x growing method effect:

Results on the interaction between cultivars and growing methods combined over the two years have emphasized the significant superiority of the BRT+2 growing method over the DS method for both cultivars (Table 3). However, the number of vegetative branches, total bolls and green bolls/plant, were insignificantly different. The BRT+2 growing method resulted in the highest significant values for the cultivar Giza 86 for all traits, except the number of fruiting branches/plant, where the cultivar Giza 88 was significantly higher, as shown in Table (3). Regarding seed-cotton yield/fed, all the studied transplanting methods significantly surpassed the DS method by 11.4, 3.2 and 3.7% for the BRT+2, BRT+1 and BRT+0 growing methods for the cultivar Giza 86, respectively. On the other hand, only the BRT+2 growing method significantly exceeded the seed-cotton yield/fed of the DS method by 4.9%, for the cultivar Giza 88. The BRT+1 and BRT+0 showed significantly 6.3 and 4.9% lower yields than the DS for the cultivar Giza 88. Results clearly indicated that cultivars responded differently to the different transplanting treatments. The BRT+2 method for the cultivar Giza 86 yielded 11.4% higher than the DS growing method as compared to only 4.9% for the cultivar Giza 88 (Table 3).

Based on the previous results, it could be concluded that at least five foliar applications of macro-nutrients were essential to ensure a survival rate of 70% of the bare-root cotton transplants for the two studied cultivars (data not shown). Although those five sprays were enough for survival and resumption of vegetative growth, two more foliar applications of micronutrients were necessary to out-yield the traditional, direct sowing method. Micronutrients applied in a foliar form, is thought to improve cotton production in general and especially in soils with high pH values as observed in our experimental location (pH= 8.4). Elhamamsey *et al*. (2016) reported insignificant effects for micronutrient application on square and boll shedding, number of bolls/plant or seed-cotton yield/feddan for the cultivar Giza 90 and attributed this lack of effect to the availability of micronutrients at the test location of soil pH= 7.6 in Egypt. Abdallah and Mohamed (2013), in Egypt, on the other hand, using the cultivars Giza 90 and Giza 92, observed 4-11.4% increase in seed-cotton yield due to foliar application of micronutrients depending on the cultivar and year in a location with a soil pH of 8.3-8.6. Similar results on *G. hirustum* in Pakistan were reported by Yassen *et al*. (2013), where foliar application of micronutrients brought about 20-30% more economic benefit than ground application of NPK alone in soils of pH= 7.8. It should be rather interesting to observe the results of foliar application of micronutrients on DS cotton in the Delta region, since the practice is recommended by the MALR only in the newly reclaimed areas (CAAES, 2017b).

Since cotton is a perennial plant with indeterminate growth, the occurrence of varying stages of floral and fruiting organs on the same plant simultaneously is quite common (Loka and Oosterhuis, 2012). At the same time, the length of the growing season is correlated with the heat units accumulated by the plants (Peng *et al*., 1989).

Table 3. Means for plant height, number of fruiting branches and open bolls/plant, seed-cotton and lint weight/plant and seed-cotton yield/feddan combined over the two growing seasons 2015 and 2016 as affected by the interaction between the cultivars and the growing methods

Cultivar	Growing method	Plant Height (cm)	No. of fruiting branches /plant	No. of open bolls/plant	Seed-cotton weight/plant (g)	Lint weight/plant (g)	Seed-cotton yield/fed (Kentar)
Giza 86	DS	124.75c	9.92c	10.94d	28.08b	9.42b	9.10c
	BRT+0	131.42c	8.59d	9.83e	27.28b	9.14bc	9.44b
	BRT+1	124.2c	10.02c	11.50c	31.21b	10.46b	9.39b
	BRT+2	162.72a	11.0b	15.08a	46.37a	15.53a	10.14a
Giza 88	DS	78.35e	6.75f	8.25f	21.36c	7.16c	8.83d
	BRT+0	77.88e	7.75e	9.65e	26.42bc	8.87bc	8.40e
	BRT+1	89.12d	6.67f	9.68e	29.29b	9.80b	8.27e
	BRT+2	146.02b	12.43a	13.62b	31.13b	10.43b	9.26bc

Means followed by the same letter (s) within the same column are insignificantly different at 0.05 level of probability.

Table 4. Means for fiber upper half mean, uniformity index, fiber strength, elongation, micronaire reading, short fiber and maturity ratio measured for the cultivar Giza88 combined over the two growing seasons 2015 and 2016 as affected by the growing method

Growing Method	Upper half mean (U.H.M) mm	Uniformity index (U.I.) %	Strength (Str.) g/tex	Elongation (Elg.) %	Micronaire reading (Mic.)	Short fiber (S.F.) %	Maturity rate (M.R.) %
DS	35.37a	87.75a	43.63a	5.02a	4.34a	5.50a	0.878a
BRT+0	36.02a	89.18a	46.03a	4.95a	4.35a	5.45a	0.878a
BRT+1	35.60a	88.30a	45.50a	4.88a	4.35a	5.57a	0.878a
BRT+2	35.13a	86.77a	44.47a	5.08a	4.34a	5.87a	0.875a

Means followed by the same letter within the same column are insignificantly different at 0.05 level of probability.

It is thus important to determine when and how to end the growing season of the cotton plants.

In our work here, two approaches were practiced after beginning of flowering to direct the plants faster towards reproductive growth. The first was halting irrigation at the age of 90 DAT, as Singh (1975) indicated that moister stress prior to flowering was noticed to increase blooming rate and yield. The second approach was the spraying of micronutrients at the age of 81 and 94 DAT while ceasing nitrogen foliar application, as cotton delays flowering with increased nitrogen rates (Leffler and Hunter, 1985). Results presented here have indicated that both approaches combined, successfully achieved the goal and at the same time supported enough number of bolls for satisfactory seed-cotton yield. A future promising approach would be to grow cotton a month earlier (March), to improve on the amount of heat units accumulated and that should enhance higher seed-cotton production.

Negative effects of transplanting on fiber properties have been reported by Dwedar (1998) and Ismail *et al*. (2000). The fiber properties of the cultivar Giza 88, studied over the two years (Table 4), were insignificantly affected by the growing methods under study, indicating that the transplanting method employed here with the foliar application of nutrients, had no effects on fiber properties. Furthermore the fiber properties measured complied with the standard characteristics of the cultivar according to ICAC (2010).

Optimum production inputs of transplanted cotton plants should be further investigated. Rao *et al*. (1999) reported that the efficiency in nutrient acquisition from the soil (especially phosphorus) depends greatly on the root length, distribution density, diameter and the geometrical arrangement of the root hairs, especially in low nutrient status in the soil. Also, Wise *et al*. (2000) and Wahid *et al*. (2003) pointed out that the low yielding, better fiber quality, sensitive to suboptimal conditions and of longer growing season *G. barbadense* L. differs in many aspects from the *G. hirsutum* L. Thus, it could be concluded that there is definitely a window for improvement on yield using the BRT method employing different cultivars, but also under different production conditions, mainly due to the change in the morphology of the BRT root system compared to the normal cotton plant. Such improvements can be better realized if studies were focused on local cultivars.

The results presented here have clearly indicated that it is now feasible to grow cotton using the bare-root transplanting technique, provided that foliar application of macro and micronutrients are timely applied to improve the transplants' survival rate and to insure enough bolls and lint for commercial production. The BRT method is definitely cheaper than potted-transplanting and requires less effort. Similar to rice, cotton nurseries could be grown in March, uprooted and transplanted directly to the permanent field without negative impacts on the preceding winter crop in Egypt. Further application of the BRT method would be the utilization of thinned cotton plants especially in areas devoted for cultivars' seed multiplication instead of wasting the thinned plants. Finally, once adopted, the BRT method would reduce the amount of seeds the government needs to produce and distribute annually, thus allowing for more focus on seed quality and genetic purity rather than seed mass production.

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REFERENCES

Abdallah, A. M. and H. F. Y. Mohamed. 2013. Effect of foliar application of some micronutrients and growth regulators on some Egyptian cotton cultivars. *J. Applied Sci. Res.*, 9(6): 3497-3507.

Bakheit, E. S. 1965. Growing cotton by transplanting. M.Sc. Thesis, Faculty of Agric. Assiut Univ.

CAAES. 2017a. Central Administration for Agricultural Extension Service, Egypt, (In Arabic). [online] Retrieved from http://www.caaes.org/topics/144123#http://www.caaes.org/posts/592080 [15 December 2017].

CAAES. 2017b. Central Administration for Agricultural Extension Service, Egypt, (In Arabic). [online] Retrieved from http://www.caaes.org/topics/144123#http://www.caaes.org/posts/595066 [15 December 2017].

CAPMAS. 2017. Statistical year book of the Central Agency for Public Mobilization and Statistics, Egypt. Issue no.108 Ref. no. 71-01111-2017.

Christidis, B. G. 1962. Growing cotton by transplantation. Crop Sci., 2(6): 472-475.

Cothren, J. T. 1999. Physiology of the cotton plant. *In*: Cotton: origin, history, technology, and production. C. W. Smith and J. T. Cothren (eds.) Vol. 4., John Wiley & Sons.

Dwedar, M. D. H. 1998. The effect of transplanting and some cultural practices on cotton productivity and fiber quality in Fayoum region. M.Sc. Thesis, Faculty of Agric. El-Fayoum, Cairo Univ.

Eleyan, S. E. D, A. A. Abdall, A. M. Abdallah and R. A. Houda. 2014. Effect of foliar application of manganese and iron on growth characters, yield and fiber properties of some Egyptian cotton cultivars (*Gossypium barbadense* L.) *Int. J. Agric. Crop Sci.*, 7 (13): 1283-1292.

Elhamamsey, M. H., E. M, Shalaby, E. A. Ali and M. A. Emara. 2016. Effect of some cultural practices on shedding and yield of Egyptian cotton. *Assiut J. Agric. Sci*., 47 (4): 41-51.

Ghaly, F. M., K. El-Bayomy and F. Radwan.1987. Effect of transplanting cotton seedlings on yield and its components in Giza 75 cotton cultivar. *Ann. Agric. Sci. Moshtohor*, 25(4): 1853-1860.

Gillham, F. E. 1995. Cotton production prospects for the next decade (Vol. 23). World Bank Publications.

Guinn, G. 1982. Causes of square and boll shedding in cotton., U.S. Department of Agriculture Technical Bulletin No.1672, 21 p., illus.

Hamed, F. S. 1995. Effect of transplanting on growth and yield of Egyptian cotton. M.Sc. Thesis, Faculty of Agric. Assiut Univ.

ICAC. 2010. Arab Republic of Egypt statement of the Egyptian delegation to the 69th plenary meeting of the International Cotton Advisory Committee (ICAC) 20-25 September 2010 Lubbock, Texas, USA, pp: 18.

Ismail, F. M., M. R. A. Abd El-Malak and M. D. Hassan. 2000. Effect of transplanting and some cultural practices on earliness, productivity and some technological fiber properties of Egyptian cotton. *Mansoura J. Agric. Sci.,* 25(12): 7345-7356.

Kamel, A. S., K. E. El-Habbak, M. A. El-Masry, M. M. El-Mihi and M. A. Abou-Kresha. 1991. New agrotechniques in transplanting cotton in Egypt. *Ann. Agr. Sci.*, Moshtohor, 29(2): 681-687.

Karve A. D. 2003. High yield of rainfed cotton through transplanting. *Curr. Sci.*, 85 (2):122-123.

Leffler, H. R. and J. H. Hunter. 1985 Reproductive development and seed quality of cotton cultivars as affected by nitrogen fertilization. *Field Crops Res.,* 10: 219-228.

Loka, D. A. and D. M. Oosterhuis. 2012. Water stress and reproductive development in cotton, pp. 51-58. *In*: Flowering and fruiting in cotton. Oosterhuis, D.M. Cothren, J. T. and Robertson, W. C. (eds.). The Cotton Foundation, Cordova, Tennessee, USA.

Peng, S., D. R. Krieg and S. K. Hicks. 1989. Cotton lint yield response to accumulated heat units and soil water supply. *Field Crops Res.*, 19(4): 253-262.

Radwan, F. E. and K. K. I. Abdel-Malak. 1995. Effect of cotton transplanting, N and P_2O_5 on yield and its components. *Assuit J. Agr. Sci.,* 26(2): 93-104.

Rao, I. M., D. K. Friesen, and M. Osaki. 1999. Plant adaptation to phosphorus-limited tropical soils, pp. 61-95. *In*: Handbook of plant and crop stress. Pessarakli M. (ed.). 2nd edition, Marcel Dekker Inc., New York. Basel.

Sankaranarayanan, K., C. S. Praharaj, P. Nalayini, K. K. Bandyopadhyay and N. Gopalkrishnan. 2010. Effect of magnesium, zinc, iron and boron application on yield and quality of cotton (*Gossypium hirsutum*). *Indian J. Agric. Sci.,* 80(8): 699-703.

SAS Institute, Inc. 2007. SAS Technical Report SAS/STAT Software; Changes and Enhancements Users Guide. Volume 2, Version 9.1.3, Fourth Edition, Cary, NC: SAS Institute Inc.

Singh, S. P. 1975. Studies on the effects of soil moisture stress on the yield of cotton. *Indian J. Plant Physi.*, 18:49-55.

Transplant. 2017. In *Merriam-Webster's* online dictionary [online] Retrieved from https://www.merriam-webster.com/dictionary [15 December 2017].

USDA FAS. 2016. United States Department of Agriculture, Foreign Agricultural Service: Egypt cotton and products annual 2016 [online] Retrieved from https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Cotton%20and%20Products%20Annual_Cairo_Egypt_3-31-2016.pdf [9 December 2017].

Wahid, A., S. Bukhari, and E. Rasul. 2003. Inter-specific differences in cotton for nutrient partitioning from subtending leaves to reproductive parts at various developmental stages: consequences for fruit growth and yield. *Biol. Plantarum*, 47(3): 379-385.

Winer, B. J. 1971. Statistical principles in experimental design. 2nd Edition. McGraw-Hill Kogakusha, LTD.

Wise, R. R., G. F. Sassenrath-Cole and R. G. Percy. 2000. A comparison of leaf anatomy in field-grown *Gossypium hirsutum* and *G. barbadense*. *Ann. Botany*, 86(4): 731-738.

Xu, N. and M. Fok. 2007. Multiple-factor adoption of GM Cotton in China: Influence of conventional technology development and rural change in Jiangsu Province. *In*: World Cotton Research Conference, Lubbock (Texas, USA), 10-14/09/2007.

Yassen, M., A. Wazir, and M. Shahbaz. 2013. Role of foliar feeding of micronutrients in yield maximization of cotton in Punjab. *Turkish J. Agric. For.*, 37: 420-426.

الملخص العربي

الإستفادة من نباتات الخف عارية الجذور فى القطن عن طريق الشتل والتسميد الورقى

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أجريت هذه الدراسة بمزرعة كلية الزراعة – جامعة الأسكندرية بأبيس فى موسمى الزراعة ٢٠١٥ و٢٠١٦ بهدف دراسة تأثير شتل نباتات القطن عند عمر ٣٠ يوم بعد خفها من الجور فى الأرض المستديمه و ذلك لصنفى القطن جيزه ٨٦ وجيزه ٨٨. وشتل نباتات الخف عارية الجذور أطلق عليها هنا مصطلح (Bare-root transplants; BRT) للتفرقه بينها و بين طريقة الشتل المتعارف عليها فى القطن و التى يتم فيها زراعة البذور فى عبوات ورقية أو بلاستيكية فى تربة معدة لذلك فى المشتل (Potted-transplants; PT) ثم يتم نقلها للأرض المستديمة بجذر وتدى سليم محاط بالتربة لتستكمل نموها طبيعياً. عوملت النباتات المشتوله بعد ذلك بثلاث معاملات مختلفة من الرش الورقى بمجموعة من العناصر الكبرى و مجموعة أخرى من العناصر الصغرى و تم مقارنتها بالنباتات المنزرعة بالبذرة بالطريقة التقليدية. أظهرت طريقة الشتل BRT مع خمس رشات من العناصر الكبرى و رشتين من العناصر الصغرى تحسناً كبيراً فى نسبة نجاح النباتات بعد الشتل وصلت إلى ٧٠% وتفوقت نباتات هذه المعاملة على النباتات المنزرعة بالبذره فى المحصول ومكوناته. وقد وصلت الزيادة فى المحصول إلى ١١.٤% للصنف جيزه ٨٦ و٤.٩% للصنف جيزه ٨٨ مقارنه بنفس الصنف المنزرع بالبذره. كذلك لم تؤثر طريقة الشتل مع أى من معاملات التسميد المختلفة على صفات الألياف للصنف جيزه ٨٨ والذى أجريت عليه إختبارات التيله. لذلك تم إقتراح طريقة الشتل BRT مع معاملة النباتات بسبع دفعات من العناصر الكبرى والصغرى رشاً على الأوراق كطريقة عملية منخفضة التكاليف مقارنة بطريقة الشتل (PT) والتى أوردتها وزارة الزراعة كطريقة لزراعة القطن. وبذلك ١- يمكن زراعة مشاتل للقطن بداية من شهر مارس فى قطعة صغيره من الأرض المستديمة، يتم تفريد شتلاتها بعد ٣٠ يوم لإعطاء محاصيل الموسم الشتوى الفترة اللازمة لإتمام النضج والحصاد بدلاً من تأخير زراعة القطن لشهر أبريل. ٢- يمكن الإستفادة من نباتات الخف فى القطن المنزرع بالبذره خاصة فى مناطق إنتاج التقاوى و التى يتم التخلص منها تقليدياً. ٣- سوف تؤدى هذه الطريقة حال إستخدامها إلى تركيز جهود وزارة الزراعة فى إستعادة نقاوة الأصناف المصرية بدلاً من العمل على توفير كميات كبيرة من التقاوى يتم إنتاجها سنوياً لتلبية إحتياجات الزراعة بالبذرة يفقد جزء كبير منها نتيجة عملية الخف.