Potential of transplanting bare-root seedlings comparing with direct seeding in some Egyptian cotton cultivars

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ABSTRACT: Limitation of cultivated area and shortage of irrigation water are mainly challenges of Egyptian agriculture. One of the possible solutions to improve the utilization efficiency of cultivated land, increase cotton cultivation area and guarantee the harvest of extra cutting from Egyptian clover is cotton transplanting. Therefore, this study aimed to evaluate the possibility of transplanting seedlings comparing with direct seeding methods and their effect on growth, yield and fiber quality for cotton cultivars Giza 92, Giza 94 and Giza 95. Two field experiments were conducted in Agricultural Research and Experimental Station, Faculty of Agriculture, Cairo University, Giza, Egypt during 2019 and 2020 seasons. The experiments were laid out in a split-plot based on a Randomized Complete Block Design with three replicates. A significant effect of transplanting seedlings compared with direct seeding, which increased plant height (10.46%), sympodial branches per plant (5.54%) and decreased 1st sympodial node position (14.17%), on the other hand, decreased open bolls per plant (7.04%), boll weight (2.90%), seed index (6.57%), seed cotton yield per plant (5.98%) and per feddan (6.79%) and most studied cotton fiber quality parameters; however, insignificant effect on total bolls per plant, lint percentage, fiber length and elongation. Cotton cultivars recorded significant differences in most studied parameters, Whereas, Giza 95 as showed superiority in yield and yield components, while Giza 92 and Giza 94 in fiber quality parameters. We need more researches for suitable germination growth medium, age of transplanting seedlings and economic feasibility to recommend transplanting as an alternative to direct seeding.

Keywords: Cotton, *Gossypium barbadense* L., transplanting, growth parameters, cultivars, fiber quality.

INTRODUCTION

Egyptian cotton cultivars are classified globally as a high-quality fiber (extra-long and long staple). Despite this, we find the cotton cultivated area (65,000 ha in 2020/21 according to USDA, 2021) is limited for various reasons, including the limitation of total agricultural land area and irrigation water in Egypt, at the same time, feed crops such as Egyptian clover, as well as grain crops such as wheat can precede cotton planting. Therefore, transplanting allows the farmers to harvest wheat crop in proper time and obtain extra cutting from Egyptian clover before planting cotton which contribute to solve shortage of feed crops and increase cotton cultivation area.

Generally, little studies have been conducted to improve the utilization efficiency of cultivated area by enhancing cotton productivity using transplanting seedlings. Previous studies cleared different trends in the effect of transplanting seedling cotton plants on growth, productivity and fiber quality compared with direct seeding. Many researchers found that transplanted cotton profitable because it maintains optimum plant population and a greater number of bolls per unit area. Similarly, advantages of transplanted cotton relative to increase seed cotton and lint yield have been found in other cotton-growing countries (Karve, 2003; Dong *et al.*, 2007 and Akbar *et al.*, 2015). Transplanting seedlings enhance soil N-balance, less depletion of P and K for plants and improved the cotton productivity by 14.2% over direct seeding (Rajpoot *et al.*, 2016 and Ahmad *et al.*, 2018). Seif-El-Nasr *et al.* (1996) showed that transplantation, not only reduces the use of fertilizer, but also increases the yield compared to direct seed planting and also transplanting after wheat harvest. Also, Leskovar et al. (2021) showed significant and consistent improvements in root and shoot traits, and yield for transplants as compared to direct seeded plants.

On the other hand, many researchers found that cotton transplanting gave lower yield and fiber quality than direct seeding method. In Egypt, Cotton transplanting experiments using bare-root transplanting (BRT) was the earliest documented at Assiut University by Bakheit (1965). 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, which yielded only 20-57% that of directly sown cotton. Abdel-Ghaffar *et al.* (1976) and Radwan (1988) reported that the transplanting cotton seedlings with bare roots usually yielded less than direct seeding this due to the damages usually happens to the root system during transplanting process. Hamed (1995), Dwedar (1998) and Ismail *et al*. (2000) all came to the conclusion that seed-cotton yield of direct seeded cotton was higher than transplanted cotton plants. Also, adoption of the transplanting technique is regarded expensive to farmers compared to the market price of seed-cotton (Kamel *et al.*, 1991). In India, Karve (2003) reported that the BRT plants failed to survive after transplanting. Moreover, cotton transplantation after barley harvest, gave cotton yield same as direct seed plantation (Choi *et al*., 1992). Delay in transplantation reduce the number of bolls and boll weight (Jahromi and Mahboubi, 2012). High plant population has been found to give higher plant height, lower number of branches per plant and reduced boll weight (Wali and Koraddi, 1989). The main objective of this study is to investigate the effect of transplanting bare-root seedlings on cotton plant growth, yield and its components and fiber quality comparing with direct seeding method.

MATERIALS AND METHODS

Field experiment

Field experiments were carried out in Agricultural Research and Experimental Station, Faculty of Agriculture, Cairo University, Giza, Egypt (31º 11' 33.43'E, 30º 1' 36.16' N) during two successive summer seasons (2019 and 2020) to evaluate the possibility of transplanting cotton plants to improve the utilization efficiency of cultivated land and guarantee the harvest of extra cutting from Egyptian clover (*Trifolium alexandrinum* L.) before planting cotton.

The experiments were laid out in a split-plot based on a Randomized Complete Block Design (RCBD) with three replicates. Treatments included two planting methods (direct seeding and transplanting bare-root) in main plots and three cotton cultivates (Giza 92 extra-long staple and Giza 94 long staple grown at lower Egypt, and Giza 95 long staple grown at upper Egypt) were applied in sub-plots. Each plot (experimental unit) had six ridges, each of 0.6 m in width and 4.0 m in length, occupying an area of 14.4 m^2. The preceding crop was Egyptian clover. In the direct seeding methods, seeds were planted on the first week of April in both seasons in ridges with hills 20 cm apart. Seeds were sowen in nursery at the same time of direct seeding in both seasons, after 4 weeks (seedlings achieve 3-4 leaves), seedlings were pulled in presence of water and two healthy seedlings were transplanted within less than one hour in the permanent field plots in hills 20 cm apart on the ridge. Transplanted seedling plots were irrigated every week after transplanting for three times. Nitrogen at a level of 60 kg N fed^{-1} as ammonium sulfate (20.5% N), potassium at 48 kg K_2O fed^{-1} as potassium sulphate (48% K_2O) and Phosphorus at 30 kg P_2O_5 fed^{-1} as calcium super phosphate (15.5% P_2O_5) were applied. The other agricultural practices were carried out according to the usual practices in the cotton fields. The harvesting was performed two times on the second and fourth weeks of September in both seasons.

Soil analysis

A composite soil samples were collected from 0-30, 30-60 and 60-90 cm depth during the study years before planting and were prepared for analyses in laboratory. The particle size distribution, pH, EC, total $CaCO_3$, organic matter (OM), total and available nitrogen (N), Phosphorus (P), Potassium (K) according to standard methods outlined by Jackson (1973) and Keeney and Nelson (1982). Details of soil analysis are given in (Table 1).

Collection of experimental data

Growth parameters

Plant height (cm) and position of 1^{st} sympodial node were recorded on ten random plants taken from two ridges of each experimental plot at 120 days after sowing (DAS).

Yield and yield components

Ten guarded plants were taken at random from each plot to determine, number of sympodial branches per plant, number of total and open bolls per plant, boll weight (g), seed index (g) and seed cotton yield per plant. Seed cotton yield kentar per feddan (kentar (ken.) =157.5 kg and feddan (fed.) = 4200 m^2) was calculated from the two central rows of each plot after multiplying by the appropriate conversion factor. Lint cotton% (calculated from lint weight to seed cotton weight expressed as percentage).

Fiber properties

Fiber properties of Giza 92, Giza 94 and Giza 95 across the two growing seasons were measured as the following; fiber length (mm), uniformity ratio (%) was determined by the digital fibrograph, fiber strength (g/tex) by using the Pressely tester at zero-gauge length and fiber fineness (micronair reading) measured by micronair apparatus, fiber elongation (%) and color attributes values i.e., Reflectance (Rd %) and Yellowness (+b %). All fiber tests were carried out at the Laboratories of the Cotton Research Institute, Agricultural Research Center, Giza, Egypt, under controlled conditions of 70º F± 2 temperature and 65% ± 2 of relative humidity.

Statistical analysis

The obtained data were subjected to statistical analysis of variance for each season, for all characters under study according to the procedure described by Snedecor and Cochron (1981). Significance of differences among variables were done according to Least Significant Differences test (LSD) at 5% level of probability. Finally, all statistical analyses were carried out using "MSTAT-C" computer software package (Freed *et al*., 1989).

Table 1. Some physical and chemical properties of the experiments soil during 2019 and 2020 cotton growing seasons.

Soil characteristics	Seasons					
	2019 Soil depth (cm)			2020 Soil depth (cm)		
	0-30	30-60	60-90	0-30	30-60	60-90
Physical properties:						
C. Sand%	4.15	5.25	6.25	4.72	5.58	6.05
F. Sand%	36.50	33.52	37.50	35.54	34.15	38.41
Silt%	27.95	26.69	29.15	29.52	27.30	27.54
Clay%	31.42	34.55	27.25	30.25	33.05	28.15
Texture*	C. L.	C. L.	C. L.	C. L.	C. L.	C. L.
Soil bulk density (gcm^{-3})	1.18	1.35	1.38	1.15	1.31	1.35
Chemical properties:						
pH (paste extract)	7.72	7.84	7.97	7.75	8.02	8.12
EC (dSm^{-1})	1.95	2.27	2.48	1.96	2.48	2.87
Calcium carbonate (%)	3.17	3.52	4.96	3.27	3.38	3.97
Organic matter (%)	2.03	1.89	1.51	2.25	1.75	1.45
Plant available nutrients (mg kg^{-1})						
Nitrogen	35.65	28.55	20.26	33.52	25.25	18.56
Phosphorus	9.15	7.24	6.48	8.99	8.24	7.17
Potassium	255	238	225	248	235	215
Total nutrients content						
Nitrogen (mg kg^{-1})	989	756	515	930	740	635
Phosphorus (mg kg^{-1})	710	533	510	740	620	560
Potassium (%)	2.33	2.24	2.12	2.35	2.25	2.10

*C.L. = clay loam

RESULTS AND DISCUSSIONS

Plant growth attributes

Plant height and position of 1st sympodial node

It is quite evident from Table (2) that planting methods (direct seeding and transplantation) and cotton cultivars recorded significant differences at the 5% level of probability regarding plant height and the first sympodial node position in both seasons. However, plant height was 151.9 cm for transplanting and 137.5 cm for directed seeding method which recorded 10.46% increase; also, position of 1st sympodial node was 6.55 for transplanting and 7.63 for directed seeding method which recorded 14.17% decrease as an average of both seasons. In this regard, Hemeid *et al.* (2018) and Emara *et al*. (2018 and 2021) found that the tallest plants were recorded in the transplanted plants than normal seeding. Cotton cultivars recorded a significant difference in plant height in the following order; Giza 92 (159.5) > Giza 95 (144.1) > Giza 94 (130.5 cm) as an average of both seasons. The interaction between planting methods and cotton cultivars for plant height and first sympodial node position were significant. In both seasons as an average, the 164.59 cm was recorded for Giza 92 under transplantation and the shortest one (127.8 cm) was recorded for Giza 94 under direct seeding method. However, the lowest position of 1st sympodial node (6.33) was recorded for Giza 95 under transplantation and the highest one (7.94) was recorded for Giza 92 under direct seeding method.

Seed cotton yield and its components

Sympodial branches per plant

Data in both seasons (Table 2) indicate that, the main effect of planting methods, cotton cultivars and their interaction recorded a significant effect on the number of sympodial branches per plant. Sympodial branches per plant in transplantation (17.0) were more than those in direct seeding (16.11) as an average, which recorded higher value (5.54%) for transplantation than direct seeding method. These results are in the same line with those of Sarvestani and Kordi (2001); Hemeid *et al.* (2018) and Emara *et al*. (2018 and 2021) they found that transplanted cotton increased sympodia than direct seeding. Cotton cultivars varied significantly in the number of sympodial branches per plant as following order; Giza 95 (17.60) > Giza 92 (16.56) > Giza 94 (15.51) as an average in the both seasons. The highest increase was recorded at Giza 95 (13.46%), followed by Giza 92 (6.77%) compared with Giza 94. The interaction between planting methods and cotton cultivars for number of sympodial branches per plant showed significant effect, whereas, as an average for both seasons, the highest value (18.14) was recorded for Giza 95 under transplantation and the lowest one (15.55) was recorded for Giza 94 under direct seeding method.

Total and open bolls per plant

Total bolls per plant were significantly affected only by cotton cultivars, however insignificant there was variation for planting methods treatments and their interaction (Table 2). As an averaged across two seasons Cotton cultivars recorded increases in total bolls number per plant in the following order; Giza 95 (29.04) > Giza 94 (24.79) > Giza 92 (20.5). However, planting methods led to significant differences in open bolls per plant whereas direct seeding recorded higher number of open balls (18.17) than transplantation (16.89) as an average of both seasons, which was hiegher by 7.57% for direct seeding than transplantation method. Lower open bolls per plant in transplantation method may be due to BRT plants flowered and matured much later and were heavily affected by boll weevils than direct seeded cotton. This finding agrees with those of Bakheit (1965); Dwedar (1998) and Ismail *et al*. (2000), however it disagrees with those of Sarvestani and Kordi (2001); Hemeid *et al.* (2018) and Emara *et al*. (2018 and 2021) who used the nursery bed (trays) method and found that transplanted cotton increased open bolls per plant than direct seeded. Cotton cultivars recorded significant variation in open bolls per plant in the following order; Giza 95 (20.99) > Giza 94 (17.25) > Giza 92 (14.36) as an average of both seasons. The interaction between planting methods and cotton cultivars for number of open bolls per plant showed significant effect in both seasons as an average, the highest number (21.06) was recorded for Giza 95 under direct seeding and the lowest one (14.10) was recorded for Giza 92 under transplantation method. The decrease of open bolls may be due to the high-density leaves in plants during the boll opening stage, therefore we suggest using leaves drop agent to remove leaves to increase penetration of sun light to plants which increase the number of open bolls.

Table 2. Mean values of planting methods, cotton cultivars and their interaction for cotton plant height, position of 1st sympodial node, sympodial branches per plant, total and open bolls per plant during 2019 and 2020 seasons.

Planting methods	Cultivars	Plant height (cm)		Position of 1st sympodial node		Sympodial branches plant^{-1} (No)		Total bolls plant^{-1} (No)		Open bolls plant^{-1} (No)	
		Growing seasons									
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Direct seeding		138.33b	136.67b	7.78a	7.48a	16.41b	15.81b	24.59	24.59	18.04a	18.30a
Transplanting		152.52a	151.23a	6.63b	6.47b	17.14a	16.87a	25.64	24.28	17.17b	16.62b
F. test		Sig	Sig	Sig	Sig	Sig	Sig	NS	NS	Sig	Sig
	Giza 92	160.42a	158.62a	7.44a	7.14a	16.57b	16.55b	20.93c	20.08c	14.60c	14.11c
	Giza 94	134.39c	126.53c	7.36a	6.77b	16.28b	14.75c	26.09b	23.50b	17.84b	16.66b
	Giza 95	141.48b	146.69b	6.81b	7.01ab	17.47a	17.73a	28.35a	29.73a	20.36a	21.61a
LSD		7.02	7.90	0.41	0.26	0.84	0.94	1.49	1.67	0.71	1.67
	Giza 92	158.89a	150.00b	8.00a	7.89a	16.11b	15.33b	20.79a	19.63a	15.00d	14.22c
Direct seeding	Giza 94	129.44bc	126.11c	7.67a	7.22b	16.22b	14.89b	25.65a	25.23a	18.89b	18.78b
	Giza 95	126.67c	133.89c	7.67a	7.33b	16.89ab	17.22a	27.34a	28.92a	20.22a	21.89a
	Giza 92	161.94a	167.24a	6.88b	6.40cd	17.03ab	17.76a	21.06a	20.52a	14.20d	14.00c
Transplanting	Giza 94	139.33b	126.96c	7.05b	6.32d	16.33b	14.61b	26.52a	21.77a	16.80c	14.53c
	Giza 95	156.29a	159.50ab	5.96c	6.69c	18.05a	18.24a	29.36a	30.55a	20.50a	21.33a
LSD		9.90	11.26	0.57	0.36	1.19	1.33	NS	NS	1.01	2.37

Means sharing different letters differ significantly from each other at p (≤ 0.05).

Boll weight

In both seasons the analysis of variance for boll weight (g) showed a significant effect of planting methods, cotton cultivars and the interaction between them (Table 3). Whereas, boll weight in direct seeding (2.07 g) was more than that of transplantation (2.01 g) as an average of the two seasons, which recorded higher percentage value (2.99%) for direct seeding than transplantation method. These results might be due to that higher-density leaves in transplanted cotton plants leads to the lower efficient utilization of solar radiation resulting in decreasing the photosynthetic rate therefore decreasing accumulation of dry matter in leaves, so less photosynthates translocation from source (leaves) to sink (boll) and thus boll weight decreases. High plant population has been found to give taller plants and reduced boll weight (Wali and Koraddi, 1989). Cotton cultivars recorded increase in boll weight in the following order; Giza 95 (2.32) > Giza 94 (1.92) > Giza 92 (1.89 g). The interaction between studies factors (Table 3) showed a significant effect on boll weight in both seasons. The highest boll weight value was 2.39 g for Giza 95 under direct seeding planting method however the lowest one was 1.88 g for Giza 92 under transplantation method as an average of both seasons.

Seed index

Results cleared that, seed index (g) was significantly influenced by planting methods, cotton cultivars and the interaction between them (Table 3). Whereas, seed index in direct seeding (9.59 g) was higher than that in transplantation (8.97 g) as an average of both seasons, which recorded higher percentage increase (6.91%) for direct seeding than transplantation method. These results might be due to the decrease in mobilization of photosynthates and directly influenced boll weight that coincide with decreased seed index. Cotton cultivars recorded increases in seed index in the following order; Giza 94 (9.99 g) > Giza 95 (9.03 g) > Giza 92 (8.82 g). The interaction between study factors (Table 3) cleared a significant effect on seed index in both seasons. The highest seed index was (10.68 g) for Giza 94 under direct seeding planting method however the lowest one was (8.8 g) for Giza 92 under transplantation method as an average of both seasons.

Lint percentage

Lint percentage was influenced Insignificantly and significantly by planting methods and cotton cultivars, respectively in both seasons (Table 3). Cotton cultivars recorded increases in lint percentage in the following order; Giza 95 (38.06%) > Giza 94 (36.98%) > Giza 92 (34.26%). The interaction between study factors (Table 3) was significant for lint percentage in both seasons. The highest lint percentage was 38.90% for Giza 95 under direct seeding planting method and the lowest value was 34.03% for Giza 92 under direct seeding planting method as an average of both seasons.

Seed cotton yield per plant

Seed cotton yield per plant (g) was significantly influenced by planting method, cotton cultivars and their interaction in both seasons (Table 3). Whereas, direct seeding produced higher seed cotton per plant (35.5 g) than transplantation (33.37 g) as an average of two seasons, which was higher by 6.38% than transplantation method. These findings agree with those of Rehab (1963); Abdel-Ghaffar *et al*. (1976) and Radwan (1988) they reported that transplanting cotton seedlings with bare root yielded less than direct seeding due to the damages usually happens to the root system during transplanting process. Regarding cotton cultivars seed cotton yield per plant varied in the following order; Giza 95 (39.44) > Giza 94 (33.76) > Giza 92 (30.11 g). The interaction between study factors (Table 3) shwoed a significant effect on seed cotton yield per plant in both seasons. The highest seed cotton yield per plant was (39.66 g) for Giza 95 under direct seeding planting method and the lowest value was (29.42 g) for Giza 92 under transplantation method as an average of both seasons.

Seed cotton yield per feddan

Data in both seasons showed that, seed cotton yield (ken./fed.) was significantly influenced by planting methods, cotton cultivars and their interaction in both seasons (Table 3). Whereas, seed cotton yield per feddan in direct seeding (8.54) was more than that in transplantation (7.96 ken. /fed.) which was higher by 7.29% than transplantation method. The same trend was reported by Hamed (1995); Dwedar (1998) and Ismail *et al*. (2000) They concluded that seed-cotton yield of direct seeded cotton was higher than transplanted cotton. Cotton cultivars recorded increases in seed cotton yield per feddan in the following order; Giza 95 (9.32) > Giza 94 (8.31) > Giza 92 (7.12 ken. /fed.). The interaction between study factors (Table 3) cleared a significant effect on seed cotton yield per feddan in both seasons. The highest seed cotton yield was (9.8 ken. /fed) for Giza 95 under direct seeding planting method however the lowest value was (7.08 ken. /fed.) for Giza 92 under transplantation method as an average of both seasons. Results of this study showed that seed cotton yield, whether per plant or per feddan, was higher in the direct seeding method than transplanting method, this might be due to the increase in open bolls per plant, boll weight and seed index as a result of direct seeding method, which contradicts many previous studies and could be due to the fact that we did not use leaves drop agent

Table 3. Mean values of planting methods, cotton cultivars and their interaction for cotton boll weight, seed index, lint cotton%, seed cotton yield per plant and per feddan during 2019 and 2020 seasons.

Planting methods	Cultivars	Boll weight (g)		Seed index (g)		Lint cotton (%)		Seed cotton yield plant^{-1} (g)		Seed cotton yield fed^{-1} (Ken.)	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Direct seeding		2.08a	2.06a	9.58a	9.60a	36.56	36.48	35.53a	35.46a	8.51a	8.57a
Transplanting		2.01b	2.00b	8.95b	8.98b	36.35	36.34	33.58b	33.16b	8.01b	7.92b
F. test		Sig	Sig	Sig	Sig	NS	NS	Sig	Sig	Sig	Sig
	Giza 92	1.90b	1.86b	8.77b	8.86b	34.14c	34.39c	30.38c	29.84c	7.22c	7.03c
	Giza 94	1.95b	1.88b	10.08a	9.91a	37.19b	36.77b	34.25b	33.26b	8.27b	8.34b
	Giza 95	2.29a	2.34a	8.94b	9.11b	38.04a	38.08a	39.04a	39.84a	9.30a	9.35a
LSD		0.06	0.04	0.41	0.30	0.78	1.23	1.02	1.64	0.34	0.36
	Giza 92	1.90c	1.86c	8.97bc	8.70d	33.88c	34.18d	31.25c	30.36c	7.25d	7.07d
Direct seeding	Giza 94	1.96c	1.91c	10.73a	10.63a	37.07b	36.20bc	36.11b	35.95b	8.50bc	8.82b
	Giza 95	2.38a	2.39a	9.03bc	9.48b	38.74a	39.06a	39.25a	40.07a	9.78a	9.81a
	Giza 92	1.89c	1.87c	8.57c	9.02cd	34.40c	34.60cd	29.52d	29.31c	7.18d	6.98d
Transplanting	Giza 94	1.94c	1.86c	9.43b	9.18bc	37.31b	37.33ab	32.39c	30.58c	8.03c	7.87c
	Giza 95	2.21b	2.29b	8.86bc	8.74d	37.34b	37.09b	38.82a	39.60a	8.81b	8.90b
LSD		0.08	0.06	0.58	0.42	1.11	1.74	1.45	2.32	0.48	0.52

Cotton fiber properties

Cotton fiber length, uniformity index, fiber bundle strength, micronaire reading, fiber elongation, color as reflectance (Rd%) and yellowness (+b) has been defined as the quality of cotton fibers needed for textile production (Watts *et al*., 2014). The effect of planting methods and cotton cultivars on these traits will be discussed as follows:

Fiber length

In both seasons fiber length (mm) was significantly influenced by cotton cultivars, while insignificantly effect by planting methods and the interaction between cotton cultivars and planting methods (Table 4). Cotton cultivars recorded different values of fiber length in the following order; Giza 92 (32.9) > Giza 94 (31.3) > Giza 95 (30.28 mm). Giza 92 is an extra-long staple cultivar while Giza 94 and Giza 95 are long staple cultivars according to Cotton Incorporated (2013) classification.

Length uniformity index (%)

Fiber uniformity is important because it reduces waste and yarn breakage (Glade, 1981). In both seasons, length uniformity index was significantly influenced by planting methods, cotton cultivars and interactions between them (Table 4). Whereas, length uniformity index in direct seeding (85.84%) was higher than that in transplantation (82.83%) as an average of two seasons, which was higher by 3.63% than transplantation method. Cotton cultivars recorded different values in length uniformity index in the following order; Giza 95 (84.7) at par with Giza 94 (84.6) > Giza 92 (83.7%). The interaction between study factors (Table 4) showed a significant effect on length uniformity index in both seasons. The highest length uniformity index value was (86.1%) for Giza 94 under direct seeding planting method however the lowest one was (81.8%) for Giza 92 under transplantation method as an average of both seasons. Obtained values for uniformity index are considered high according to (Cotton Incorporated, 2013) which mentioned values 83 to 85% are high fiber uniformity which is important in cotton manufacturing processing because it reduces waste and yarn breakage (Glade, 1981).

Fiber bundle strength

Yarn spinning ability has a good indication for fiber bundle strength, cotton varieties which produce weak fiber (low strength), are difficult to be handled in manufacturing process. Fiber bundle strength is the force required to break a standard bundle of cotton fibers. Fiber bundle Strength measurements are reported in g tex^{-1} with a tex unit being the weight (g) of 1000 m of cotton fiber (USDA-AMS, 1980). In both seasons, the analysis of variance showed a significant influence on fiber bundle strength by planting method, cotton cultivars and interactions between them (Table 4). Regarding planting methods fiber bundle strength in direct seeding (40.96 g/tex) was higher than that in transplantation (38.05 g/tex) as an average of two seasons, which was 7.65% higher than transplantation method. Cotton cultivars showed fiber bundle strength values 40.28 g/tex (Giza 94) > 39.27 g/tex (Giza 95) > 38.95 g/tex (Giza 92). This trend agrees with Subhan *et al.* (2001) and Bednarz *et al*. (2005) they mentioned that, cotton fiber quality is mainly influenced by genotype of the cultivars but agronomic practices and environmental conditions are the secondary factors influencing fiber quality. The interaction between study factors represented a high fiber bundle strength value (41.57 g/tex) for Giza 94 in direct seeding method and a low one (36.84 g tex^{-1}) for Giza 92 in transplanting method as an average of both seasons. All fiber bundle strength measurements fell into the base or strong range and therefore would not have affected cotton value according to Watts *et al.* (2014).

Fiber fineness (micronaire reading)

In both seasons, micronaire reading was significantly influenced by planting methods, cotton cultivars and interactions between them (Table 4). Whereas, micronaire reading in transplantation (3.96) was more than that in direct seeding (3.59) as an average of two seasons, which recorded 10.3% higher than direct seeding method. Cotton cultivars showed micronaire reading values 4.21 (Giza 95) > 3.80 (Giza 94) > 3.29 (Giza 92). The interaction between study factors represented a high value (4.30) for Giza 95 in transplanting method and a low value (2.87) for Giza 92 in direct seeding methods as an average of both seasons. Therefore, the most fineness cultivar is Giza 92. Similar differences in micronaire values due to cultivar have also been reported by Faircloth *et al.* (2004).

Fiber elongation (%)

The degree of fiber elongation before rupture plays an important role in almost all textile manufacturing processes as mentioned by Benzina *et al.* (2007) and Mathangadeera *et al*. (2020). In both seasons, fiber elongation (%) was insignificantly influenced by planting methods while, significant effect was found by cotton cultivars and interactions between them (Table 5). Cotton cultivars recorded different values in fiber elongation in the following order; Giza 94 (7.37) > Giza 95 (7.31) > Giza 92 (6.68%). The interaction between study factors (Table 5) cleared a significant effect on fiber elongation in both seasons. The highest value was (7.53 %) for Giza

94 under transplantation method however the lowest one was (6.13 %) for Giza 92 under transplantation method as an average of both seasons.

Table 4. Mean values of planting methods, cotton cultivars and their interaction for cotton fiber length, length uniformity index, fiber bundle strength and fiber fineness during 2019 and 2020 seasons.

Planting methods	Cultivars	Fiber length (mm)		Length uniformity index (%)		Fiber bundle strength (g/tex)		Fiber fineness (micronaire reading)	
		2019	2020	2019	2020	2019	2020	2019	2020
Direct seeding		31.91a	31.80a	86.01a	85.67a	41.18a	40.73a	3.49b	3.68b
Transplanting		31.08a	31.18a	82.73b	82.93b	38.08b	38.02b	3.93a	3.99a
F. test		NS	NS	Sig	Sig	Sig	Sig	Sig	Sig
	Giza 92	32.82a	32.98a	83.67b	83.75b	39.15b	38.78b	3.32c	3.27c
	Giza 94	31.32b	31.28b	84.58a	84.55a	40.07a	40.48a	3.78b	3.83b
	Giza 95	30.35c	30.20c	84.87a	84.60a	39.67ab	38.87b	4.03a	4.40a
LSD		0.91	1.16	0.79	0.72	0.61	1.05	0.24	0.10
	Giza 92	33.07a	33.17a	85.57a	85.67a	41.30a	40.90a	2.90c	2.83d
Direct seeding	Giza 94	31.87a	31.90a	86.03a	86.13a	41.03a	42.10a	3.70b	3.80bc
	Giza 95	30.80a	30.33a	86.43a	85.20a	41.20a	39.20b	3.87ab	4.40a
	Giza 92	32.57a	32.80a	81.77c	81.83d	37.00d	36.67c	3.73b	3.70c
Transplanting	Giza 94	30.77a	30.67a	83.13b	82.97c	39.10b	38.87b	3.87ab	3.87b
	Giza 95	29.90a	30.07a	83.30b	84.00b	38.13c	38.53b	4.20a	4.40a
LSD		NS	NS	1.13	1.02	0.87	1.48	0.34	0.13

Means sharing different letters differ significantly from each other at p (≤ 0.05).

Color attributes

Color is quantified from two parameters, degree of reflectance (Rd%) which shows the brightness and yellowness degree (+b) depicts the degree of cotton pigmentation based on colorimeter readings. In both seasons, brightness (Rd%) and yellowness (+b) were significantly influenced by planting methods, cotton cultivars and interactions between them (Table 5). Whereas, planting methods showed a significant difference in brightness (Rd%) (68.09%) and yellowness (+b) (9.75) in direct seeding comparing with brightness (Rd%) (63.56%) and yellowness (+b) (11.79) in transplantation as an average of two seasons. Cotton cultivars recorded different values in brightness (Rd%); Giza 94 (69.04) > Giza 92 (64.40) > Giza 95 (64.04%) while for, yellowness (+b); Giza 95 (11.88) > Giza 92 (10.42) > Giza 94 (9.99%). The interaction between study factors (Table 5) cleared a significant effect in both seasons. The highest brightness (Rd%) was (72.33 %) for Giza 94 under direct seeding methods however, the lowest one was (62.35%) for Giza 95 under transplantation method as an average of two seasons. On the other hand, yellowness (+b) recorded the highest value (12.58) for Giza 95 under transplanting method and the lowest one (8.62) for Giza 92 under direct seeding method as an average of two seasons.

Table 5. Mean values of planting methods and cotton cultivars and their interaction for cotton fiber elongation, reflectance degree (Rd%) and yellowness during 2019 and 2020 seasons.

Planting methods	Cultivars	Fiber elongation (%)		Reflectance degree (Rd%)		Yellowness (+b)	
		2019	2020	2019	2020	2019	2020
Direct seeding		7.12a	7.28a	68.28a	67.91a	9.71b	9.79b
Transplanting		7.07a	7.02a	63.59b	63.54b	11.90a	11.68a
F. test		NS	NS	Sig	Sig	Sig	Sig
	Giza 92	6.50b	6.87b	64.53b	64.28b	10.43b	10.38b
	Giza 94	7.42a	7.33a	69.62a	68.47a	9.90c	10.10b
	Giza 95	7.37a	7.25a	63.65b	64.43b	12.08a	11.72a
LSD		0.41	0.33	1.19	1.44	0.53	0.40
	Giza 92	6.93b	7.53a	66.40b	66.03b	8.67e	8.57e
Direct seeding	Giza 94	7.23ab	7.20a	72.90a	71.77a	9.47d	9.37d
	Giza 95	7.20ab	7.10a	65.53b	65.93b	10.99c	11.43b
	Giza 92	6.07c	6.20b	62.67c	62.53c	12.20b	12.20a
Transplanting	Giza 94	7.60a	7.47a	66.33b	65.17b	10.33c	10.83c
	Giza 95	7.53a	7.40a	61.77c	62.93c	13.17a	12.00a
LSD		0.57	0.51	1.60	2.04	0.75	0.56

Means sharing different letters differ significantly from each other at p (≤ 0.05).

CONCLUSION AND RECOMMENDATIONS

The overall goal of this study was to evaluate the effect of transplantation method on growth, yield and fiber quality of some Egyptian cotton cultivars. From the foregoing discussion, it may be concluded that the advantage of using transplanting of seedling i.e., reduced field duration, maintenance of plant population, sowing at optimum time, beneficial over sowing seeds under delayed crop raising situations, and also suitable for the farm with undesirable quality of irrigation water for germination. However, cotton is not highly amenable for transplanting due to its tap root system. Therefore, we recommended to conduct future studies about suitable nursery media for cotton seedling without disturbing the tap root and suitable agronomic practice.

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