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Growing Cotton by Transplantation

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CROP seeds are generally sown directly. It is possible, however, first to raise seedlings in a nursery or seed-bed, and then transplant them in the field. This practice, known since early days, is usually applied with vegetables (tomatoes, peppers, etc.). In the case of farm crops, tobacco is traditionally grown by transplanting, and in many countries this practice is applied successfully also to rice. Transplanting maize, potatoes, mangolds, and sugar beets gave striking results in Bavaria (12). In Canada, yield increases of 36 and 52% have been obtained with transplanted sugar beets (1). Transplanting is mostly indicated where crop seeds are small or delicate, the growing season is relatively short, or for obtaining higher yield and earlier crops.

Attempts to apply the above method to cotton seem to have started in Turkestan as early as 1912; but they were mostly unsuccessful, since 70% or more of the seedlings perished during the process. Tests were resumed after 1924, and the results proved so encouraging that in the 1930s cotton was reported to be grown by the new method on thousands of hectares.

According to a number of Russian workers, the benefits of transplanted cotton are many. Plants flower and mature their crop much earlier than cotton sown directly, and this is of exceptional importance in the case of late varieties, such as the Egyptians (5, 6, 11). With regard to the technique used, 4 to 5 seeds were sown in small paper pots; the pots were placed in seed-beds, heated by a 30-cm. layer of decomposing farm manure. The method was described in detail in a number of earlier Russian publications (2, 4, 13, 14).

In recent years, there is hardly any reference to growing cotton by transplantation. In the Soviet Union, developments after the war are unknown (the method does not seem to be now applied commercially). But according to personal information, transplanting is practiced on a considerable scale in China, and in North Korea, where the growing period is rather short.

In the Belgian Congo, tests in 1948 showed that transplanting results in reduced yields (7). In Peru, the practice was new in 1959, but its many advantages over direct sowing were recognized (9). Then, as mentioned in a short note by Kulkarni et al. (8), transplanting of long staple cotton in India met with success (survival about 95%). The new method is applied commercially on a few hundred hectares in Yugoslavia and Bulgaria, where a simple moulding contraption is used for making soil cubes.

The present paper deals with experimental work, carried out in Greece, for studying growing cotton by transplanting as compared to direct seeding.

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MATERIAL AND METHODS

The first tests on transplanting started in Greece at the Cotton Research Institute as early as 1934; they lasted until 1940. Transplanted seedlings had bare roots, as is the case with tobacco. The results were not encouraging because of a low rate of survival and a relatively long period needed for recovery after transplanting. On the average, only about half of the transplanted seedlings survived and yields were not improved. Further experience led to the development of better techniques, which were applied in a set of experiments carried out in 1958–61 and dealt with in this paper.

In these tests three seeds were sown in small soil cubes or in soil in paper pots. Cubes or pots were about 10 cm. long and 5 cm. in diameter; the soil was a suitable mixture of loam, farmyard manure, and peat. Damage to seedlings by soil diseases or insects was avoided by disinfecting with a combination of zineb and aldrin (30 and 3 g. of active material per cubic meter of soil, respectively). Captan (10) gave good results at 10 g. per cubic meter. Cubes or pots were placed in a cold temporary seed-bed, protected only by a cover of plastic, burlap sheet, or other suitable material.

Seed-beds were sown at the beginning of March. Transplanting was done at the end of April or the beginning of May. At that time the seedlings had acquired 4 to 6 permanent leaves and reached 15 to 20 cm. in height. If seed-beds are properly taken care of, soil cubes or pots with well-developed seedlings need not be less than 80% of those sown. Cubes or pots, after being placed in their permanent position in the field, need watering unless the soil is well provided with moisture or rains follow. After transplanting, the field is treated as if cotton were sown directly.

The foregoing technique has been indicated by the results of numerous field trials, carried out for this purpose. Modifications will, no doubt, be needed if working under different conditions.

EXPERIMENTAL RESULTS

During the 4-year (1958–61) period, 11 transplanting experiments have been carried out at Sindos. To save space they are not described in detail, but their results with regard to yield and earliness are summarized in Table 1.

In the exploratory test of 1958, the effect of transplanting was studied with 3 cotton varieties: 2 Upland (16X and 10E) produced at the Institute and 1 Egyptian (selected from Menoufi). A large number of characteristics were considered. They included: seedling survival after transplanting, number of flowers (opening flowers were counted every day), mean date of flowering, number of bolls picked (17 pickings from August 11 to October 10), mean date of picking (according to boll number, not their weight), bolling period (determined for every boll separately), weight of individual bolls, yield of seed cotton, earliness in maturity (according to the method described by Christidis and Harrison (3), lint percentage, lint length, fiber strength (Pressley), and fineness (Micronaire).

The results are summarized in Table 2. To reduce the amount of figures, the data are given in differences, "transplanting minus direct seeding", instead of separately for each of the two methods. LSD quoted is always based on

Table 1—Yield and earliness of cotton grown by transplanting and direct seeding at Sindos, Greece.

Tests	Yield				Earliness			
	Trans-plant	Direct seed.	Differ-ence	LSD ±	Trans plant	Direct-seed.	Differ-ence	LSD ±
1958	3,124	2,325	799	210	35.3	43.6	- 8.3	1.3
1959								
1st	2,617	2,135	482	125	22.0	27.2	- 5.2	0.63
2nd	3,000	2,108	892	109	12.0	20.9	- 8.9	0.60
3rd	3,653	2,295	1,358	368	18.6	25.8	- 7.2	1.21
1960								
1st	1,261	896	365	48.4	25.7	31.0	- 8.3	0.54
2nd	1,438	1,037	401	48.9	31.3	39.2	- 7.9	0.78
3rd	935	415	520	151.8	17.1	29.4	-12.3	2.92
1961								
1st	3,170	2,551	619	196.9	30.6	37.3	- 6.7	1.48
2nd	3,959	2,727	1,232	462.8	13.6	21.7	- 8.1	1.8
3rd	3,799	2,296	1,503	408.4	22.7	37.2	-14.5	2.22
4th	1,722	1,026	696	306.6	15.3	20.4	- 5.1	1.33
Average	2,607	1,801	806	79.4	22.20	30.61	- 8.41	±.71

Table 2—Differences in performance of 3 cotton varieties tested at Sindos in 1958, expressed as transplanting minus direct seeding values.

Properties	Varieties				Average	
	16x	10E	Menoufi	LSD	Differ.	LSD
Survival*	98.2	91.1	94.8	ns	95	±2.20
Flowering						
1,000 flowers/ha.	349.0	222.2	329.6	-	300.0	-
Date†	-10.5	-5.4	-6.8	-	-7.6	-
Bolling						
1,000 bolls/ha.	246.0	156.2	321.6	±111.4	241.3	± 63.3
Date‡	-9.9	-8.2	-7.2	± 1.74	-8.4	± 1.01
Period	2	0	1	ns	1	ns
Boll weight	-0.32	-0.20	1.0	± 0.23	-0.14	± 0.13
Yield	925	510	963	±363	799	±210
Earliness	-9.8	-7.7	-7.5	± 2.2	-8.3	± 1.3
Lint percentage	-1.6	-1.3	-1.9	± 1.55	-1.6	± 0.90
Fiber properties						
Length, mm.	1.0	0	1.8	± 1.10	0.9	± 0.64
Strength	-0.3	0.3	0.1	ns	0.06	ns
Fineness	-0.5	0.2	-0.5	± 0.40	-0.24	± 0.23

* Percentage of transplanted seedlings that survived. The average diff. (95) is the mean survival for all varieties; the value 2.20 (under LSD) is the standard error.
† Starting date: July 31, July 31, and August 7 for the 3 varieties, respectively.
‡ Starting date: Sept. 16, Sept. 19, and Oct. 5 for the 3 varieties, respectively.

P = .05. Flowering and yield data for variety 16X are also illustrated in Figures 1 and 2, respectively.

The other 10 tests, carried out in the subsequent 3 years (1959–61), were concerned with the study of transplanting as affected by variety, date of transplanting, the use of warm or cold seed-beds, the application of water at the time of transplanting, etc. Evidently, the great mass of data obtained cannot be presented here. However, it might be useful to note that flowering and yield data followed the same general trend as in Figures 1 and 2. Fiber properties, such as length, strength, and ginning out-turn, did not vary appreciably with the method of growing the crop (i.e., by transplanting or direct seeding). That is why data for these properties are not given in Table 1.

The date of transplanting may be of practical importance depending on weather conditions, while some varieties respond to transplanting better than others. The use of warm seed beds does not seem necessary for Greece, and supplying water at the time of transplanting may be dispensed with only under favorable conditions.

In an experiment in 1960 transplanting was studied with 4 cotton varieties and all 6 F_1's between them. Actual yields, illustrated in Figure 3, reveal significant heterotic effects as well.

DISCUSSION

Transplanting has a profound effect on some of the most important agronomic characters of cotton. This effect seems to change but little under a variey of conditions.

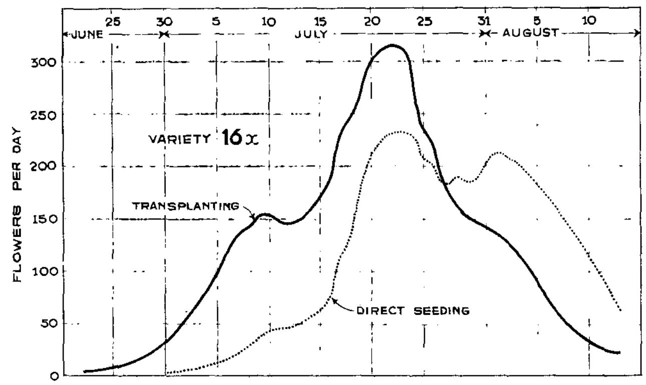

Figure 1—Flowering curves, showing the daily production of flowers by transplanting or direct seeding in 1958.

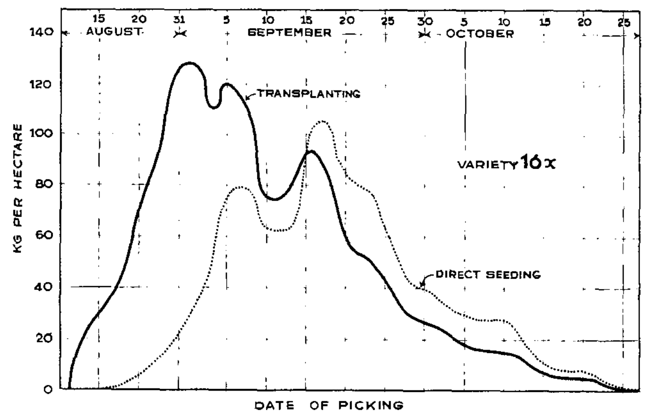

Figure 2—Yield obtained by transplanting or direct seeding in 1958.

Transplanting would be of little practical consequence if a large number of seedlings were to perish during the process. After transplanting, seedlings must also be able to continue their normal growth, almost uninterruptedly. Attempts to grow cotton by transplanting, made in Greece before World War II, failed largely due to the use of seedlings with bare roots, resulting in heavy loss of seedlings and the need of a long period for recovery.

The technique applied since 1958 has been very satisfactory in this connection. Survival reached practically 100% and transplanted seedlings grew normally.

Yield

Yield increased enormously as a result of transplanting, as indicated in Table 1. The odds that differences, such as those observed, would be obtained by chance are far below the one per thousand point.

Differences in yield cannot be attributed to a larger boll weight, actually somewhat smaller with transplanted cotton, nor to increased flowering, since differences in the total number of flowers are relatively small. The extra yield seems to come from a larger number of bolls. Early flowering, induced by transplanting, has a much lower rate of shedding than late flowering, favored by direct seeding (Figure 1).

This conclusion is fully supported by data in Table 2. Differences in number of flowers, number of bolls, and yield may be expressed as percentages of total values obtained for cotton sown directly. These percentages for 10X, IOE, and Menoufi, respectively, were 21, 14, and 30 for the number of flowers; 45, 28, and 44 for the number of bolls; and 35, 21, and 51 for yield. Transplanting exceeds direct sowing much more in boll numbers than in flower numbers. If percentages for boll numbers are not the same as yield percentages, this is accounted for by differences in boll weight. For varieties 16X and IOE, where transplanting reduced boll weight, yield percentages are lower than the corresponding figures for boll numbers. The opposite holds in the case of Menoufi, where transplanting resulted in the production of larger bolls.

Similar results were obtained in subsequent years.

Earliness

Transplanted cotton is always much earlier than cotton sown directly, average differences varying from 5.2 to 14.5 days (Table 1). Such differences cover unquestionably the whole range of earliness (from the earliest to the latest variety) in the Upland group; they almost reach the differences in earliness between Egyptian and American cotton. The earliness observed is accounted for mostly by earlier flowering, the bolling period remaining practically unaltered (Table 2).

Earliness is related not only to yield, but also to quality, since the harvest can be largely completed before the rainy season in autumn. It also affects the cost of picking. In addition, such earliness as obtained by transplanting might enable cotton growing to expand northwards. Long-staple varieties (usually late) or even Egyptian cotton might profitably be grown in new areas.

Lint Percentage and Various Fiber Properties

Lint percentage was little affected by transplanting. The same applies to fibre length, strength, and fineness, on which transplanting has a negligible effect.

In both yield and earliness some varieties seem to respond to transplanting better than others. Such intertaction, though by no means general, indicates that it is always advisable to choose varieties with the highest response. In tropical or subtropical countries, where climatic conditions differ markedly, the effect of transplanting might be far less striking than in Greece.

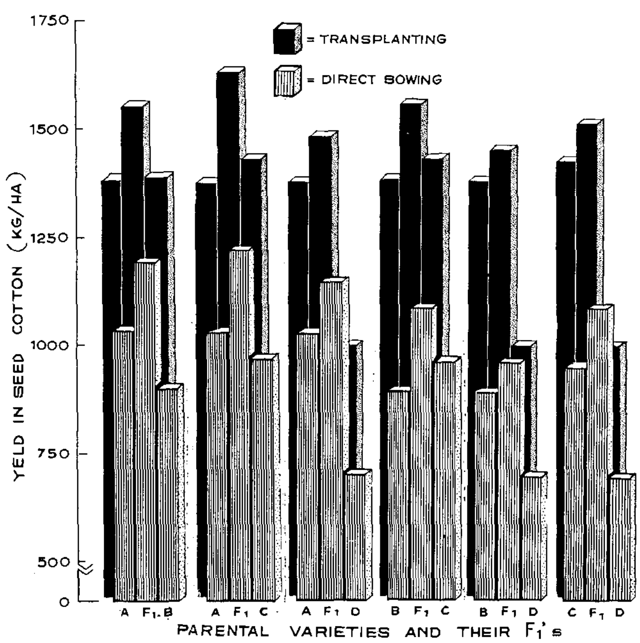

Figure 3—Yield of 4 varieties and of all 6 F_1's between them, grown by transplanting or direct seeding (Data of Expt. 2, in 1960).

Practical Importance

The high rate of seedling survival shows transplanting to be practicable. Its importance will depend on whether the advantages outweigh the additional cost involved.

In the case of soil cubes, it has been estimated that the work necessary for transplanting 1 hectare of sugar beets is about 170 man-hours, as compared with 150 man-hours for direct sowing, thinning, etc. With a transplanting machine, the man-hours needed were between 125 and 140 (12). Cotton requires less plants per hectare, but the man-hours for transplanting might be higher on account of the watering commonly needed during the process.

With the paper pot method, the work necessary for making the pots, filling with earth, placing them in the seedbed, and transplanting is naturally much higher. It may roughly be estimated at 920 man-hours per hectare. About 70 man-hours should be subtracted for ordinary sowing, possible resowing, one hoeing, and thinning, usually saved by transplanting. Hence, the additional work amounts to 850 man-hours per hectare. In Greece, this would cost about $144 (17 cents per hour for girl workers) or the equivalent of 520 kg. of seed cotton. The extra yield obtained by transplanting averaged 806 kg. per ha. Hence, in Greece there seems to be a real benefit in growing cotton by this method. The same may apply to other countries under similar conditions.

Transplanting is certainly more advantageous than the above figures indicate. Earliness, with all its beneficial results, should be taken into account, also the possibility of using better the farmer's labor potential, where such is available. On the other hand, in countries such as the United States, where labor is scarce and costly, the method under its present form is clearly out of the question. However, it might become completely mechanized and make transplanting profitable, wherever it is justified by its beneficial effect on yield and earliness.

SUMMARY AND CONCLUSIONS

In the period 1951 to 1961, 11 tests were carried out to study different techniques for transplanting cotton and the effect of these methods on various characteristics of the cotton. Seedlings of 3 varieties, 16X, IOE, and Menoufi, were grown in soil cubes or soil in small paper pots. When seedlings had 4 to 6 permanent leaves, the cubes or pots were set in rows in the field, where seedling survival was nearly 100% if adequate water was available or was added. Thereafter, the fields were cultivated and the crops harvested by the usual methods. A large number of characteristics of the crops were measured and compared with those of crops grown by direct seeding.

Two properties of exceptional practical consequence, yield and earliness, were favored markedly by transplanting. Increase in yield averaged 806 (LSD = ±79.4) kg. of seed cotton per hectare. The crop also matured earlier by 8.74 (LSD = ±.74) days. In all cases, observed differences in both characters were highly significant.

The higher yield was accounted for mostly by the larger number of bolls produced (lower shedding of flowers that opened early in the season), the rest was contributed by variations in boll size. Earliness of maturity was due to early flowering and early boll formation. The bolling period showed negligible changes between the two methods.

Lint percentage and a number of fiber properties (length, strength, fineness) remained practically the same with either transplanting or direct seeding.

Transplanting involves additional labor. In the case of paper pots, it is roughly estimated at 850 man-hours per hectare, equivalent to 520 kg. of seed cotton under conditions prevailing in Greece. The amount can be reduced markedly with experience, by using soil cubes, or by mechanizing the whole process.

Even as now practiced, transplanting may in some cases be of considerable interest to the small grower. Besides an increase in yield (over the extra cost incurred), and an earlier crop, he can take advantage of the family's labor potential, which would otherwise remain idle.

Further experience with transplanting and a substantial reduction in cost (largely through mechanization) would make transplanting a profitable method for growing cotton in several countries. The general application of this method might have the most unsuspected results on the production of cotton in the world.

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