STUDY OF LONG-TERM FEEDING OFF TREATMENTS ON COTTON APPLIED TO FIXED ROTATION OF CROPS

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1. INTRODUCTION

In the Sudan Gezira cotton is grown in rotations under irrigation and a series of long-term experiments have been carried out with cotton as the main crop (Crowther and Cochran, 1942; Ferguson, Kordofani and Roberts, 1960; Dutta-Roy and Kordofani, 1961; Burhan and Mansi, 1967). The present experiment was initiated in 1935 to see how far the deficiencies in the soil could be rectified in a closed farming system, where straw, legume hay and cotton cake all obtained from the land were returned to the soil in the form of animal excreta.

2. DESCRIPTION OF THE EXPERIMENT

In this experiment, the treatments were applied to a fixed rotation of crops, namely **Dura-Fallow-Cotton-Lubia-Fallow.

Cotton. The six year cycle of rotation, which contained two cotton crops was broken up, for the sake of convenience in interpretation into two halves or 'legs',—the cotton in the first or dura leg was used to measure the direct effects of treatments, while cotton in the lubia leg measured the residual effects of the treatments. The treatments fed on the plots were as follows :—

(I) Dura straw (3460 kg/acre) and lubia hay (650 kg/acre) fed to penned sheep 18 months before sowing cotton.

(II) Same ration fed to penned sheep 6 months before sowing cotton.

(III) In addition to treatment II, cotton cake (supplying about 26 kg/acre of nitrogen) fed to sheep 6 months before sowing cotton.

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** Dura is Sorghum vulgare and lubia is the legume Dolichos lablab. Plots under fallow were hoed in the experiment.

(IV) In addition to treatment I, cotton cake (supplying about 26 kg/acre of nitrogen) fed to sheep 18 months before sowing cotton.

(V) Control (no feeding).

Prior to 1944, treatment IV was similar to treatment II in that the fixed ration of dura straw and lubia hay was fed to sheep 6 months before the cotton was sown. In order that treatment comparisons could be made each year, six sites were allocated for this trial, one for each phase of the rotation. Any particular phase of the rotation returned to the same plot once, every six years. On each site there were six randomised blocks, each block consisting of five plots to accommodate the treatments.

3. Method of Analysis and Results

The comprehensive statistical analysis was made on yields of cotton for the period 1937/38 to 1957/58 for the dura leg and 1940/41 —1957/58 for the lubia leg. The mean yields of seed cotton for each treatment with their respective standard-errors computed from the annual data are shown in appendices 1 and 2. The composite standard-errors derived from the combined analysis are shown for cotton yields both in the dura and the lubia legs.

3.1. Treatment Effects and Rates of Increase In Yields Per Year

Treatment means averaged over 21 years for cotton yields in the dura leg and on 18 years for cotton yields in the lubia leg were estimated disregarding the correlations introduced by having cotton grown on any particular plot once in every 6 years. Because of the change in Treatment IV, the treatment means were also calculated for the period before and after the change on both direct (in the dura leg) and residual (in the lubia leg) yields (see Table 1).

These means were not the most unbiased estimates of the treatments but were considered to be fairly accurate for all practical purposes. In the same way, the effect of correlations between successive yields on a particular plot was ignored in the estimation of linear regression coefficients on time. For dura leg, the regressions were based on 21 years and for lubia leg, 18 years (see Table 2). The standard-errors of the regression coefficients were obtained from the 'treatment x year' interaction after deducting the regression component on time, which is discussed in the next section.

TABLE 1

Mean Yield of Different Treatment in Kg/Acre

Treatments	Dura Leg			Lubia Leg		
	37/38 — 45/46	46/47 — 57/58	37/38 — 57/58	40/41 — 48/49	49/50 — 57/58	40/41 — 57/58
I. Dura straw and lubia hay fed 18 months before sowing cotton.	750	862	814	954	1179	1066
II. Dura straw and lubia hay fed 6 months before sowing cotton.	776	849	818	941	1228	1085
III. As treatment II + Cotton cake.	852	886	871	956	1230	1092
IV. (Old) as treatment II, but impregnated earth spread on plots.	772	—	—	973	—	—
V. (New) as treatment I+ Cotton cake.	—	950	874	—	1237	1104
VI. Control (unmanured).	649	754	709	934	1151	1043

TABLE 2

Mean Rates of Increase of Yield per year in Kg/ Acre

Treatments	*Dura leg (1937/38—1957/58*	*Lubia leg (1940/41—1957/58)*
I	+ 15 5	+ 21·3
II	+ 13·5	+ 27·1
III	+ 9·4	+ 24·8
IV (Old & New)	+ 19·6	+ 25·0
V (Control)	+ 14·3	+ 20·4
S. E.	± 1·91 (76 d.f.)	± 1·50 (64 *d.f.*)

These estimates of regression coefficients included a component because of possible permanent differences between plots. On the other hand, regressions on time obtained from comparisons between cotton yields from the same plots are not affected by these differences. The differences between regression coefficient obtained by both these methods were fairly close and so only ordinary regression coefficients on time were used for this study.

3.2. Variances

In long-term experiments of the type under consideration, the errors of the yields of a particular plot can be considered to be composed of a component which is constant for the plot throughout the period of experimentation, a component which is characteristic of the year and another component which varies independently from plot to plot and year to year. The variance of these components will be denoted by S^2p, S^2y and S^2e. The value of S^2p and S^2e can be estimated from the plot and plot $\times$ year analysis and S^2y can be directly estimated from the treatment x year table.

The method of analysis and consequently the tests of significance for treatment effects depend considerably on the nature of S^2y. If the treatment effects do not show real year-to-year variation, as shown in the case of Cotton Yields in the lubia leg (see Table 3), the errors need only be based on S^2p and S^2e. In situations where the presence of year-to-year variation in treatment comparisons cannot be ignored, it is possible that treatment x year interaction is not the same for different treatment comparisons. In that case, separate S^2y should be obtained and treatment comparisons should be tested with their respective S^2y. These will be further discussed.

The yearly analysis of variance for both direct and residual cotton is straight-forward and the structure of the analysis of variance can be described as follows :—

Source	*d.f.*
Blocks	5
Treatments	4
Blocks $\times$ Treatments	20
Total	29

Since the fixed rotation considered in the present study is six-course (*DFCLFC*), six separate series of plots are used for both direct and residual cotton and the yields are obtained from each plot, once every six years. Therefore, in the case of analysis of direct cotton based on 21 years, plot totals would consist of four observations for the first three series, while only three observations for the remaining three series. Years in which plots on direct cotton were available for each series are shown as follows :—

Series	*Years*	*Number of Years*
S_1	$Y_1, Y_7, Y_{13}, Y_{19},$	4
S_2	$Y_2, Y_8, Y_{14}, Y_{20},$	4
S_3	Y_3, Y_9, Y_{15}, Y_{21}	4
S_4	$Y_4, Y_{10}, Y_{16},$	3
S_5	$Y_5, Y_{11}, Y_{17},$	3
S_6	$Y_6, Y_{12}, Y_{18},$	3

The model for plot-total analysis can be described as

$$x_{ijk}=\mu+T_i+B_j+(TB)_{ij}+S_k+(TS)_{ik}+(BS)_{jk}+e_{ijk}$$

where x_{ijk}=Observation for i_{th} treatment, jth Block and kth series and μ=General Mean, T_i=ith Treatment effect.

B_j=jth Block effect, S_k=k_{th} Series effect,

$(TB)_{ij}$, $(TS)_{ik}$, $(BS)_{jk}$ the corresponding

interactions and e_{ijk}=experimental error.

Blocks are assumed to be representative of a wider universe of environmental conditions and therefore can be considered random. Similarly, series (S_k) effect may also be assumed to be random since a particular series consists of years at successive intervals. Although years are not apparently selected at random, the year effects can be considered to be random. Therefore, apart from μ and T_i, all other terms in the above model can be considered random and the model can be truly described as a mixed model.

Since T_i is considered fixed $\Sigma_i T_i=0$ and it also seems reasonable to assume $\Sigma_i (TB)_{ij}=0$

Therefore, we have

$$E(S_k)=0 \qquad E(S^2_k)=\sigma^2_k$$
$$E(B_j)=0 \qquad E(B^2_j)=\sigma^2_b$$
$$E[(TS)_{ik}]=0 \qquad E[(TS)^2_{ik}]=\sigma^2_{TK}$$
$$E[(BS)_{jk}]=0 \qquad E[(BS)^2_{jk}]=\sigma^2_{BS}$$

The major object of the trial is the evaluation of treatment effects and their interactions with years. These are discussed in details later. The structure of the analysis for plot-totals is described as follows:—

Source	*d.f.*	*E (M.Sq)*
Blocks (B)	$b-1$	
Treatments (T)	$t-1$	$\sigma^2 p+b\sigma^2_{st}+\frac{Sb}{t-1}\sum_i (t_i-\bar{t})^2$
Series (S)	$s-1$	$\sigma^2 p+t\sigma^2_{sb}+b\sigma_{st}^2+bt\sigma^2_s$
$S\times B$	$(s-1)(b-1)$	$\sigma^2_p+t\sigma^2_{sb}$
$S\times T$	$(s-1)(t-1)$	$\sigma^2_p+b\sigma^2_{st}$
$B\times T$	$(b-1)(t-1)$	
$S\times B\ X\ T$	$(s-1)(b-1)(t-1)$	σ^2_p
Total	$sbt-1$	

But the components of variances of plot-error arises not only because of plot to plot variation within blocks ($\sigma^2 p$) but also due to the component σ^2_e, which varies independently from plot to plot and year to year. Since the plots mean square involves comparison between plot-totals, consisting of four observations for the first three series and only three observations for the remaining three series, the coefficient of $\sigma^2 p$ could be obtained as follows:—

$$\frac{4^2+4^2+4^2+3^2+3^2+3^2}{21}=\frac{25}{7}$$

Therefore the expected mean square for plot-error was considered to be $\frac{25}{7}S^2p+S^2e$ for direct cotton. In the case of residual cotton, the analysis was based on 18 years, which allowed three observations on each plot and therefore the expected mean squares for plot-error was $3\,S^2p+Se$, From individual yearly analysis, it is evident that the total error sums of squares for direct cotton based on 21 years consists of 420 (=21×20) degrees of freedom, which is again sum of squares due to plot error and plot×year error. The latter term can be obtained by subtracting plot-error sums of squares from the total error sums of squares, as shown in Tables 3 and 4.

TABLE 3

Analysis of Variance of Cotton Yields in the Dura Leg for 21 years in kg./acre.

Sources	*d.f.*	*Mean Squares*
Years (including series)	20	1857346
Blocks within years	105	15743
Treatment	4	561197
Treatment×years	80	19431
Regression on time	4	62340
Deviation	76	17174
Error : Plot	120	6164 $(25/7\ S^2p+S^2e)$
Plot×year	300	3073 $(=S^2e)$
Total	629	

TABLE 4

Analysis of Variance of Cotton yields in the Lubia leg for 18 years in Kg/acre

Source	*d. f.*	*Mean Squares*
Years (including series)	17	3198928
Blocks within years	90	22678
Treatments	4	63420
Treatments × years	68	7571
Regression on time	4	22541
Deviation	64	6636
Error : Plot	120	12241 $(3S^2p+S^2e)$
Plot × year	240	4069 (S^2e)
TOTAL	539	

The estimates of components of error variances are therefore as follows :—

$$S^2p = 866$$

$$S^2e = 3073$$

The estimates of components of error variances are therefore as follows : —

$$S^2p = 2723$$

$$S^2e = 4069$$

3.3. ERRORS OF MEAN YIELDS AND REGRESSION COEFFICIENTS

The errors of mean yields as well as regression coefficients were estimated from the above two components. The estimates did not include contributions from the components of the year-to-year variations, which will be discussed in the next section.

For yields of cotton in the Dura leg, the variance of a treatment mean averaged over 21 years was based on $21 \times 6 = 126$ observations, 6 in each year.

The estimated variance $= \dfrac{S^2e + 25/7\ S^2p}{126} = 48{\cdot}92$ and the corresponding standard-error $= \pm 6{\cdot}95$.

The errors of other treatment means were as follows : —

Period	*Formula*	*Estimated Variance*	*Standard Error*
Dura leg 12 years	$(S^2e+2S^2p)/6\times 12$	66·73	± 8·2
Dura leg 9 years	$(S^2e+5S^2p/3)\ 6\times 9$	83·65	± 9·1
Dura leg 1 year	$(S^2e+S^2p)/6$	656·51	±25·6
Lubia leg 18 years	$(S^2e+3S^2p/6\times 18)$	113·34	±10·6
Lubia leg 9 years	$(S^2e+5S^2p/3)\ 6\times 9$	159·42	±12·7
Lubia leg 1 year	$(S^2e+S^2p)/6$	1132·07	±33·7

Variances and standard-errors of linear regression coefficients were obtained in the same way. The higher order regression coefficients did not appear to be of much importance and so these are not discussed here.

The variance of a linear regression coefficient on time is $V(b)$, which for direct yields based on 21 years is $V(L/\Sigma\xi_i^2)$, $L=\Sigma\xi_i x_i$, x_i being the mean yield for a particular treatment in the ith year and "ξ_i" the corresponding polynomial coefficient for $n=21$. The coefficient of S^2e in the variance of a single L was $=\frac{770}{6}$; the divisor was six because each x_i was derived from six cotton yields. Summation of polynomial coefficients corresponding to the yields of each plot was necessary to obtain the coefficient of S^2p. There were altogether six series of six plots with a particular treatment and the values, substituted for the years followed the sequence shown below :—

Series						
I	−10	−4	+2	+8	=	−4
II	− 9	−3	+3	+9	=	0
III	− 8	−2	+4	+10	=	+4
IV	− 7	−1	+5		=	−3
V	− 6	0	+6		=	0
VI	− 5	+1	+7		=	+3

The coefficients of $S^2p=(-4)^2+(+4)^2+(-3)^2+(+3)^2=\frac{50}{6}$ and

$$V(L) = \frac{50\,S^2p + 770\,S^2e}{6}$$

$\therefore V(b)=\frac{1}{770\times6}\,(S^2e+5/77\,S^2p) = 0{\cdot}6772$ and the corresponding standard-error$=\pm0{\cdot}82$.

Proceeding in the same way, the variance of linear regression coefficient for a particular treatment of cotton yields in the lubia leg based on 18 years is $V(b)=\frac{1}{969\times3}\,(S^2e+\frac{105}{323}\,S^2p)=1.7027$ and the corresponding standard error $=\pm1{\cdot}31$.

3.4. Annual Variation in Treatment Effects

The standard-errors of means as well as regression coefficients did not include year-to-year variation and as such were smaller than the true standard-errors. The magnitude of these errors depend mainly upon the seasonal fluctuations of the treatments (Dutta-Roy and Kordofani, 1961). The treatment effects often show year-to-year variation because of differential slow changes produced by the treatments themselves. If the treatment x year interaction is negligible, or entirely due to slow changes, the interpretation of results can be based on means and regression coefficients. If on the other hand, even after taking account of the slow changes, there still remains an appreciable amount of seasonal fluctuation of treatment effects, the standard-errors of mean and regression coefficients obtained from plot and plot × year error would be relevant only to the particular set of conditions obtained in the experiment.

In order to draw conclusions about treatment effects on a wider basis, the contributions from the real year-to-year variation were included in the error variance after allowing for slow changes and other external factors influencing the variation in treatment effects. The major change that occurred during the period of experimentation, which might have introduced an extra variation in seasonal variation of treatments was the effect of changing treatment IV in the middle of the experiment. In this particular experiment, cultural practices have been kept more or less uniform except for changing the variety since 1943, from *X* 1530*A* to *X* 1730*A*, and the introduction of spraying since 1951 to suppress the incidence of pests on cotton plots. Variety *X* 1530*A* was sown only for four years in the lubia leg and so it was thought that the contribution because of the change in variety could not be of practical importance for yields in the lubia leg. A large number of varietal trials including these two varieties were also carried out over the years at the Gezira Research Station which confirm the absence of interaction between seasons and these two varieties.

In the Sudan Gezira, the annual fluctuations of cotton yields are enormous and it is thought that the climatic factors play a dominant role in determining yield. Crowther (unpublished work) showed that for the whole of the Gezira, presowing rainfall (1st July—mid August) was beneficial and rainfall of the previous season falling on the fallow phase, preceding the cotton crop in the rotation was harmful to the yields of cotton. In the Gezira, until recently, only a small percentage of the whole area was hoed and it is thought that hoeing the fallows would eliminate the yield reduction due to previous season's rain and thus reduce the fluctuations in yields (Ferguson, Kordofani and Roberts 1960).

It was mentioned earlier, that the yields of cotton on both the dura and lubia legs were highly correlated with the mean yields of the Gezira as a whole, and it was thought that the year-to-year variation in treatment effects could be accounted for by these rainfall factors. In the present experiment, where fallows were hoed, conventional multiple regression techniques were used to determine the effects in the case of direct yields (in the dura leg) only. None of these climatic factors were shown to contribute appreciably to the cause of year-to-year variation in treatment effects and therefore, the contribution due to external factors was not considered in testing the mean effects or regression coefficients.

An approximate test of the annual variation in treatment effects is based on the ratio of treatment x year sums of squares to the value which would be taken by the corresponding mean squares if the variation under test were non-existent. On the null hypothesis this ratio is approximately distributed as x^2.

The estimated contributions of the components of error variance to the various sums of squares for cotton yields in the dura leg were as follows :—

	d. fr	*Estimated error contribution to the Sums of Squares*
Years (uncorrected for Mean)	21	$82719 = 21\ (S^2e + S^2p)$
Treatments	4	$24656 = 4\ (S^2e + 25/_7\ S^2p)$
Linear Regressions	4	$12514 = 4\ (S^2e + 5/_{77}\ S^2p)$
Remainder	76	293705 = (by subtraction)
Total (uncorrected for Mean)	105	$413594 = 105\ (S^2e + S^2p)$

The error contribution to the remainder mean square was $\frac{293705}{76} = 3864\ (\sigma^2)$ and the ratio nS^2/σ^2 (see Table 3) was about 338, which was considerably large in comparison with the theoretical x^2 value and as such, the existence of real seasonal fluctuations in treatment effects could not be ignored for cotton yields in the dura leg (see Figure 1). The contribution from the above estimated variation was therefore added to S^2p and S^2e obtained earlier. However, in

TABLE 5

Tests of Treatment Effects and Linear Regression Coefficients taking account of Annual Variation (Cotton Yields after Dura in Kg/acre)

Comparison	*Mean Effect*	*S.E.*	*Reg. Coeff.*	*S. E.*
(*a*) II Vs. 1	+4	±14·3	—2·0	±2·0
(*b*) 2III Vs. II+1	+55***	±11·6	—5·1**	±1·6
(*c*) 1+II+III Vs 3V	+125***	±15·2	—1·5	±2·3
(*d*) IV Vs Rest	+71**	±17·7	+6·4*	±2·7

TABLE 6

Tests of Treatment Effects & Linear Regression Coefficients (Cotton Yields after lubia in Kg/acre)

Comparison	*Mean Effects*	*S. E.**	*Reg. Coeff.*	*S. E.**
(*a*) II Vs. I	+19	±15·0	+5·8**	±2·4
(*b*) 2.III Vs II+I	+17	±13·1	+0·6	±1·5
(*c*) 1+II+III Vs. 3V	+38*	±12·3	+4·0**	±1·5
(*d*) IV Vs. Rest	+32*	±11·9	+1·6	±1·4

*From S^2p and S^2e only.

the case of lubia leg, the additional contribution due to seasonal fluctuations were negligible and these were accordingly ignored (See figure 2). Appropriate treatments and regression coefficients with their respective standard-errors are shown separately for the dura and lubia legs in Tables 5 and 6 respectively.

4. Discussion

There is no doubt about the beneficial effect of organic manuring in heavy alkaline soil as evident from the response of yields of cotton to feeding off treatments. The overall response of straw and hay containing about 36 kg. of nitrogen/acre fed to sheep, was about 140 kg/acre of seed cotton, 107 kg/acre, being the direct response and

33 kg/acre, the residual response. The additional response to cotton cake containing about 27 kg. nitrogen/acre fed off on the plot was 60 kg/acre of cotton, 53 kg/acre being the direct response and only 7 kg/acre as residual response. As mentioned earlier, the residual treatment effects are masked by the lubia effects of the LFC phase, as evident from the high yields of even unmanured plots in the above phase. Although the application of organic manuring as feeding off treatments are shown to be beneficial, they are much smaller than what is expected from the direct application of the same quantity of inorganic nitrogen.

An interesting feature about the treatments without cotton cake was that there was practically no difference in response whether feeding off took place 6 months or 18 months before cotton was sown (see Table 1). The situation was, however, not similar when additional ration was fed to sheep in the form of cotton cake.

Considering the trends in time for different treatment comparisons, the rate of deterioration for additional cotton cake (comparison of IIIVs I+II) was shown to be marked ($P < \cdot 01$) in the case of direct yields (see Table 5). However, no such phenomenon was evident in the case of residual yields (see table 6).

Despite the violent seasonal fluctuations of cotton yields in the Gezira, it was shown that yearly treatment fluctuations in cotton yields were much less in the lubia phase as compared with the yields in the dura phase. This can be explained by the fact that lubia in the LFC phase acts as an insurance against low nutrient availability while dura residues have a tendency to lock up soil nitrogen, so essential for physiological growth of crop.

The most striking result of this trial was in response to lubia grown in rotation and grazed off by sheep. The beneficial response to lubia appeared to be declining with increasing nitrogen content available in the ration fed to sheep.

5. Summary

An experiment, designed to compare various feeding off treatments on a fixed rotation of crops was carried out at the Gezira Research Station from 1935 to 1958. Two series of cotton yields, one from the dura leg of the rotation, which measured the direct effects of treatments and the other on lubia leg, measuring the residual effects of treatments were studied. The treatment effects in the

dura leg were more pronounced than in the lubia leg. In the case of cotton yields, in the dura leg, real seasonal fluctuations in treatment effects were obtained even after allowing for variation of treatment effects due to slow changes. In order to allow for the year-to-year variation in treatment effects, the contributions from this variation were included in the estimation of standard-errors.

It was evident that the response to organic manure in the Gezira soil was beneficial, although manurial efficiency in terms of available nitrogen in the soil was much less than by direct application of the same quantity of inorganic fertilizers. It was also shown that feeding off treatments gave the same response, whether feeding took place 6 months or 18 months before cotton was sown. The most striking feature of the experiment was in response to lubia, grown in the rotation and subsequently grazed off by sheep. The response to lubia appeared to be declining with increasing nitrogen content available in the feeding material.

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APPENDIX I

Yields of Cotton following the application of feeding off treatments (Dura leg). Treatment Means and their Standard-errors in Kg/acre

Year	*Dura Straw and Lubia Hay applied 18 months before sowing cotton*	*Same as (1) applied 6 months before sowing cotton*	*As (2) plus cotton cake*	*As (1) plus cotton cake since 1946/47*	*Control*	*Seasonal Mean*	*s. e. (20 d.f.)*
	(1)	(2)	(3)	(4)	(5)		
*1937	808	844	851	799	799	804	±32
38	671	658	878	714	596	704	±40
39	589	667	795	669	522	649	±15
40	391	478	543	508	363	457	±18
41	747	652	731	637	623	678	±23
42	877	930	957	930	778	894	±20
43	871	856	949	851	772	860	±16
44	1027	1119	1143	1022	829	1028	±18
45	774	774	822	812	635	764	±16
46	862	815	882	877	742	836	±27
47	623	627	641	793	515	640	±19
48	533	477	507	589	446	510	±10
49	812	840	872	928	732	837	±23
50	1228	1235	1287	1476	987	1242	±40
51	703	680	788	739	663	714	±23
52	563	491	517	583	469	525	±21
53	935	824	892	1032	799	896	±19
54	870	961	961	901	862	911	±30
55	1278	1301	1317	1339	1238	1294	±27
56	1361	1389	1355	1528	1114	1350	±48
57	570	551	609	616	484	566	±12

*The year refers to the cotton season. The cotton crop is in the ground from the middle of August to April, of the following year.

Pooled standard-error for treatment means in single year derived from plot error and plot × year error = ±25 6.

APPENDIX 2

Yields of cotton in the lubia leg. Treatment Means & their standard errors in Kg/acre

Year	Dura Straw and Lubia Hay applied 18 months before sowing previous cotton	Same as (1) applied 6 months before sowing previous cotton	As (2) plus cotton cake	As (1) plus cotton cake since 1949/50	Control	Seasonal Mean	s. e. (20 d.f.)
	(1)	(2)	(3)	(4)	(5)		
*1940	538	478	526	496	486	504	±24
41	859	844	900	875	853	866	±27
42	983	1020	1051	1036	980	1020	±22
43	892	845	863	879	870	870	±19
44	1385	1422	1372	1492	1369	1407	±44
45	845	871	877	911	812	863	±22
46	1273	1213	1256	1202	1243	1238	±29
47	932	908	900	941	931	923	±26
48	874	864	860	894	867	872	±27
49	1081	1095	1106	1066	1082	1085	±23
50	1704	1768	1742	1804	1621	1727	±52
51	924	992	1009	1050	916	979	±40
52	837	824	870	832	837	840	±30
53	1306	1352	1362	1308	1287	1322	±33
54	1212	1306	1262	1320	1209	1262	±38
55	1303	1305	1336	1339	1252	1307	±30
56	1586	1742	1727	1710	1524	1658	±60
57	654	672	653	698	628	661	±30

*The year refers to the cotton season. The cotton crop is in the ground from the middle of August to April of the following year.

Pooled standard-error for treatment means in a single year derived from plot-error and plot $\times$ year error $= \pm 33\ 7$.