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TECHNICAL MEMORANDUM

PROFILE SIMILARITY FEASIBILITY STUDY

By

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16. Abstract

In the Large Area Crop Inventory Experiment (LACIE), a major source of small-grains acreage estimation error was the mislabeling of small grains as nonsmall grains (omission error) by the analyst interpreters. A technique for modeling the profile of Landsat radiance through the growth cycle of a crop has recently been developed. This modeling of the profile permits the measurement of similarity of all picture elements (pixels) in the LACIE segment with that of the modeled crop. The measurement of similarity adjusts for the variability of the time of crop emergence. This study evaluates the feasibility of using this technique to detect small-grain pixels which have been identified/labeled as nonsmall grains and thereby reduce the omission-error rate.

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1. BACKGROUND AND OBJECTIVES

An evaluation of the labeling performance in Phase III and in the Transition Year (TY) of the Large Area Crop Inventory Experiment (LACIE) identified spring small-grain (SSG) omission errors as a major problem in obtaining unbiased acreage estimates. One of the prime causes for the large omission-error rate was the variability in signatures for small grains. Frequently, these signatures were considered unusual because of early or late emergence and development (ref. 1).

The signature for small grains can be represented as a profile of Landsat spectral value versus time (acquisition date) for each of the four channels of data. Early or late emergence and development are expected to shift this profile earlier or later (to the left or right) along the time axis. A method for estimating both the shift due to late or early emergence as well as the similarity of shape of the profile to that of SSG's has been developed by G. D. Badhwar (ref. 2). This method requires at least five Landsat acquisitions (though not necessarily on different dates) and a single interpreted SSG training field. A hypothetical profile for SSG's showing the amount of shift along the time-axis which is referred to as Tau (τ) may be seen in figure 1-1. How well the profile and the picture element (pixel) selected for labeling fits the model profile of the SSG training field is designated as the Chi-squared "goodness-of-fit" (χ^2).

The purpose of this study was to determine the feasibility of using the profile similarity concept to reduce the analyst SSG omission-error rates. However, because of the acquisition history requirements of the algorithm, the utility of this concept would apply primarily to at-harvest or near-harvest crop estimations.

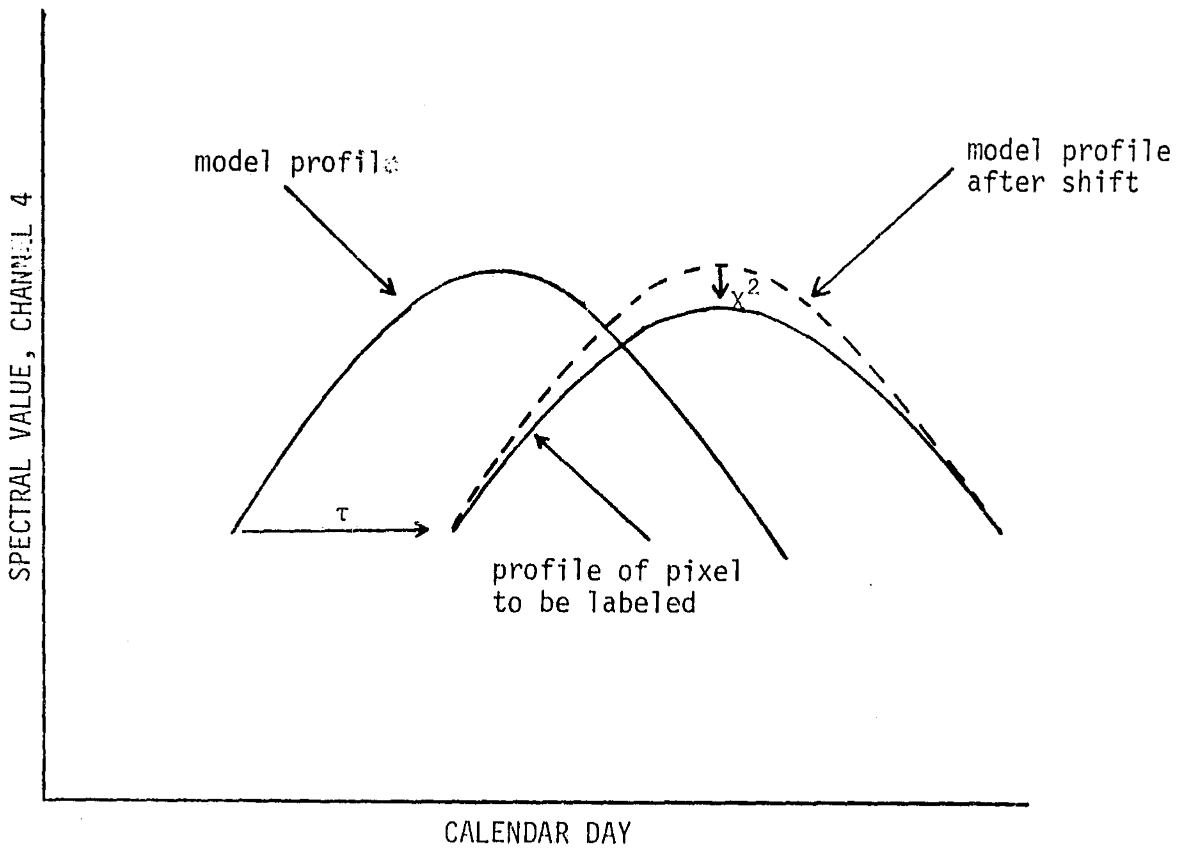

Figure 1-1.— A hypothetical representation of the profile similarity concept and the statistical measures involved.

2. APPROACH

Omission errors are caused by small-grain pixels which are mistaken by the analyst to be nongrain. Conceptually, the profiles of these mislabeled pixels should be similar to those of SSG. A measure of the degree of similarity, after adjustment for late or early emergence and development, is the Chi-squared value. Thus, the Chi-squared statistic can possibly be used as a means of detecting omission errors among the pixels labeled nongrain by the analysts. The smaller the Chi-squared value in any given Landsat channel, the better is the fit to the profile. This implies that if the Chi-squared value is low, there is a high probability that a given pixel is a small-grain pixel with the proviso that the pixel must be pure (A pure pixel is one that stays in the same category on all acquisitions used in processing.). Scale factors from one channel to the next must be considered if all four channels are to be utilized in obtaining a "correlation" between the Chi-squared value and the crop identity. Another group of dots needed to be included to provide an indication of "false alarms" that might be caused using this approach. These are the nonsmall-grain dots that were correctly labeled.

In this study, the Chi-squared values of all the pure dots that were labeled nonsmall grain were ranked one at a time; the ranks for each dot were summed, and the sums of the individual channel ranks were then ranked. An example of this procedure is shown in table 2-1. This procedure compensates for scale factors, reduces the dimensionality of the data, and gives equal weight to all of the channels.

TABLE 2-1.— AN EXAMPLE OF THE RANKING PROCESS

Dot number	Analyst label	Ground-truth label	Channel 1 rank	Channel 2 rank	Channel 3 rank	Channel 4 rank	Rank summed
55	P	SW	10	2	9	10	31
82	P	G	3	5	13	15	36
200	Z	SW	38	1	6	2	47
3	N	FX	13	4	16	19	52
138	H	OS	6	10	36	16	68
24	P	F	47	3	11	11	72
162	P	SW	45	22	8	5	80
142	P	P	19	20	24	21	84
174	H	OS	66	11	3	6	86
103	P	A	29	13	17	27	86

Symbol definition:

A = alfalfa
F = fallow
FX = flax
G = grass
H = hay
N = nonwheat
OS = spring oats
P = pasture
SW = spring wheat
Z = nonagriculture

3. DATA SET DESCRIPTION

A data set of six LACIE/TY blind sites containing SSG's was obtained. These six segments met the following criteria that were required by this study:

a. LACIE/TY ground truth for dot labels

b. An acquisition history consisting of a minimum of four acquisitions excluding pre-emergence or harvest acquisitions (Channel 1 may be duplicated to meet the required minimum of five for the algorithm.)

c. Appreciable amounts of SSG's (spring wheat, oats, and barley)

d. Analyst omission errors from LACIE/TY operational processing

The segments, acquisition histories, and the atmospheric conditions for these acquisitions are presented in table 3-1. For each of the six segments, three SSG training fields were selected based on ground-truth labels, size (minimum 20 pixels), and homogeneity. Each of these three fields were then processed through the program yielding three sets of data for each segment that the ranking system processed. One optimum field was then selected for each segment based on the means and minimum standard deviations of the data in the four channels and the minimum Chi-squared values in each of the four channels. These values are shown in table 3-2.

Of the thirty-six segments in North Dakota, Minnesota, Montana, and South Dakota, approximately seven segments met all the criteria required by the program. The remainder were rejected primarily because of poor acquisition histories (insufficient acquisitions or acquisitions that did not fall between emergence and ripe-crop conditions). One segment (segment 1542 in Roosevelt, Montana) of the six originally selected was later dropped from the analysis for lack of analyst omission errors (i.e., after the border/edge dots were eliminated manually, there were not enough pure or interior SSG dots to warrant inclusion of this segment in the data set).

TABLE 3-1.— THE SEGMENTS, ACQUISITION HISTORIES, AND QUALITY OF THE ACQUISITIONS

Segment number	State	County	Acquisitions available	Acquisitions used/duplicated	Quality of acquisitions
1636	North Dakota	Stutsman	8135		
			8154	8154	≅ 300 pixels of
					clouds/shadow
			8207	8207	
			8217	8217	
			8226	8226	≅ 600 pixels
					of haze
			8243	8243	
			8270		Haze
1653	North Dakota	Burleigh	8136	8154	
			8154	8191	≅ 200 pixels of
			8191	8191	popcorn clouds
			8208	8208	
			8217	8217	
1394	North Dakota	Burke	8120		
			8156	8156	
			8174	8174	
			8211	8211	≅ 300 pixels
					of clouds
			8219	8219	
			8228	8228	
			8264		
			8116		
1825	Minnesota	Norman	8169	8169	
			8187		Light haze
			8196	8196	
			8206	8206	
			8223	8223	
			8232	8232	
1650	North Dakota	Hettinger	8156		
			8191	8191	≅ 600 pixels of
					clouds/shadow
			8209	8209	
			8218	8218	
			8228	8228	
			8236	8236	
			8246		

TABLE 3-2. MEANS, STANDARD DEVIATIONS, AND CHI-SQUARED VALUES OF TRAINING FIELDS

Segment number	Acquisition number	Mean				Standard deviation				Chi-squared			
		Channel				Channel				Channel			
		1	2	3	4	1	2	3	4	1	2	3	4
1636	78154	22.77	21.50	23.50	21.64	1.63	1.41	2.08	1.92	31.19	19.95	0.27	0.96
	78207	17.68	12.21	56.60	61.18	1.31	1.33	2.63	2.19				
	78217	27.82	22.73	54.35	53.18	1.12	1.47	2.26	2.48	for all acquisitions			
	78226	23.27	23.68	50.88	48.93	1.34	1.91	4.19	3.48				
	78243	22.70	26.40	35.09	31.06	1.58	2.09	3.13	3.50				
1653	78154	26.48	26.08	36.85	33.24	1.36	2.14	2.38	2.26	0.94	0.0	4.38	1.18
	78191	20.37	13.53	66.55	66.32	1.19	1.16	3.09	2.18				
	78191	20.38	13.54	66.56	66.32	22.69	21.93	61.64	43.84	for all acquisitions			
	78208	21.32	18.00	50.19	49.37	0.84	1.68	2.86	3.85				
	78217	25.18	24.12	48.73	43.12	1.62	2.12	2.27	2.10				
1394	78156	32.22	32.22	41.19	34.48	3.69	6.60	5.46	4.74	4.07	5.02	2.86	5.36
	78174	29.99	32.49	41.86	35.65	3.76	6.45	3.19	2.96				
	78211	18.20	13.33	56.49	58.70	1.33	1.41	3.75	3.66	for all acquisitions			
	78219	20.73	15.68	53.08	54.18	1.02	1.80	2.31	2.71				
	78228	19.78	17.12	48.64	49.14	2.34	4.24	5.21	7.82				
1825	78169	20.84	13.56	53.81	52.10	0.79	0.91	3.70	3.97	5.18	14.22	2.18	0.50
	78196	21.84	15.53	59.07	57.64	1.06	1.39	3.29	4.28				
	78206	21.93	18.79	50.41	49.84	1.20	1.41	3.33	4.30	for all acquisitions			
	73223	28.88	33.71	49.48	42.34	1.62	2.09	3.26	2.45				
	78232	27.21	32.09	43.81	35.55	1.03	1.26	2.93	2.00				
1650	78191	24.23	18.84	68.84	66.86	2.37	3.14	8.30	8.64	5.87	0.68	5.84	4.41
	78209	20.87	15.26	64.62	68.09	1.58	2.52	3.39	4.19				
	78218	22.15	17.59	60.54	59.71	2.10	3.59	3.39	3.72	for all acquisitions			
	78228	21.78	23.94	49.86	46.71	1.23	2.74	3.26	2.71				
	78236	31.42	43.39	57.51	46.14	1.18	2.17	2.56	0.97				

4. TRAINING FIELD SELECTION

For the algorithm to perform optimally, the training fields selected must contain a minimum of 20 pixels, must be homogeneous, must be in an emerged stage by the first acquisition date, and must not be harvested by the last acquisition date (ref. 3). Of the five training fields (one per segment) finally selected and used, only one field (segment 1653) met the subjective optimum criteria described above. For the remaining four segments, little could be done to improve the training fields selected because of one or more of the following reasons:

a. Inadequate number of sufficiently large training fields in segments

b. Inadequate number of homogeneous training fields

c. Inadequate number of emerged SSG training fields from which to choose.

5. RESULTS

In table 5-1, the ranks have been divided into four equal portions over the entire data range for each segment. The numbers in the quartile columns represent the percentages of small grains and nonsmall grains (according to ground truth) that fall into each quartile. Optimally, the SSG dots should fall within the first quartile with nonsmall grains occupying the other quartiles. (The SSG dots should be within the first 25 percentile of the dots and have the lowest Chi-squared values.) It is evident that the SSG's are spread over the range of the ranks except in segment 1653 which has the majority of small-grain dots in the first quartile.

In table 5-2, only small-grain dots are considered. The numbers represent the percentage of small-grain dots compared to the total number of small-grain dots falling in each quartile of the range. Again, it can be seen that small-grain dots are spread throughout the quartiles except in segment 1653 where the majority of small-grain dots are concentrated in the first quartile.

Generally, channel 1 rankings (0.50 to 0.60) displayed the greatest variability. The ranks appeared randomly and showed a poor relationship to their ground-truth labels. Since this channel is most susceptible to atmospheric effects, it could be inferred that the ranks in channel 1 do not contribute appreciably to the ability to differentiate between small grains and nonsmall grains using this approach.

Casual observation also indicates that the ranks in channel 3 and channel 4 display a better relationship to the ground-truth labels than do channel 1 and channel 2. Clear patterns were not seen in the rankings of the dots using this procedure except in segment 1653. The reason for the relative success in segment 1653 is found in the good acquisition history and the relatively similar profile to the ideal SSG profile. Segment 1653 had postemergence and preharvest acquisitions for most small-grain fields in the scene and for the training field.

TABLE 5-1.— PERCENTAGE OF SSG AND NON-SSG DOTS IN THE DATA RANGE

[Expressed as a percentage of total dots]

Segment	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Total dots	Percent of total dots	Ground-truth label
1636	12.0	9.6	8.4	10.8	83	41.0	SSG
	13.0	15.4	15.6	14.2		59.0	Non-SSG
1653	9.4	3.1	0	1.0	96	13.5	SSG
	15.6	21.9	25.0	24.0		86.5	Non-SSG
1394	14.2	4.7	6.8	0	74	25.7	SSG
	10.8	20.3	18.2	25.0		74.3	Non-SSG
1825	4.4	2.9	2.9	4.4	68	14.7	SSG
	20.6	22.1	22.1	20.6		85.3	Non-SSG
1650	4.7	7.8	0	0	64	12.5	SSG
	20.3	17.2	25.0	25.0		87.5	Non-SSG

TABLE 5-2.— PERCENTAGE OF OMISSION-ERROR DOTS (SSG ONLY) FALLING WITHIN QUARTILES OF DATA RANGE

Segment number	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Total omission-error dots
1636	29.4	23.5	20.6	26.5	34
1653	69.2	23.1	0	7.7	13
1394	55.3	18.4	26.3	0	19
1825	30.0	20.0	20.0	30.0	10
1650	37.5	62.5	0	0	8

6. OBSERVATIONS ON THE INDIVIDUAL SEGMENTS

The segments, the acquisitions that were utilized, the growth stages for the training fields, the colors of the training fields, the relationships between the training field conditions and the rest of the SSG fields in the scene and atmospheric conditions are shown in table 6-1. All these factors are pertinent to the study in that they explain why certain segments failed to perform as expected. Figure 6-1 represents the shapes of the ideal SSG training field profiles in each of the four Landsat channels. Figures 6-2, 6-3, 6-4, 6-5, and 6-6 are the profiles of the training fields for each segment. Comparison of the.ideal profile with the actual profiles also provides an insight as to why some segments failed to perform.

6.1 SEGMENT 1636, STUTSMAN, NORTH DAKOTA

The acquisitions utilized were June, 3, July 26, August 5, August 14, and August 31. The SSG crop stages for the training fields corresponding to these dates were planting, tillering, heading, turning, and ripening, respectively.

Analysis of the segment also shows that the other spring grain fields in the scene are generally in the same stages of growth as the training field. The shapes of the model training-field profile for channels 1 and 2, shown in figures 6-2a and 6-2b poorly match the idealized situation in figure 6-1. Channels 3 and 4 (figures 6-2c and 6-2d) more closely approach the ideal case. The channel 1 profile (figure 6-2a) also shows a peculiar deflection at acquisition date 8217 (August 5). The imagery shows no evidence of anything unusual in regard to atmospheric haze or clouds. This deflection is absent from channels 3 and 4 (figures 6-2c and 6-2d) and is less pronounced in channel 2 (figure 6-2b).

6.2 SEGMENT 1653, BURLEIGH, NORTH DAKOTA

The acquisitions utilized were June 3, July 10, July 27, and August 5. The SSG crop stages for the training field corresponding to these dates are slightly emerging, tillering, turning, and ripening. Analysis of the segment also shows that the SSG fields in the scene are generally in the same stages of growth as the training field. The exception is on the acquisition of June 3, which shows that the training field is behind with respect to the other SSG fields in the scene. The shapes of the model training field very closely approach the ideal situation (figures 6-3a, 6-3b, 6-3c, and 6-3d).

6.3 SEGMENT 1394, BURKE, NORTH DAKOTA

The acquisitions utilized were June 5, June 23, July 30, August 7, and August 16. The SSG crop stages for the training field corresponding to these dates are slightly emerging, slightly emerging, tillering, early turning, and late turning. Except for the acquisition of July 11, the training field is behind the other fields in the segment. The model profiles (figures 6-4a, 6-4b, 6-4c, and 6-4d) for the training field do not resemble the idealized profile.

6.4 SEGMENT 1825, NORMAN, MINNESOTA

The acquisitions utilized were June 18, July 15, July 25, August 11, and August 20. The crop stages for the training field corresponding to these dates are tillering, heading, turning, ripening, and ripening. Analysis of the segment indicates that SSG fields in the scene are generally in the same stages of growth as the training field, except the August 20 acquisition which shows barley and other SSG's already harvested. The model profiles (figures 6-5a, 6-5b, 6-5c, and 6-5d) somewhat resemble the idealized profiles.

6.5 SEGMENT 1650, HETTINGER, NORTH DAKOTA

The acquisitions utilized were July 10, July 28, August 6, August 16, and August 24. The SSG crop stages for the training field corresponding to these dates are postemergence, heading, heading, turning, and ripening. Analysis of the segment also shows that SSG fields are generally in the same stages of growth as the training field. The model profiles (figures 6-6a, 6-6b, 6-6c, and 6-6d) do not resemble the idealized profiles.

TABLE 6-1.— DATA ON TRAINING FIELDS AND OTHER SSG FIELDS IN SCENE

Segment ground-truth label	Acquisitions used	Ground-truth label	Training field growth stage	Training field color	Growth stage of training field relative to other SSG fields	Atmospheric conditions
1636	8154	Spring wheat	Planting	Green	Equivalent	300 pixels of clouds/shadow
	8207		Tillering	Bright red	Equivalent	
	8217		Heading	Dark red	Equivalent	
	8226		Turning	Mottled red	Equivalent	600 pixels of haze
	8243		Ripening	Olive	Equivalent	
1653	8154	Spring wheat	Slight emergence	Greenish pink	Behind	
	8191		Tillering	Dark red	Equivalent	200 pixels of popcorn clouds
	8191		Tillering	Dard red	Equivalent	200 pixels of popcorn clouds
	8208		Turning	Mottled red	Equivalent	
	8217		Ripening	Mottled red/olive	Equivalent	
1394	8156	Spring wheat	Slight emergence	Mottled greenish/pink	Behind	
	8174		Slight emergence	Greenish pink	Behind	
	8211		Tillering	Dark red	Equivalent	300 pixels of clouds
	8219		Turning	Red	Behind	
	8228		Turning	Red	Behind	
1825	8159	Spring wheat	Tillering	Red	Equivalent	Light haze
	8196		Heading	Dark red	Equivalent	
	8206		Turning	Mottled red	Equivalent	
	8223		Ripening	Olive	Equivalent	
	8232		Ripening	Olive	Behind	
1650	8191	Spring oats	Postemergence	Light red	Equivalent	600 pixels of clouds/shadow
	8209		Heading	Red	Equivalent	
	8218		Heading	Dark red	Equivalent	
	8228		Turning	Mottled red/yellow	Equivalent	
	8236		Ripening	Olive	Equivalent	

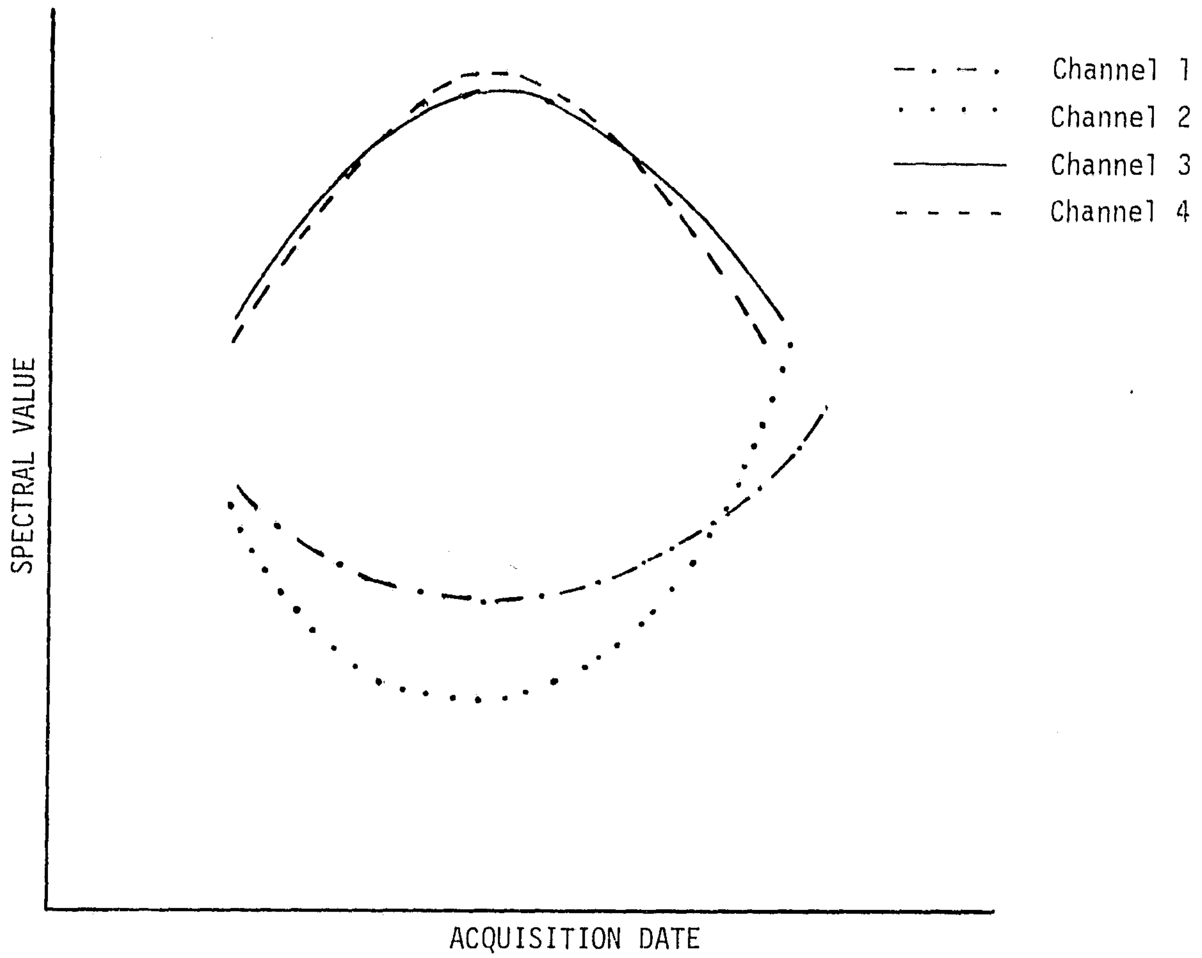

Figure 6-1.— Idealized SSG profile.

PLOT MEANS AND +/- ONE STAND DEV

3 1067 -0 0056 -0.0217 0.0118

0 2216 0.0486 0.0249 0.5916

FITTED VALUES ARE 22.89 23.82 24.03 24.23 24.65

CHISQR= 0.2845E+02

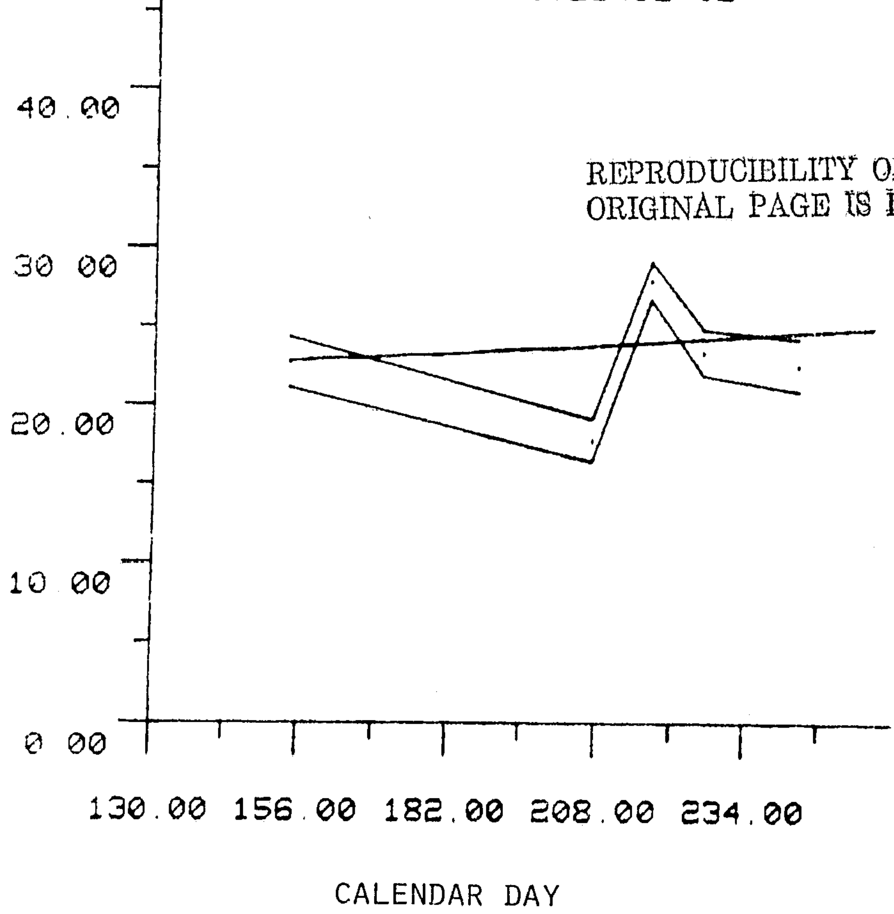

Figure 6-2a.— Segment 1636 spring wheat, channel 1.

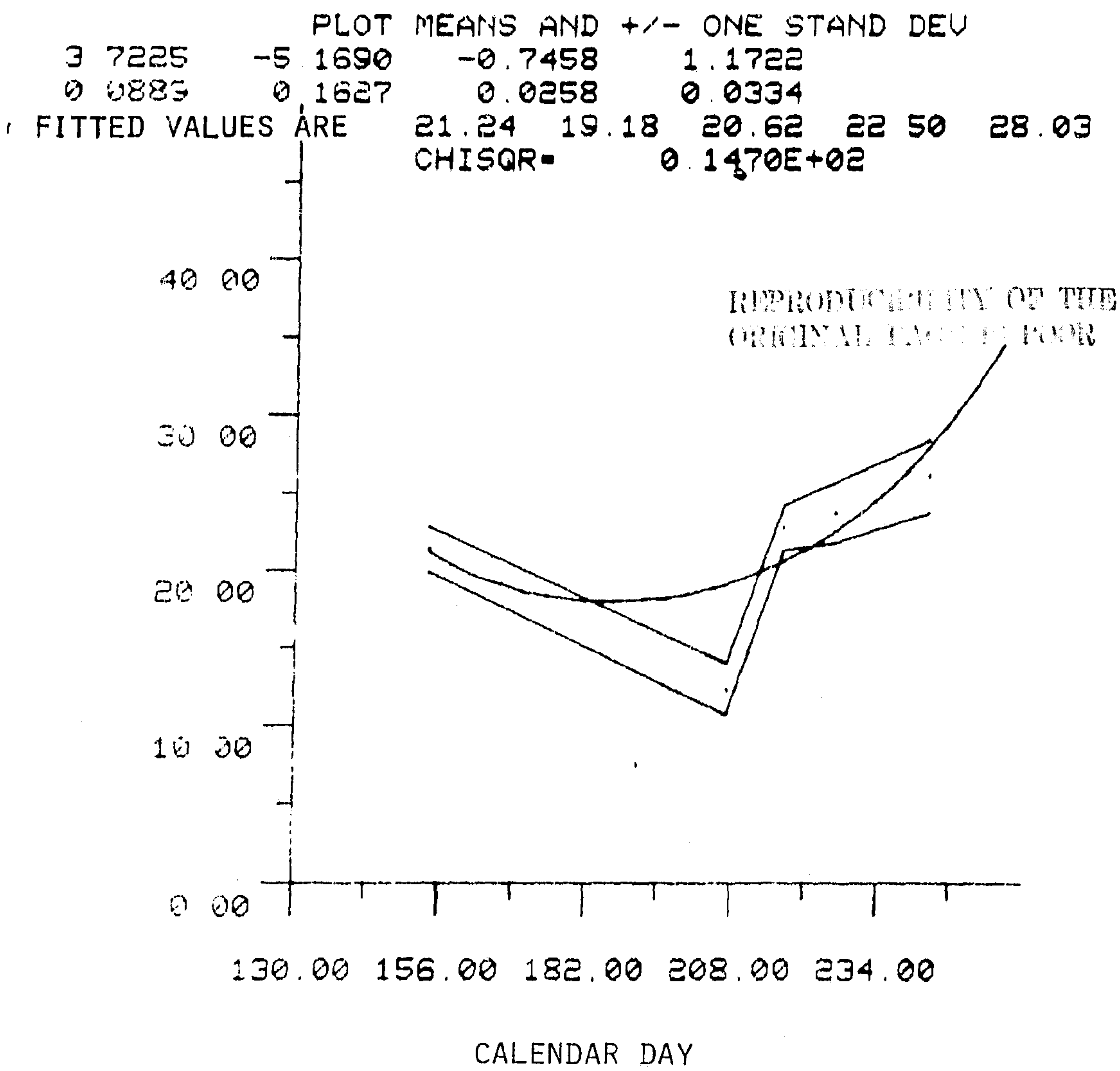

Figure 6-2b.— Segment 1636 spring wheat, channel 2.

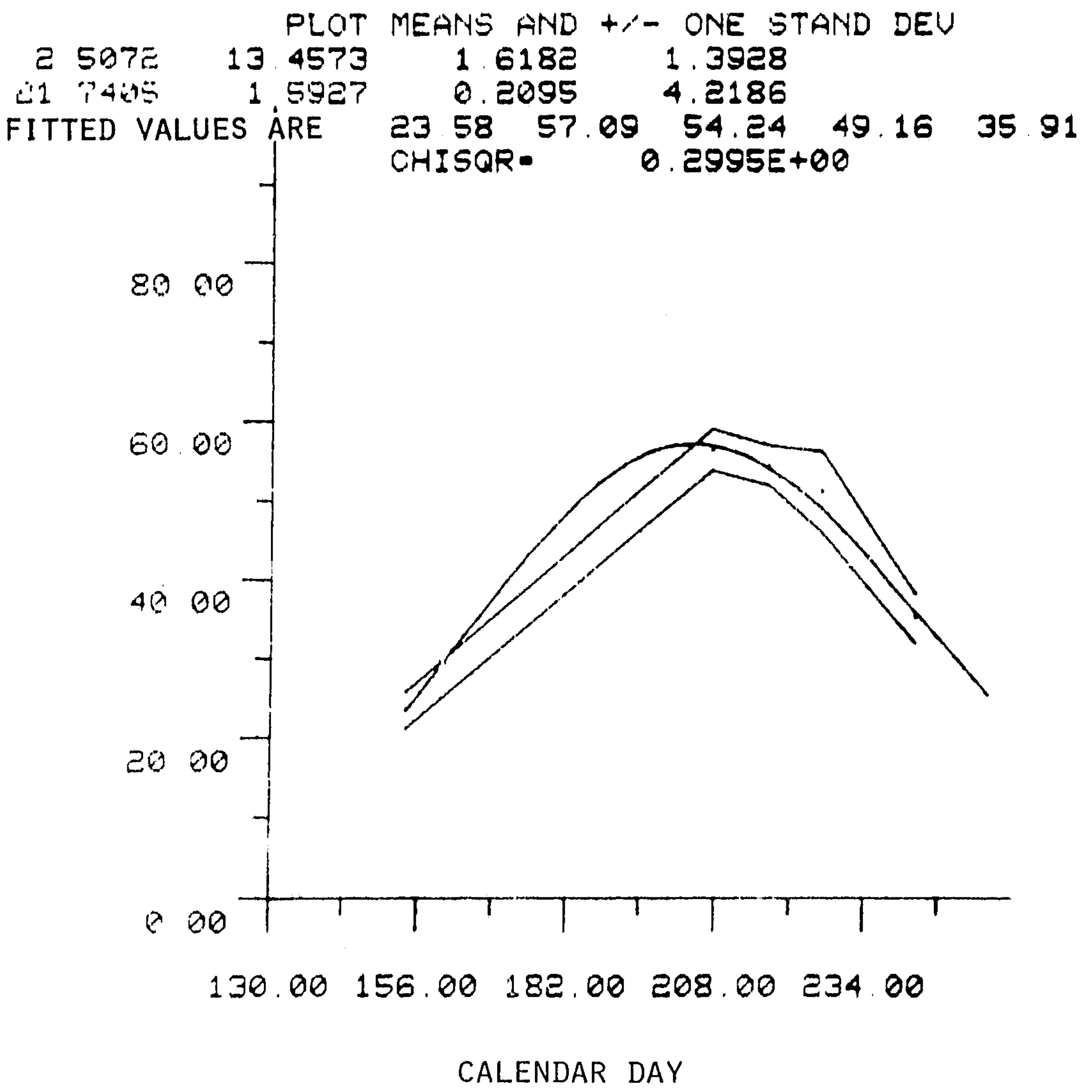

Figure 6-2c.— Segment 1636 spring wheat, channel 3.

PLOT MEANS AND +/- ONE STAND DEV
2 4684 16.9984 2.0960 1.4239
18 8058 1.6777 0.2287 3.1506
FITTED VALUES ARE 21.75 60.16 55.16 47.72 30.79
CHISQR= 0.7910E+00

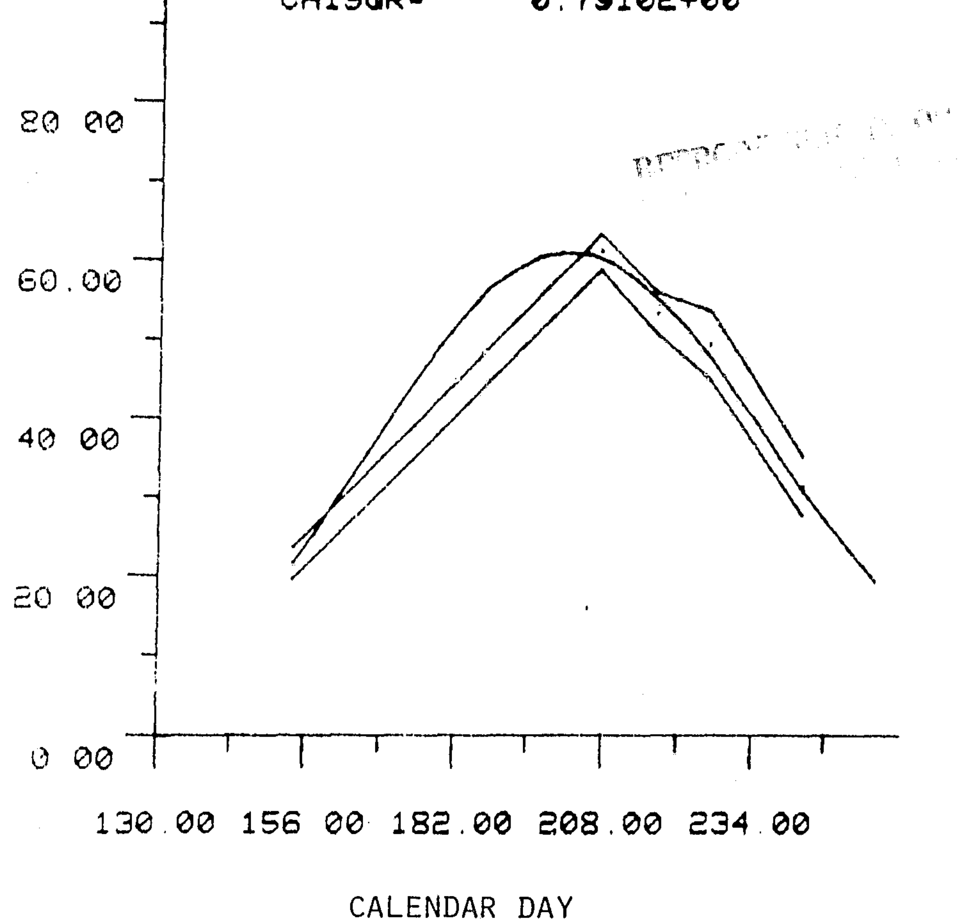

Figure 6-2d.— Segment 1636 spring wheat, channel 4.

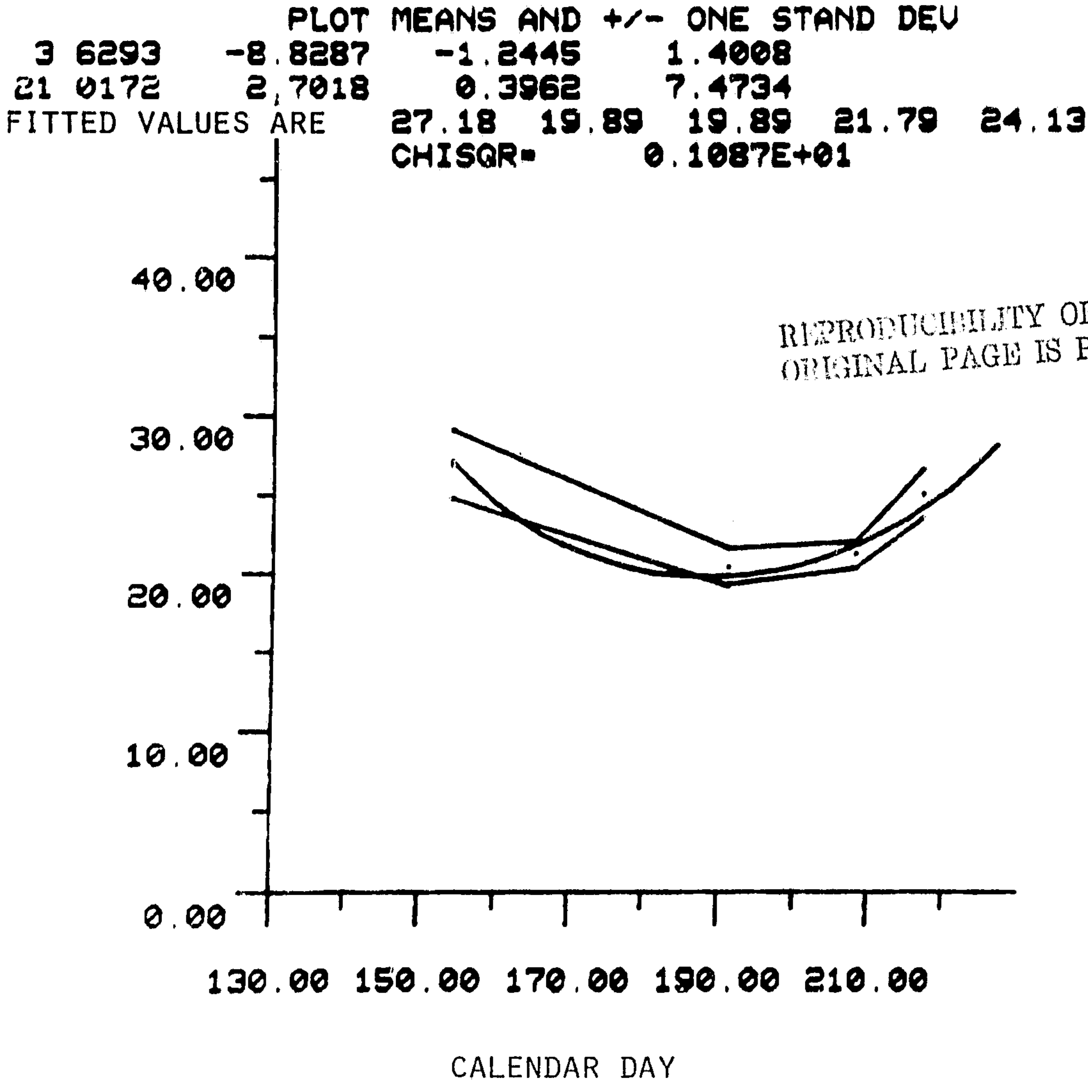

Figure 6-3a.— Segment 1653 spring wheat, channel 1.

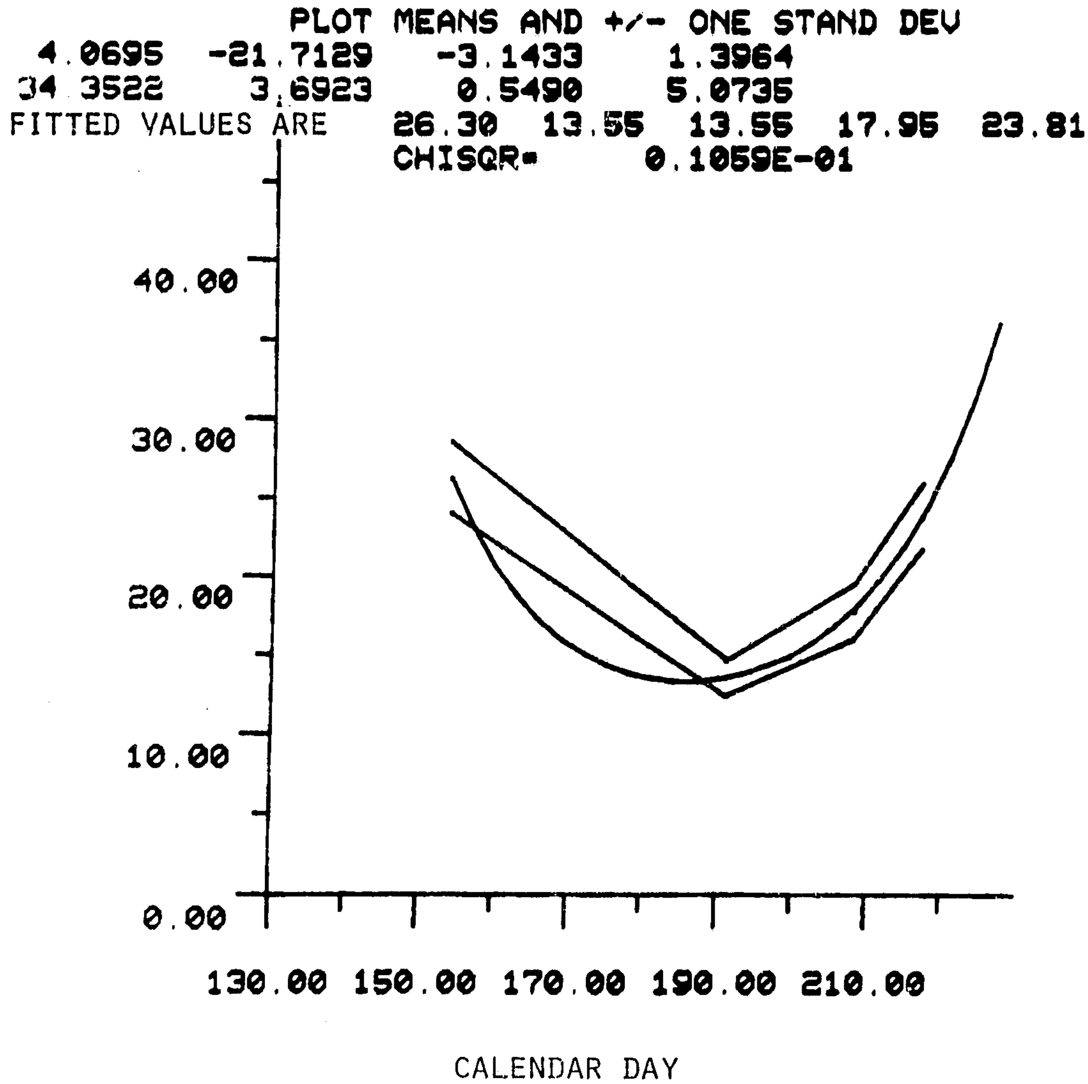

Figure 6-3b.— Segment 1653 spring wheat, channel 2.

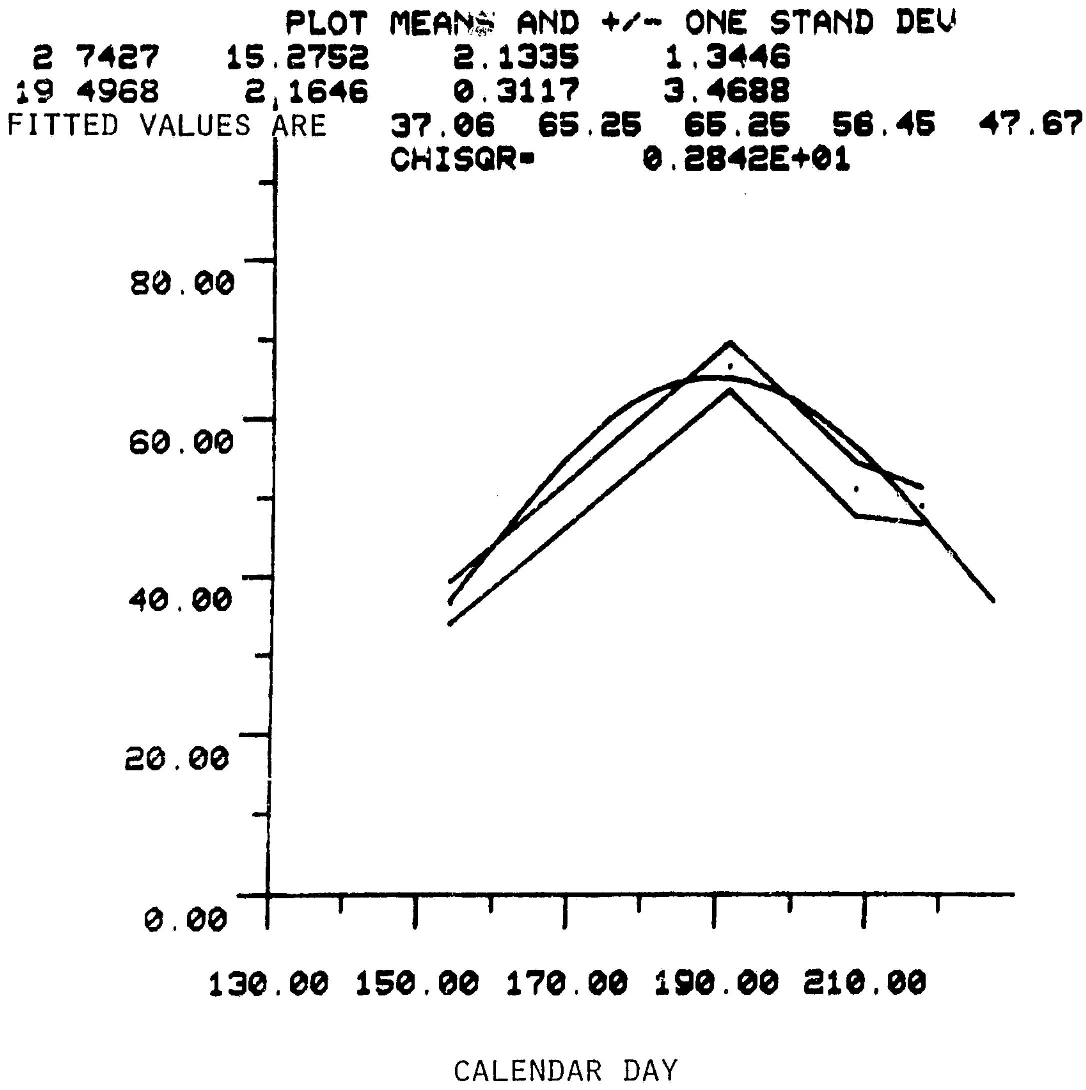

Figure 6-3c.— Segment 1653 spring wheat, channel 3.

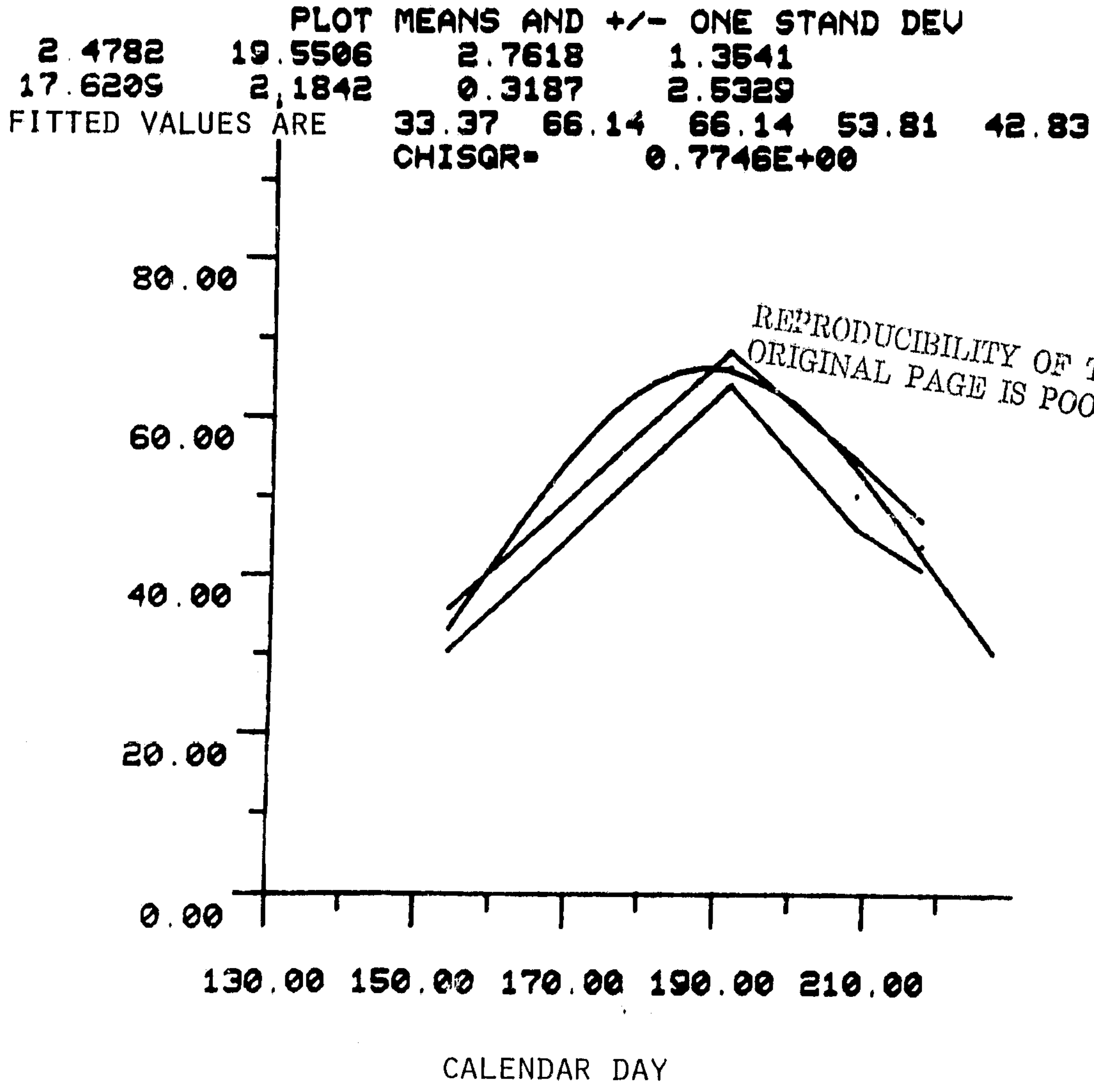

Figure 6-3d.— Segment 1653 spring wheat, channel 4.

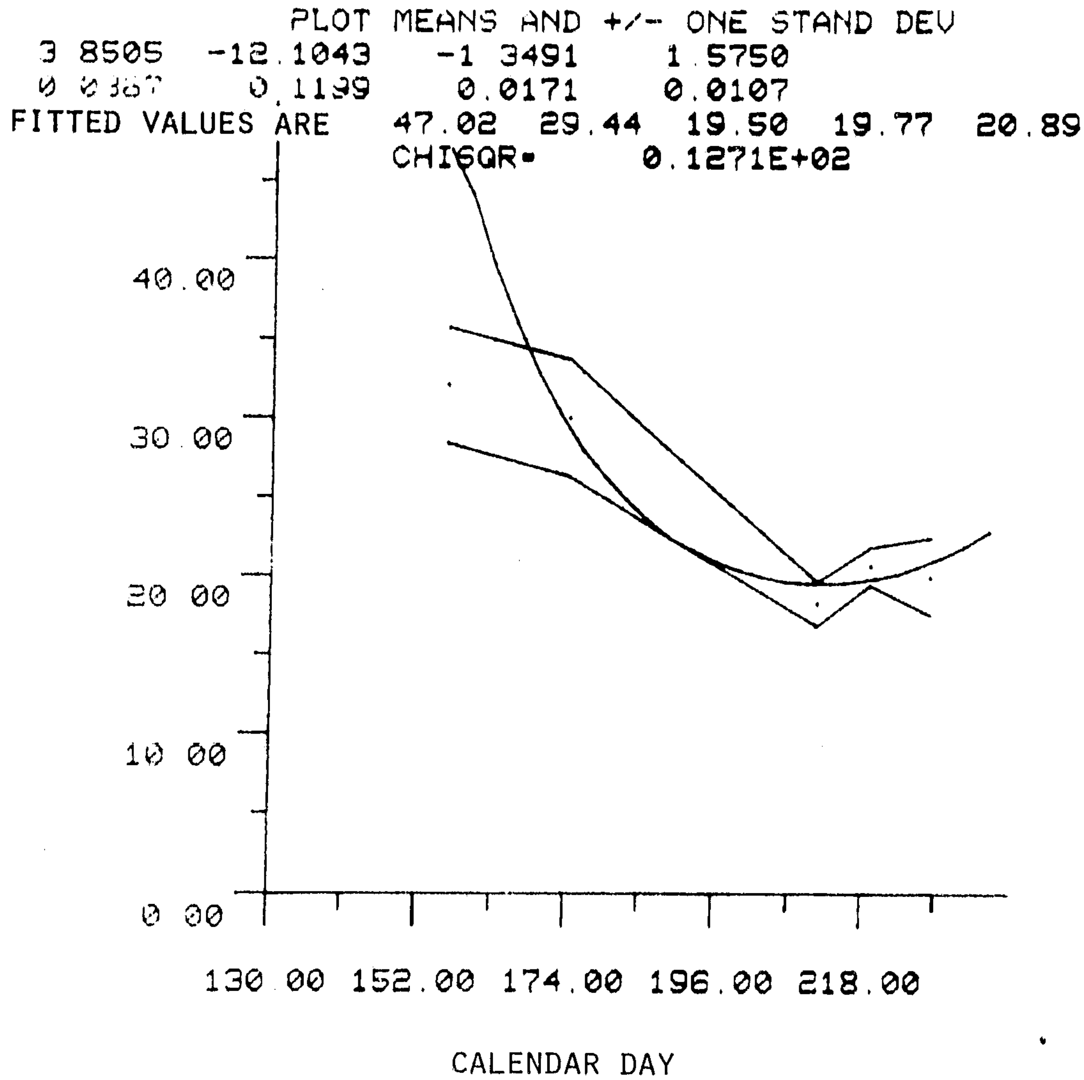

Figure 6-4a.— Segment 1394 spring wheat, channel 1.

PLOT MEANS AND +/- ONE STAND DEV

3 9868	-6 1601	-0 5114	1 4116
49 3446	7 4977	1 0423	16 9025

FITTED VALUES ARE 36.47 25.22 15.93 15.10 14.48

CHISQR= 0.4341E+01

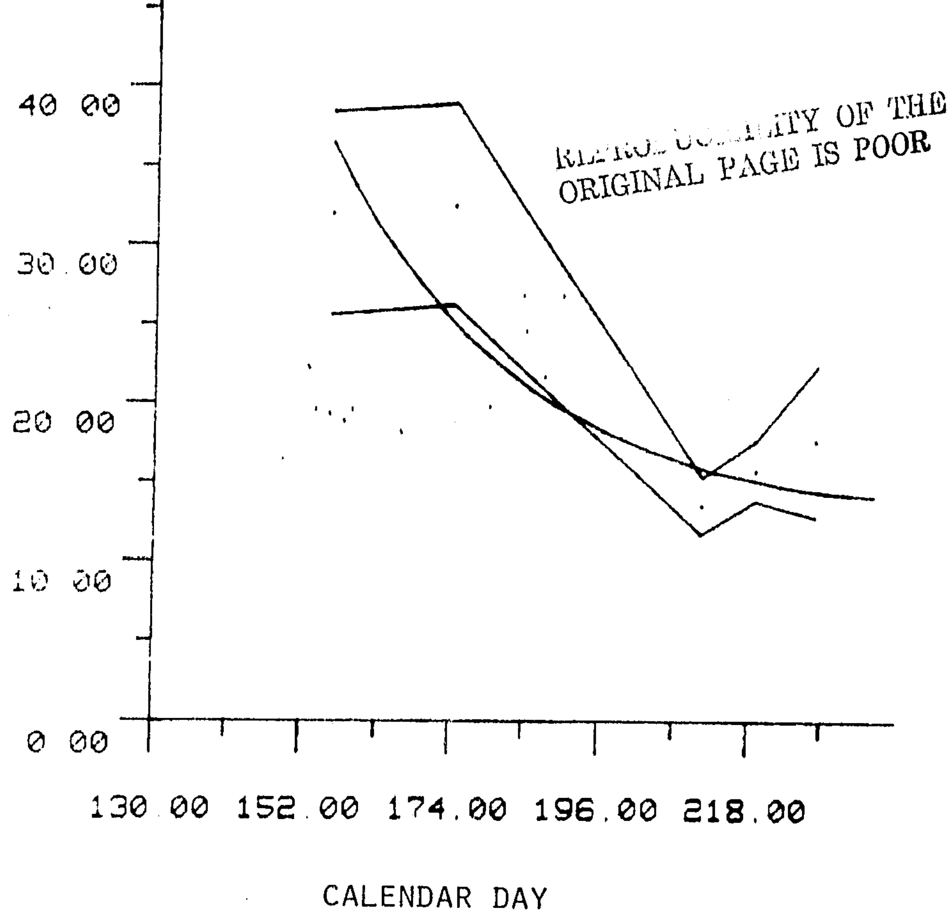

Figure 6-4b.— Segment 1394 spring wheat, channel 2.

PLOT MEANS AND +/- ONE STAND DEV

3 1432 3 2230 0.3201 1.2182

7 1426 3.8793 0.5257 3.8284

FITTED VALUES ARE 37.95 44.62 52.64 53.16 53.22

CHISQR= 0.2474E+01

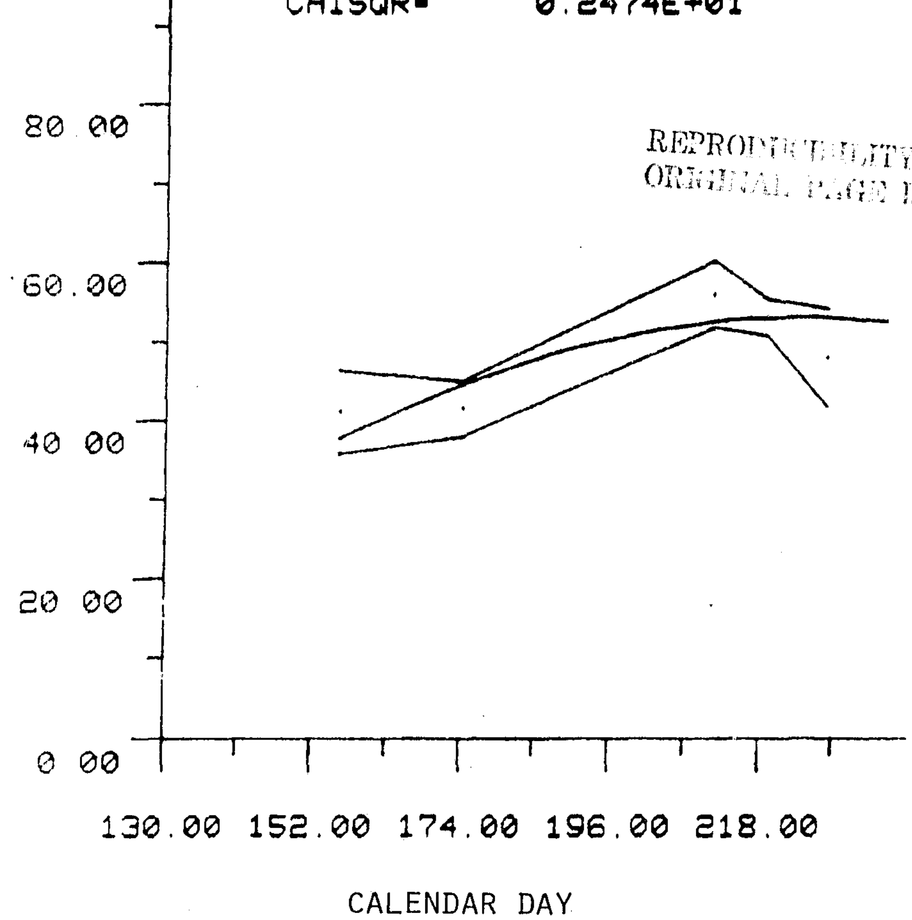

Figure 6-4c.— Segment 1394 spring wheat, channel 3.

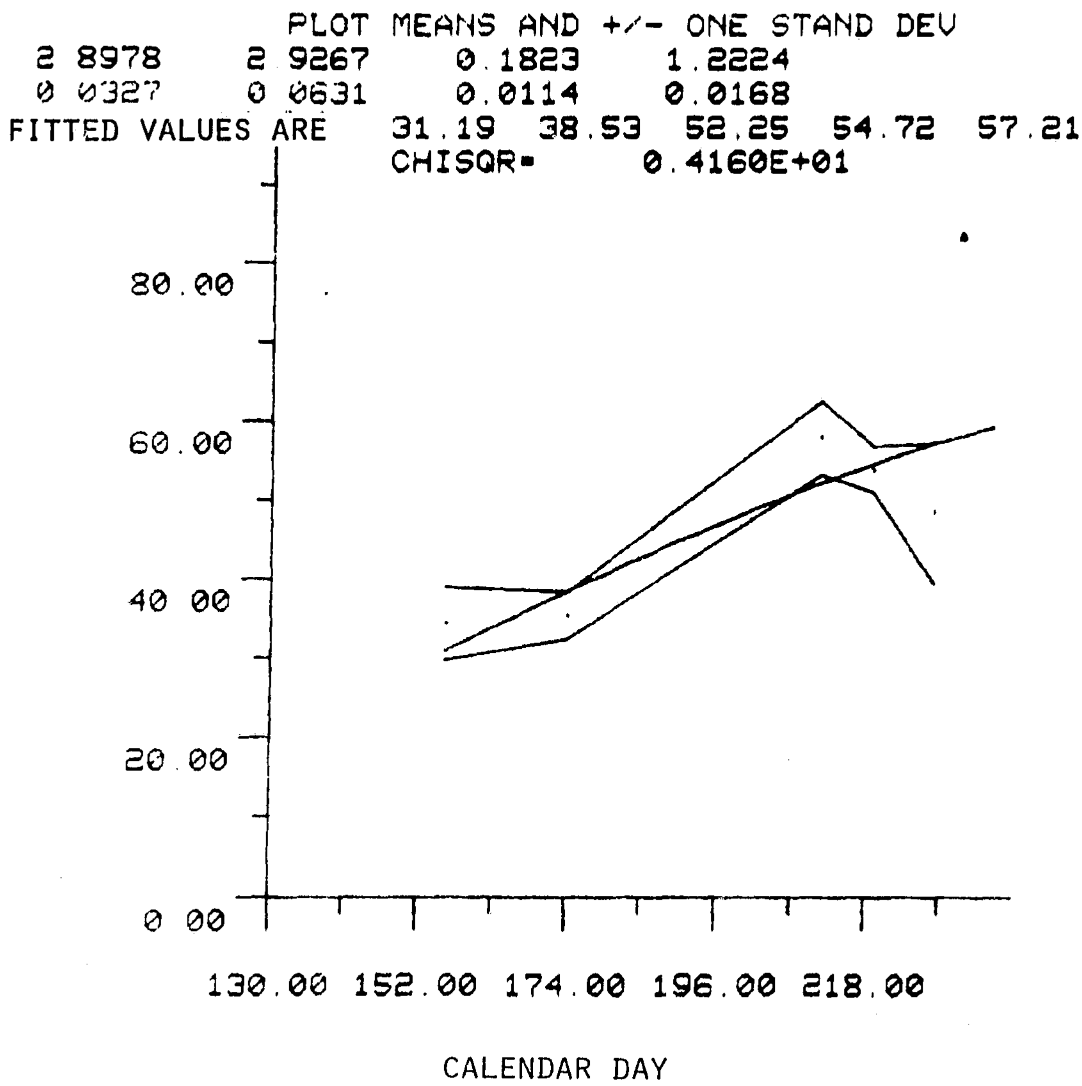

Figure 6-4d.— Segment 1394 spring wheat, channel 4.

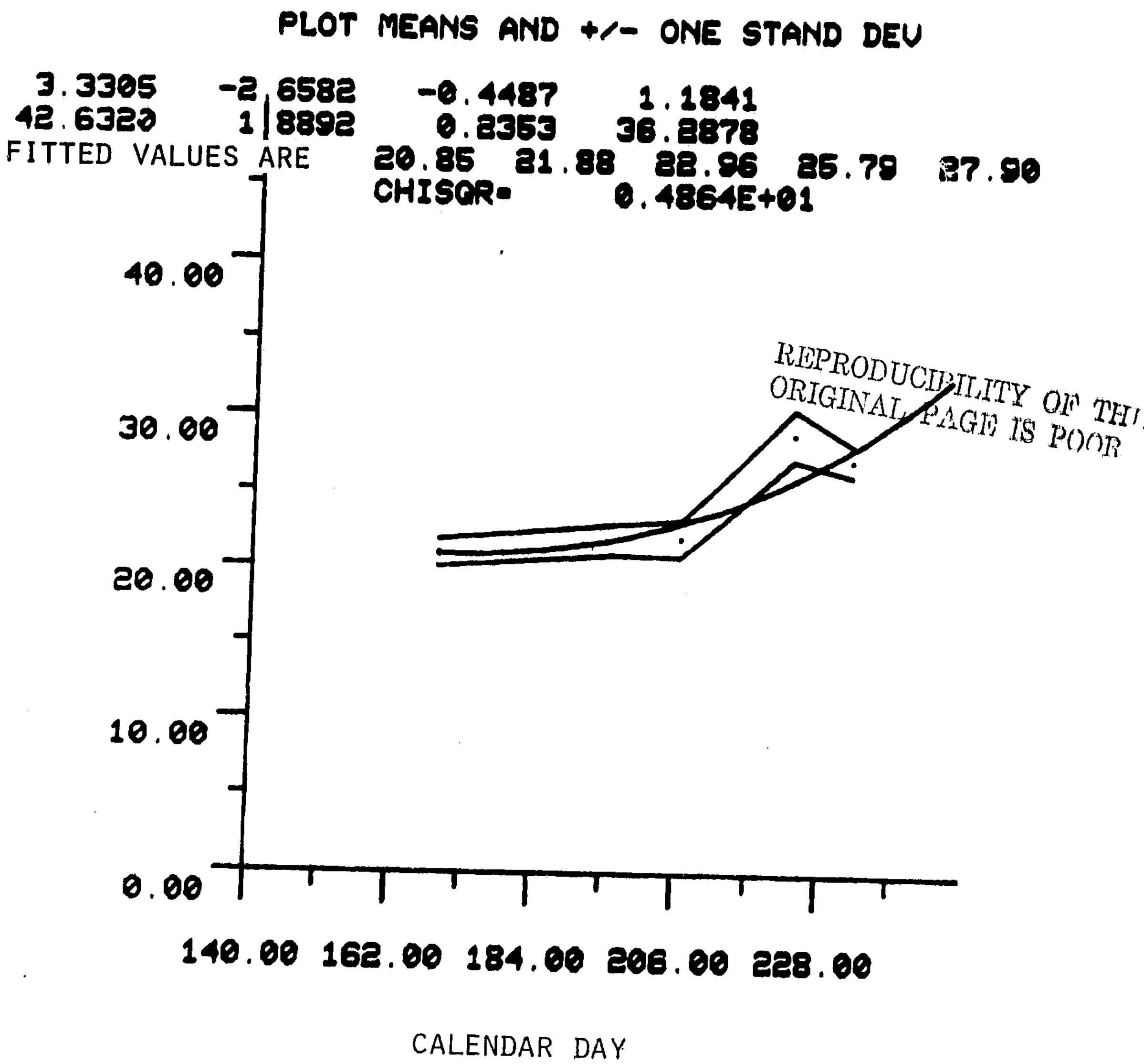

Figure 6-5a.— Segment 1825 spring wheat, channel 1.

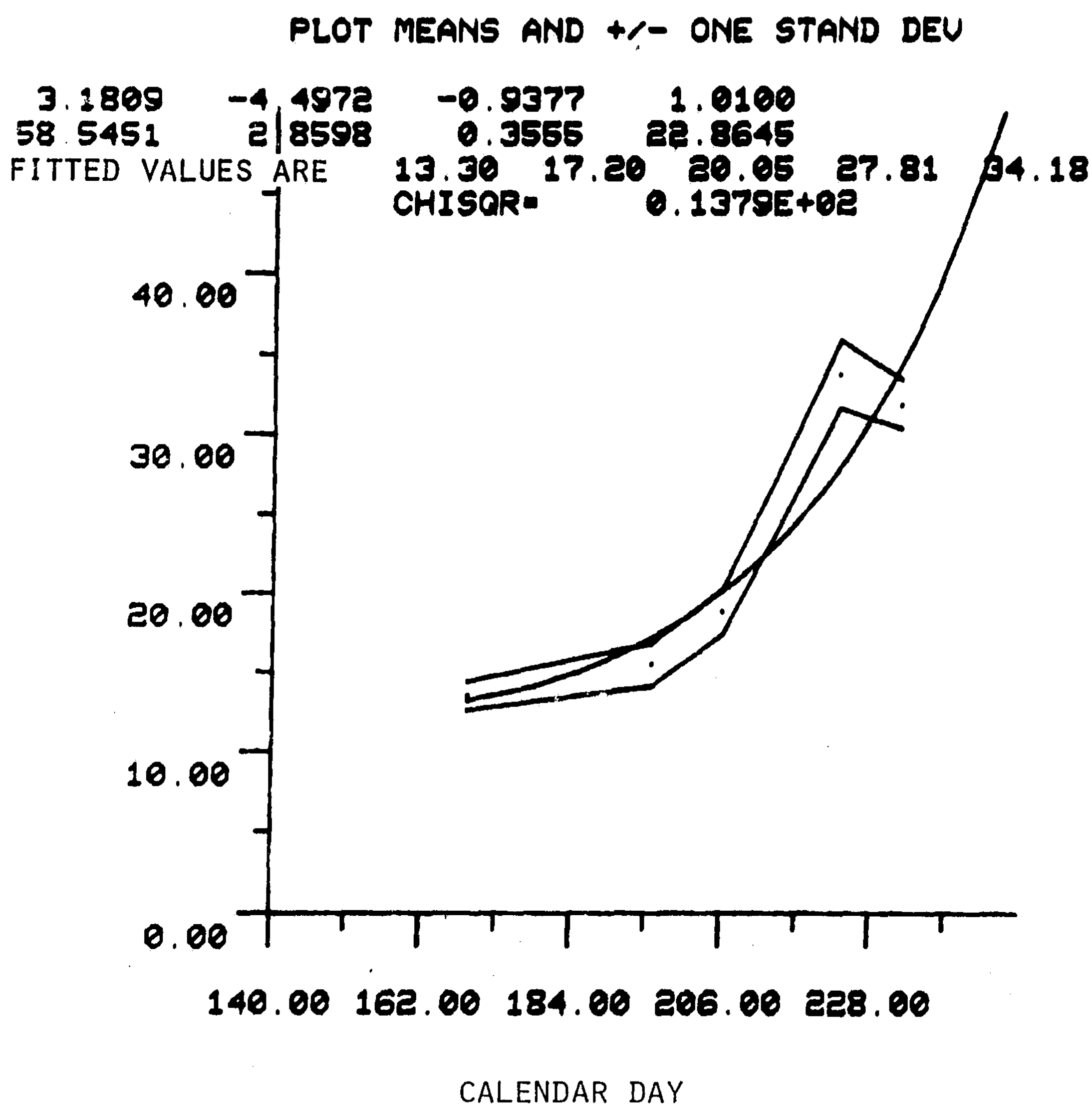

Figure 6-5b.— Segment 1825 spring wheat, channel 2.

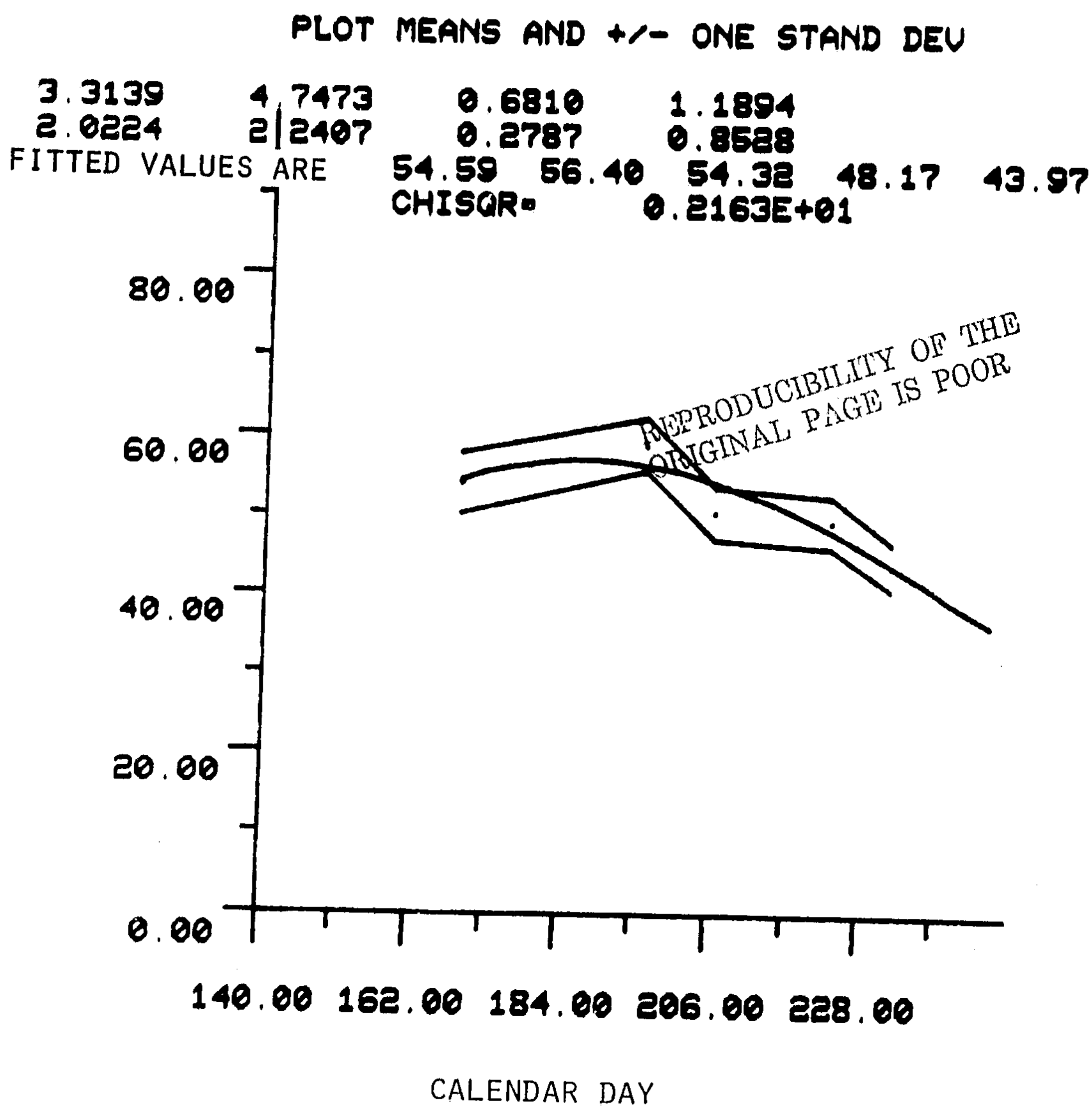

Figure 6-5c.— Segment 1825 spring wheat, channel 3.

PLOT MEANS AND +/- ONE STAND DEV

2.9730   8.7251   1.2493   1.2569
61.3308   3.0023   0.3713   16.1459
FITTED VALUES ARE   52.57   55.93   52.25   41.97   35.53
CHISQR=   0.5294E+00

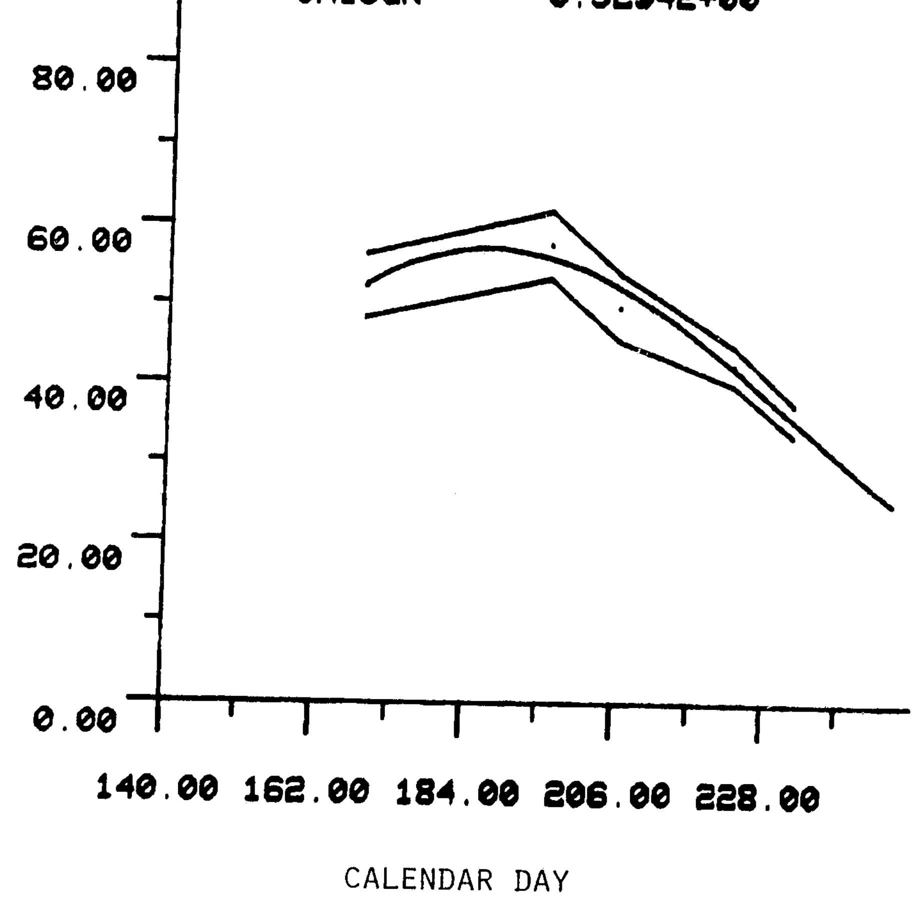

Figure 6-5d.— Segment 1825 spring wheat, channel 4.

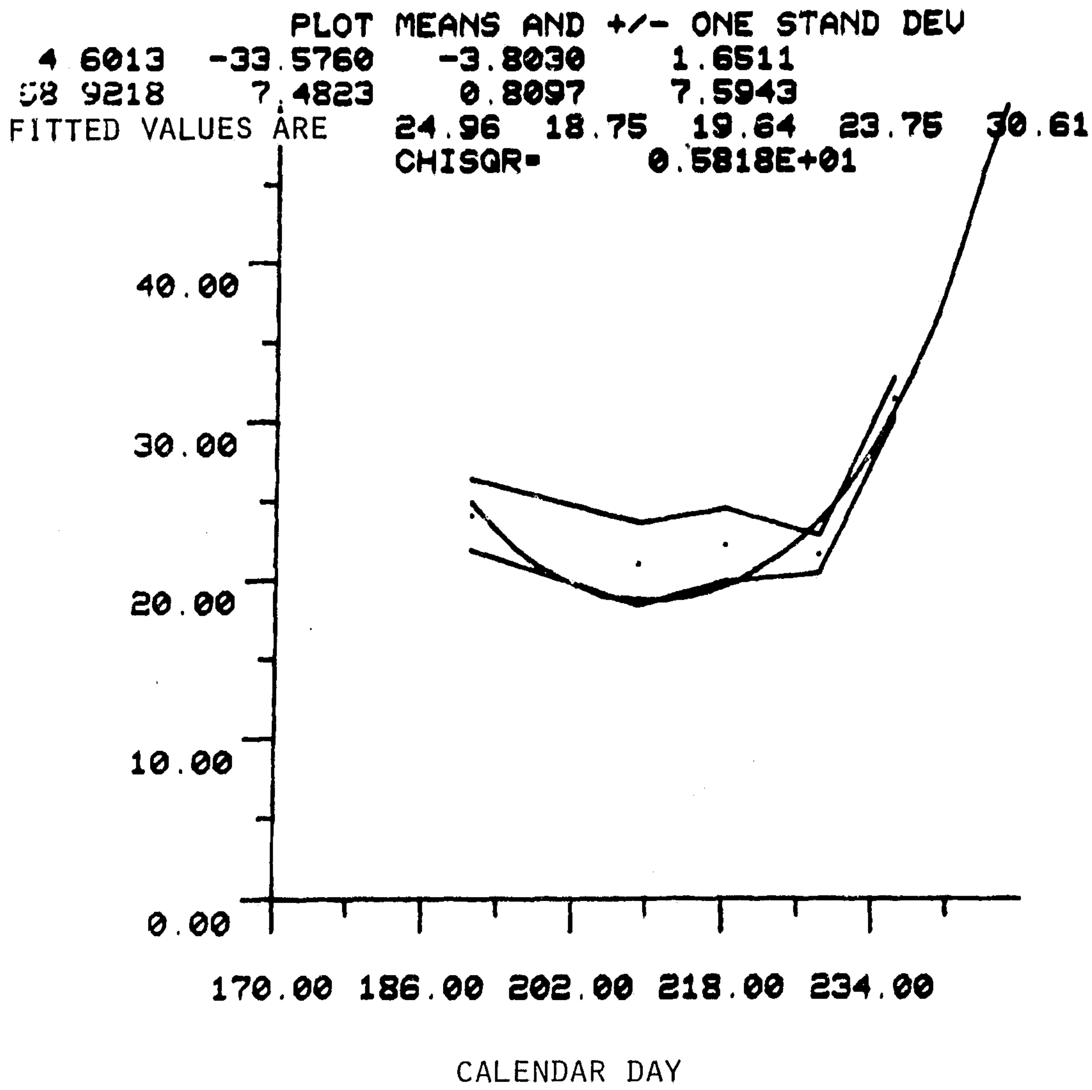

Figure 6-6a.— Segment 1650 spring oats, channel 1.

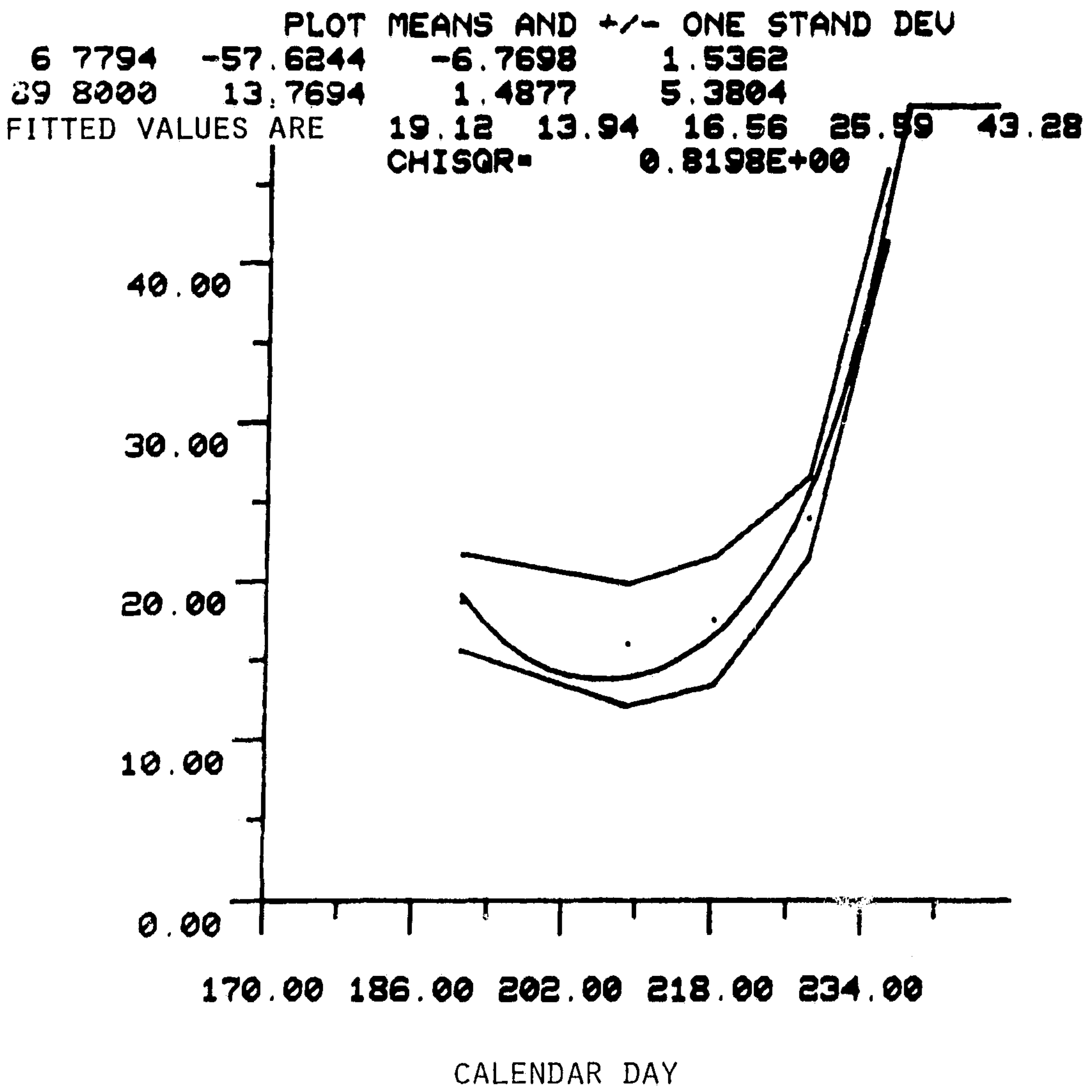

Figure 6-6b.— Segment 1650 spring oats, channel 2.

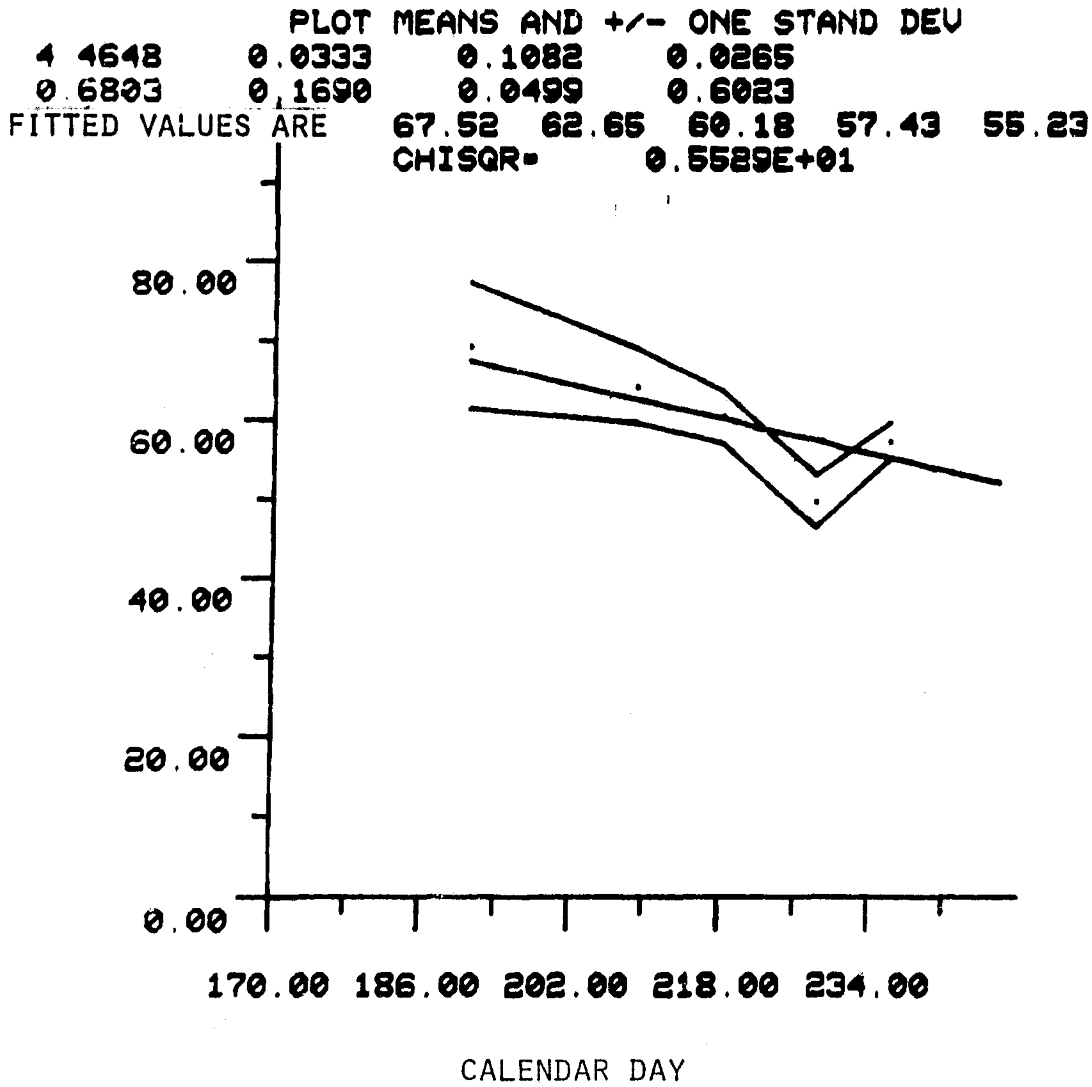

Figure 6-6c.— Segment 1650 spring oats, channel 3.

PLOT MEANS AND +/- ONE STAND DEV

3 4866 4.4998 0.7155 1.0911

1.2879 1.8894 0.2000 0.4996

FITTED VALUES ARE 69.94 62.66 57.54 51.17 45.82

CHISQR= 0.3276E+01

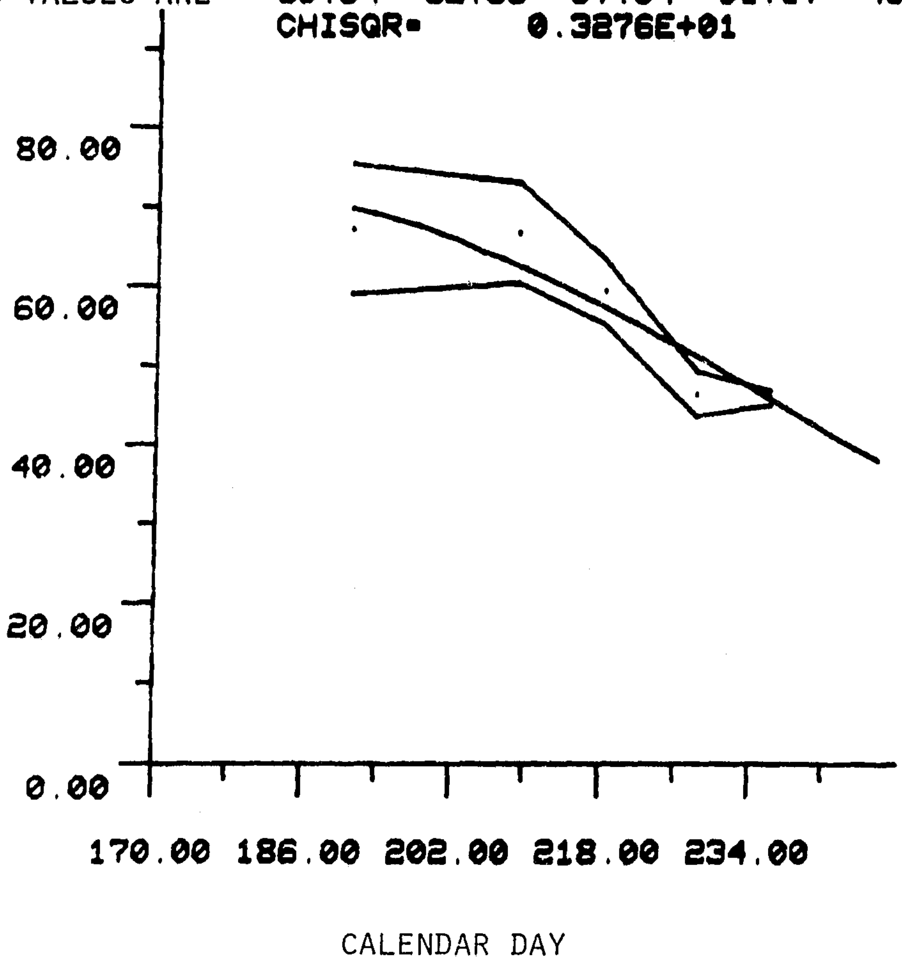

Figure 6-6d.— Segment 1650 spring oats, channel 4.

7. CONCLUSIONS AND ISSUES

7.1 COMPATIBILITY WITH CURRENT OPERATIONAL PROCEDURES

Current direct wheat (spring wheat and barley separation) classification procedures (ref. 4) require estimations in real time throughout the growing season using up to four acquisitions ranging from pre-emergence to postharvest. It is quite apparent that, given the acquisition history requirements of the profile similarity algorithm, the utility of this concept applies only to near- or at-harvest estimation procedures.

7.2 ACQUISITION HISTORY REQUIREMENTS

The Badhwar procedure appears to be highly dependent upon the optimum acquisition history for the segments. In all, 36 segments were screened for suitability and only 7 were found to meet the criteria. In general, where the segments were found to have a sufficient number of acquisitions for the algorithm, few LACIE/TY analyst omission errors (for pure dots) could be found. Segment 1542 in Roosevelt, Montana, is a case in point. Although this segment had a good acquisition history and a clearly defined field pattern, it later had to be dropped from the data set because of an insufficiency of analyst omission errors applied to pure dots. LACIE/TY data indicated that most of the omission errors were caused by border/edge conditions.

7.3 TRAINING FIELD REQUIREMENTS

In addition to acquisition history, training field selection appears to be one of the most crucial aspects for optimum performance using this approach. For the algorithm to perform, the training field requires a minimum of 20 pixels, which also should be homogeneous; must be an interior field (to eliminate misregistration effects); and the crops in the field should have emerged by the first acquisition date and not be harvested by the last acquisition date (ref. 3). Of the five training fields selected, only one field (segment 1653) met the subjective optimum criteria that has been set.

Training fields could be improved by a process of trial and error. However, at least three outcomes may result in trying to improve the selection:

a. There may not be an adequate number of large enough small-grain training fields in the segment because of the interior field requirement.

b. There may not be an adequate number of homogeneous small-grain training fields in the segment.

c. There may not be an adequate number of emerged small-grain training fields in the segment. Additionally, in order to select a training field that had emerged by the first acquisition, one acquisition at the front would have to be dropped. This leads to at least three more possible outcomes:

   1. That same field would in all likelihood be harvested by the last acquisition date, requiring elimination of the last acquisition date as well.

   2. The other spring-grain fields in the segment might also be harvested.

   3. There may not be a sufficient number of acquisitions to establish a model curve for spring grains after the last acquisition was dropped as a result of 1 and 2 above.

7.4 DOT PURITY REQUIREMENTS

In this study, the border/edge dots were eliminated manually. For this procedure to perform even quasi-operationally, a mechanism must be developed to identify the border/edge dots and subsequently eliminate them.

7.5 APPLICATION TO TYPE OF ERROR

One of the purposes of this study was to determine if the Chi-squared value (or rank) could serve as a flag for possible small-grain omission errors. To accomplish this, another group of dots was included to provide an indication of "false alarms" that might be caused using this approach. This leads to a procedure whereby all dots labeled nonsmall grain by the analyst need to be examined for omission errors. However, there is a possibility that all these dots were correctly labeled nonsmall grain in the first place. The results indicate that there is a high probability that nonsmall-grain dots could be falsely flagged as SSG.

8. RECOMMENDATIONS

Further research needs to be conducted in the following areas prior to the development of analysis procedures which might use this technique.

a. The channels or combination of channels that are most appropriate for use in measuring profile similarity should be determined.

b. The model chosen by Badhwar requires a nonlinear curve fitting. This is an iterative procedure where initial parameter estimates must be provided and convergence is not guaranteed. A study of alternative model forms that can use linear-least-squares should be investigated; this would remove the technique's dependence upon the initial parameter estimates.

c. The sensitivity of the technique to the training field selection should be measured. The need is to better understand the requirements for training field selection. This understanding includes homogeneity of emergence and development and similarity to the usual profile for the crops of interest.

d. The relative frequency at which the severe acquisition history constraints are met for the crop of interest should be estimated. This will establish how often the technique can be applied to various crops of interest.

In addition, there are other applications of the technique other than omission errors which should be evaluated. They are:

a. The detection of commission errors

b. Spectral adjustment for early or late development to enhance the barley/ other SSG's separation

c. Study of crop calendar planting date distributions

9. REFERENCES

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