LOCKHEED ELECTRONICS COMPANY, INC.
AEROSPACE SYSTEMS DIVISION
16811 EL CAMINO REAL • HOUSTON, TEXAS 77058 • TELEPHONE (AREA CODE 713) 488-6880

Ref: 642-1306
Job Order: 77-723
NAS: 9-12200
NASA CR-
140249

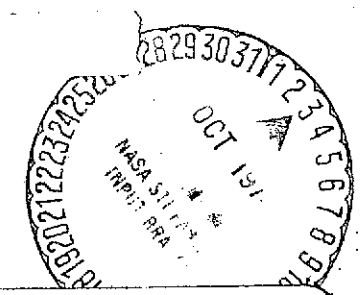
TECHNICAL MEMORANDUM

BURKE COUNTY WHEAT FEASIBILITY STUDY

by
W. A. Kunkel

Approved: C E Clouse

C. E. Clouse, Supervisor
Performance Evaluation
Section



June 1974 LEC 3783

BURKE COUNTY WHEAT FEASIBILITY STUDY

1.0 INTRODUCTION

The purpose of this document is to report the results obtained from a wheat feasibility study that was conducted over a three month period, from September 1, 1973 to December 1, 1973, using computer techniques and multispectral scanner data.

The site for which the study was undertaken was a selected area in Burke County, North Dakota, near the United States, Canadian border, with its center at approximately latitude 48° 54' 30" N and Longitude 102° 10' 30" W.

As compared to other wheat growing regions of the United States, very little or no winter wheat is grown, and all crops within the intensive test area are considered spring crops.

The test site was a 2 mile by 10 mile , (20 square miles) area in size. However, two sections (2 square miles) essentially game preserve and water reservoir were deleted from the investigation.

Dry land strip farming is a common practice in Burke County. Wheat is considered the chief crop, and oats and barley make up the remaining small grain crops. Other crops grown that make up a small part of crop acreage are corn, flax, clover and alfalfa.

Field size ranged from 1.8 to 116.2 acres. Of the 254 fields identified, approximately 113 were wheat, 14 barley and 10 oats.

ERTS-1 MSS data, scene 1317-17172, June 5, 1973 and scene 1317-17171, June 23, 1973 were two passes selected for making the analysis.

The Univac 1108 and the LARSYS pattern recognition software package was used in performing the classification.

2.0 OBJECTIVES

The object of this investigation was to determine if wheat could be distinguished from other small grain crops in a selected spring wheat growing area of the United States using a maximum likelihood classification program and ERTS-1 multispectral scanner (MSS) data.

3.0 TECHNICAL BACKGROUND

3.1 Ground Truth

Complete ground truth over the 2 by 9 mile area, within the 2 by 10 mile test site, was available. Tabulated crop acreage, annotated photo maps delineating field boundaries, and a crop calendar, (Table 1) were furnished by the Agricultural Stabilization Conservation Service, (ASCS) of the United States Department of Agriculture, (USDA). Total acres of all crops in the 2 by 9 mile area used for the investigation are summarized in Table 2.

Ground Truth was collected over the test site at approximately eighteen day intervals, usually on the same day of the ERTS satellite coverage.

4.0 TECHNICAL APPROACH

4.1 ERTS Data

The June 5 and June 23 data passes were the only two data sets usable for the investigation. Other ERTS coverage had over 50 percent cloud cover and could not be used. The ERTS data tapes were first displayed on the PMIS-DAS for cloud cover and site location by scan line and column number. The June 5 set has some scattered clouds but was used. The clouds were scattered over the eastern part of the test site and caused only minor difficulties. The June 23 set was cloud free and was considered the primary data set. Also, image to image registration by TF5 was performed on the two above passes resulting in a third data set for temporal analysis.

4.2 Field Selection

A computer line printed gray map was generated using the June 23 data pass from which training and test fields were selected. ISOCLS, a clustering computer program was also used to help establish field boundaries.

Training fields were not randomly selected, only the large well defined fields were chosen for training fields and test fields were selected from the remaining available fields. The same field selection configuration was used for the registered data set. Some modification for the June 5 training and test fields had to be made due to the scattered clouds and cloud shadows.

Not all crop types were included in the investigation. Only six categories were selected. These are as follows: 1) wheat, 2) barley, 3) oats, 4) grass, 5) water and 6) summer fallow. Crops such as flax, corn, clover and alfalfa were not included.

These crops were omitted primarily because the fields were considered too small to be used as training fields, and in some cases certain crops such as corn represented only one field. For instance, out of a total of 11,520 acres, only 79.1 acres were planted in flax, 45.0 acres in clover, 34.0 acres in alfalfa and 13.5 acres in corn. Other ground cover also not considered were the non-crop areas, which includes roads, buildings and low lying wet lands not suitable for farming.

4.3 Analysis Procedures:

A classification run was made using all available fields large enough in size to cleanly select training fields. Statistics were computed for each field and the means and standard deviations were plotted using channel 2 as the ordinate and channel 3 as the abscissa. Means of fields that show to be unseparable from other fields of a different class were deleted.

A second classification run was made, and again the means were plotted for the undeleted training field, using the same scheme as above.

The means for water were not plotted, because no difficulties were experienced in classifying water.

Scatter plots of the means and standard deviation for training fields of the June 5 and June 23 data sets were made and are shown in Figures 1 and 2.

By referring to the June 23 data pass scatter plot, wheat and barley were subdivided into subclasses. Wheat was split into six classes, and barley into two classes. Oats, grass, water and summer fallow were not subdivided, Figures 3 and 4 show mean plots where the fields were combined into classes.

Four channels of data were used for the single passes, and all eight channels were used in classifying the registered data.

For the final performance results, wheat and barley subclasses were combined so that each crop would represent a single class.

5.0 RESULTS

All results given in the following tables are confined to the 18 square miles intensive study area.

Classification results obtained after lumping the various classes of training and test fields together are shown in Tables 3, 4 and 5 for each of the three data sets. Also included are bar charts showing the accuracy of wheat classification for training and test fields, and misclassification of barley and oats into wheat, (Figure 5).

For the most part, wheat classification results were very good. Based on training field data, the June 5 coverage gave the poorest results with an overall performance of 48 percent accuracy. Using 637 pixels for the wheat training data, wheat classified to a 71.3 percent accuracy. The June 23 data set had an overall performance accuracy of 79.0 percent, and using 658 pixels for training data, wheat classified to a 90.1 percent accuracy.

Poor and irregular results obtained from the June 5 data set as compared to the June 23 data was believed to be primarily caused by plant size, age and density. There is evidence that when wheat, oats, barley, and certain grass types are in the early growing stages, classification results are determined more by the above factors than by actual crop type. When the June 5 data was collected, the small grain crops were in a very early growing stage ranging from 1 to 2 inches in height. Spectrally these crops were very near the same. Whereas when the June 23 data was collected, plant height had reached a growing height of 8 to 12 inches and were well into a boot stage, spectrally showing a greater difference between each type.

The multipass (registered) data gave the best classification performance with an overall accuracy of 87 percent, and for wheat a 92.7 percent accuracy, indicating by using 8 channel (multipass) data, classification accuracy can be improved.

Acreage estimates for wheat, oats, and barley based on a pixel count was made, (Table 6). On this table all pixels inside the 18 square mile intensive study area were considered. Again it is seen that wheat accuracy was very good, especially the multipass data where acreage estimates were 99.2 percent. From a total of 4497.4 ground truth acres in wheat, 4533.1 acres were classified as wheat.

6.0 CONCLUSION AND RECOMMENDATIONS

There is good evidence that wheat can be identified adequately for the purpose of acreage estimates using ERTS data and the present systems and methods. The following summarizes these conclusions:

- Wheat can be separated from other crops with a classification accuracy of approximately 90 percent, while maintaining a misclassification error of other crops into wheat of about 10 percent by using multi-pass data sets.

- It is recommended that for better classification

accuracy, that data be collected over a longer range of growing period and especially when the crops are in a more mature stage, probably just before ripening. This conclusion was drawn from results obtained from the June 5 and June 23 data sets.

Crop Calendar

Wheat seeding starts about May 1 and ends around May 20.

10-14 days before emergence.

30-35 days till boot stage.

42-50 days till heading

72-86 days till ripe for harvest

Harvest, from August 8 through September 5.

Barley seeding starts about April 25 and ends around May 10.

8-11 days before emergence

30-35 days till in boot stage

40-48 days till heading

72-80 days till ripe for harvest

Harvest, from July 25 through August 8.

Oats seeding starts about April 25 and ends around May 10.

8-11 days before emergence

30-35 days till in boot stage

40-48 days till heading

68-78 days till ripe for harvest

Harvest, from August 1 to August 13.

Table 1

Burke County, North Dakota
Total Acreage for the 2 x 9 Mile, (18 sq. mi., 11,520 acres) of Ground Truth.

Wheat	4494.4 acres
Barley	521.1 acres
Oats	344.0 acres
Flax	79.1 acres
Clover	45.0 acres
Alfalfa	34.0 acres
Corn	13.5 acres
Grassland	947.0 acres
Summer fallow	3521.9 acres
Non - crop	1517.0 acres

Table 2

CROP ID	TYPE	#TOTAL	#W	#B	#O	#G	#WR	#SF	#	#	#	%W	%B	%O	%G	%WR	%SF	%	%	%
	TRG.	637	454	125	39	12	2	5				71.3	19.6	6.1	1.9	0.3	0.8			
Wheat	TEST	275	171	52	12	8	3	29				62.2	18.8	4.4	2.9	1.1	10.6			
	TRG.	69	24	40	2	0	2	1				34.8	58.0	2.9	0.0	2.9	1.4			
Barley	TEST	38	25	4	1	0	0	8				65.8	10.5	2.6	0.0	0.0	21.1			
	TRG.	75	15	2	50	8	0	0				20.0	2.7	66.7	10.7	0.0	0.0			
Oats	TEST	37	13	3	20	0	0	1				35.1	8.1	54.1	0.0	0.0	2.7			
	TRG.	88	3	0	3	81	0	1				3.4	0.0	3.4	92.1	0.0	1.1			
Grass	TEST	36	5	0	0	29	0	2				13.8	0.0	0.0	80.6	0.0	5.6			
	TRG.	36	2	2	0	1	31	0				5.6	5.6	0.0	2.8	86.0	0.0			
Water	TEST	—	—	—	—	—	—	—				—	—	—	—	—	—			
	TRG.	236	59	21	3	3	1	149				25.0	8.9	1.3	1.3	0.4	63.1			
S. Fallow	TEST	357	81	45	4	7	5	215				22.7	12.6	1.1	2.0	1.4	60.2			
	TRG.																			
	TEST																			
	TRG.																			
	TEST																			
	TRG.																			
	TEST																			

TABLE 3.– June 5 data set crop classification accuracy for wheat (W), barley (B), oats (O), grass (G), water (WR) and summer fallow (SF).

CROP ID	TYPE	#TOTAL	#W	#B	#O	#G	#WR	#SF	#	#	#	%W	%B	%O	%G	%WR	%SF	%	%	%
	TRG.	658	593	27	23	13	0	2				90.1	4.1	3.5	2.0	0.0	0.3			
Wheat	TEST	270	223	13	15	9	0	10				82.6	4.8	5.6	3.3	0.0	3.7			
	TRG.	87	17	68	0	1	0	1				19.6	78.2	0.0	1.1	0.0	1.1			
Barley	TEST	35	14	17	0	3	0	1				40.0	48.6	0.0	8.6	0.0	2.8			
	TRG.	75	32	0	24	19	0	0				42.7	0.0	32.0	25.3	0.0	0.0			
Oats	TEST	38	10	0	17	11	0	0				26.3	0.0	47.7	29.0	0.0	0.0			
	TRG.	389	45	3	47	294	0	0				11.6	0.8	12.0	75.6	0.0	0.0			
Grass	TEST	32	3	0	2	25	0	2				9.3	0.0	6.3	78.1	0.0	6.3			
	TRG.	106	0	0	0	0	106	0				0.0	0.0	0.0	0.0	100.0	0.0			
Water	TEST	—	—	—	—	—	—	—				—	—	—	—	—	—			
	TRG.	475	16	8	1	3	0	447				3.4	1.7	0.2	0.6	0.0	94.1			
S. Fallow	TEST	357	14	8	2	1	0	332				3.9	2.2	0.6	0.3	0.0	93.0			
	TRG.																			
	TEST																			
	TRG.																			
	TEST																			
	TRG.																			
	TEST																			

TABLE 4.— June 23 data set crop classification accuracy for wheat (W), barley (B), oats (O), grass (G), water (WR), summer fallow (SF).

CROP ID	TYPE	#TOTAL	#W	#B	#O	#G	#WR	#SF	#	#	#	%W	%B	%O	%G	%WR	%SF	%	%	%
	TRG.	658	610	23	21	4	0	0				92.7	3.5	3.2	0.6	0.0	0.0			
Wheat	TEST	275	241	1	19	9	0	5				87.6	0.4	6.9	3.3	0.0	1.8			
	TRG.	87	9	78	0	0	0	0				10.3	89.7	0.0	0.0	0.0	0.0			
Barley	TEST	38	9	25	4	0	0	0				23.7	65.8	10.5	0.0	0.0	0.0			
	TRG.	75	9	0	64	2	0	0				12.0	0.0	85.3	2.7	0.0	0.0			
Oats	TEST	37	3	1	33	0	0	0				8.1	2.7	89.2	0.0	0.0	0.0			
	TRG.	389	4	1	24	359	0	1				1.0	0.3	6.1	92.3	0.0	0.3			
Grass	TEST	36	2	0	0	32	0	2				5.6	0.0	0.0	88.8	0.0	5.6			
	TRG.	106	0	0	0	0	106	0				0.0	0.0	0.0	0.0	100.0	0.0			
Water	TEST	—	—	—	—	—	—	—				—	—	—	—	—	—			
	TRG.	475	4	4	0	6	0	461				0.8	0.8	0.0	1.3	0.0	97.1			
S. Fallow	TEST	357	8	4	4	3	0	338				2.2	1.1	1.1	0.9	13.0	94.7			
	TRG.																			
	TEST																			
	TRG.																			
	TEST																			
	TRG.																			
	TEST																			

TABLE 5.— June 5 and 23, registrated data set crop classification accuracy for wheat (W), barley (B), oats (O), grass (G), water (WR) and summer fallow (SF).

	GND TR. ACRES	JUNE 5 ACRES EST.	JUNE 23 ACRES EST.	JUNE 5 & 23 ACRES EST.			JUNE 5 % CLASSIFIED	JUNE 23 % CLASSIFIED	JUNE 5 & 23 CLASSIFIED			
Wheat	4497.4	5342.8	4881.3	4533.1			81.2	91.5	99.2			
Barley	521.1	1648.1	1065.1	793.7			31.6	48.9	65.7			
Oats	344.0	728.6	665.4	1231.3			47.2	51.7	27.9			
Others	6157.5	3800.5	4908.2	4961.9			61.7	79.7	80.6			

TABLE 6.– Crop Acreage Estimates.

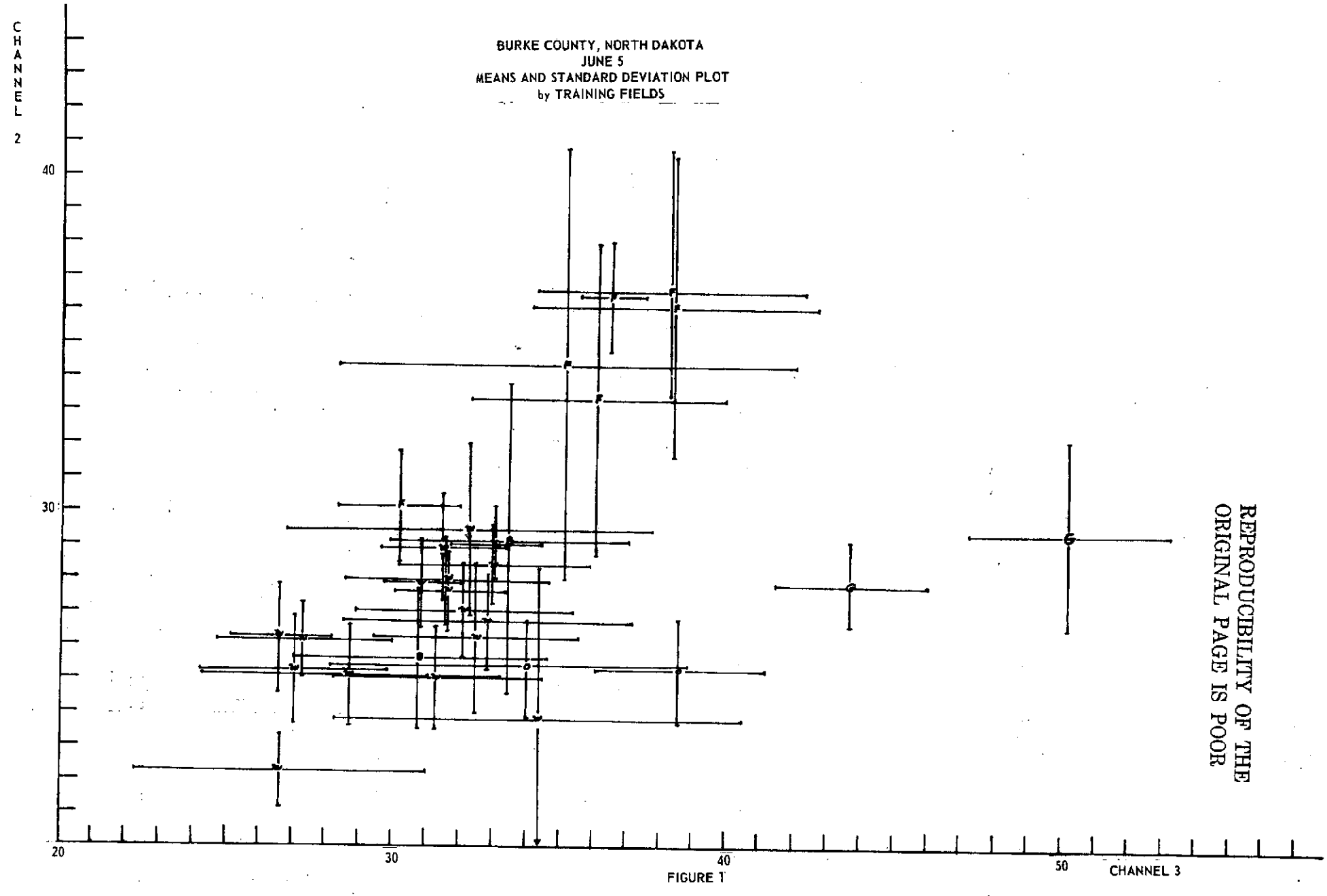


FIGURE 1

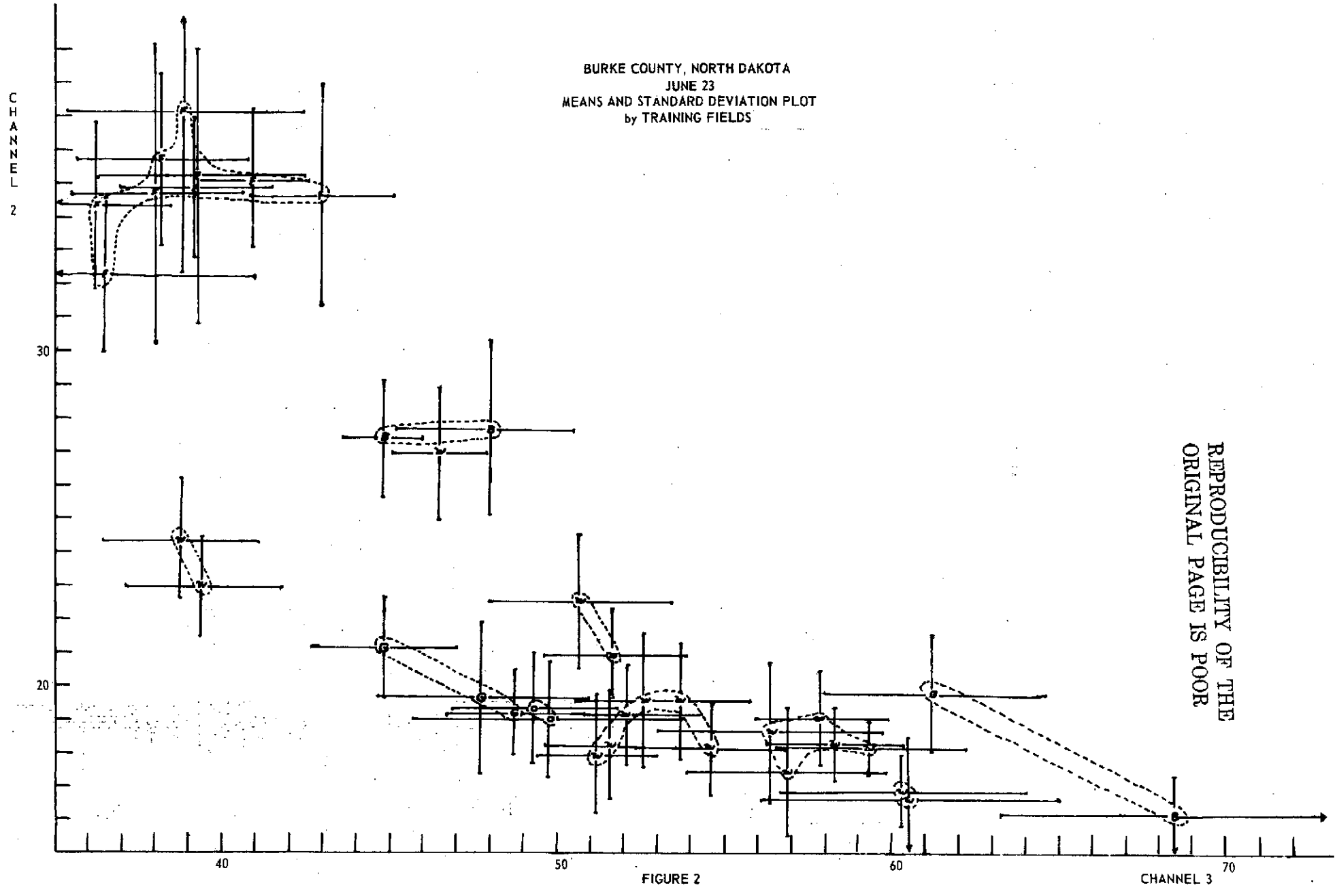


FIGURE 2

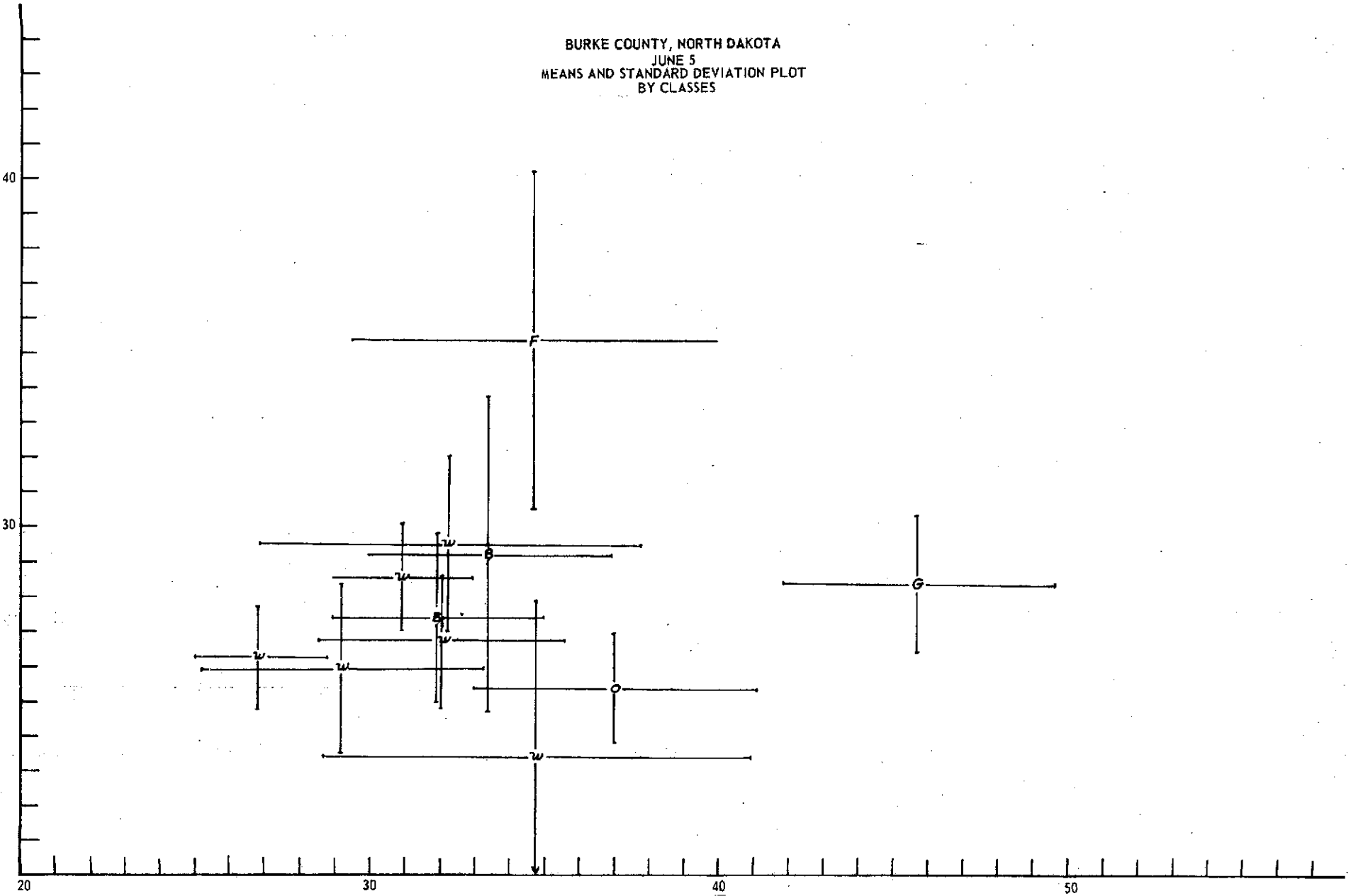

BURKE COUNTY, NORTH DAKOTA
JUNE 5
MEANS AND STANDARD DEVIATION PLOT
BY CLASSES
CHANNEL 2
40
30
20
30
40
50
CHANNEL 3
F
G
O
W
B

FIGURE 3

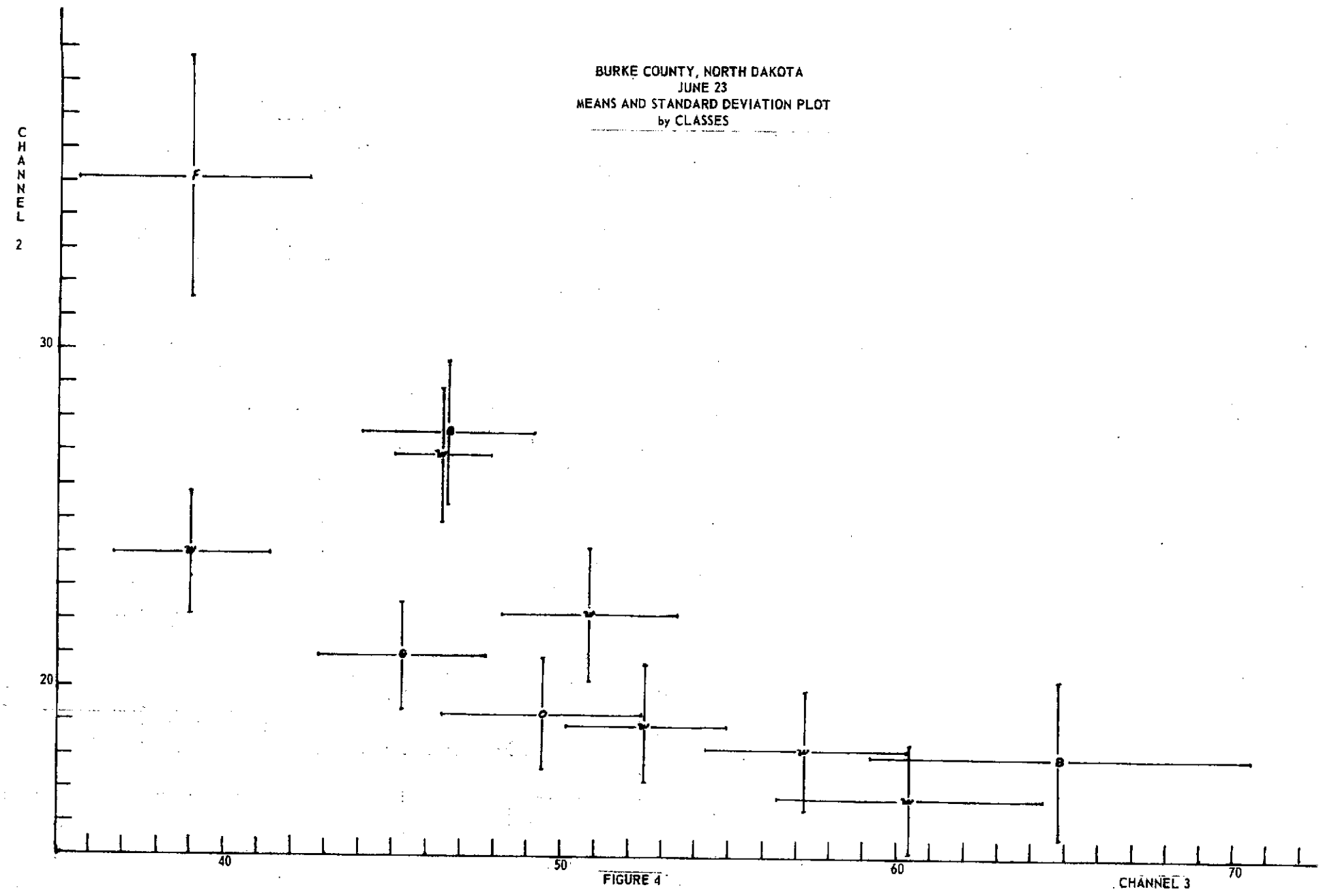
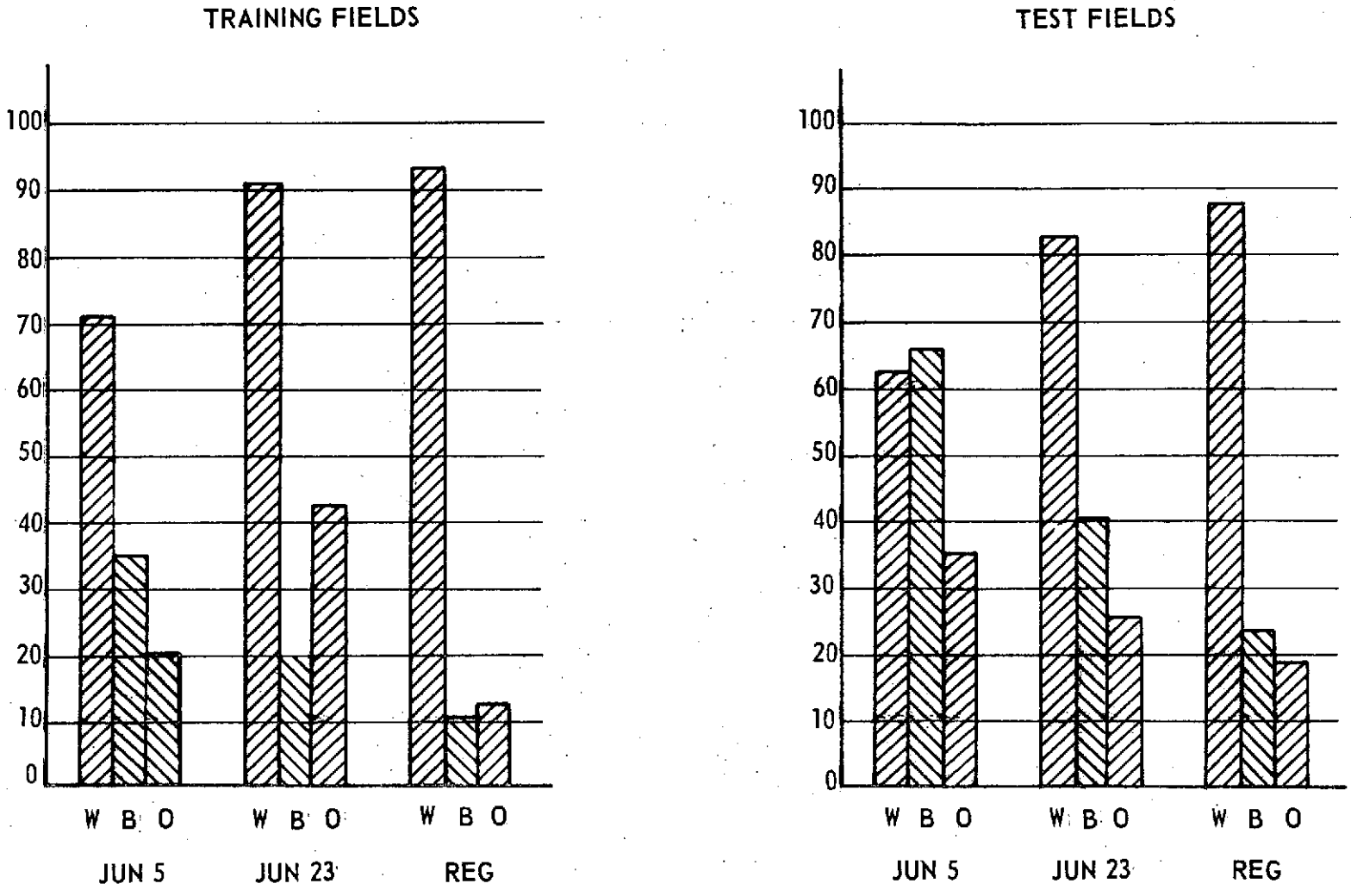

BURKE COUNTY, NORTH DAKOTA
JUNE 23
MEANS AND STANDARD DEVIATION PLOT
by CLASSES
CHANNEL 2
30
20
40
50
60
70
CHANNEL 3
F
B

FIGURE 4



Percent classification accuracy for wheat (W), and percent of oats (O), and barley (B) misclassified as wheat.

Figure 5.