MONTHLY PROGRESS REPORT
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CROP STATUS EVALUATIONS AND YIELD PREDICTIONS

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A. Significant activities and results -

1. A model for predicting the day 50% of the wheat crop is planted in North Dakota has been developed. This model incorporates location (LOC) as another independent variable. The addition of this variable with its transformations brought the total number of independent variables to 49. The Julian date when 50% of the crop was planted for the 9 divisions of North Dakota for 7 years was then regressed on the 49 variables through the step-down multiple regression procedure. This procedure begins with all of the independent variables and sequentially removes variables that are below a predetermined level of significance after each step. The Julian date of 50% planted for the years 1967-72, 74 was obtained as explained in the July 8 and August 5 reports. The validity of this procedure was confirmed by a recent USDA report, N. D. Wheat Historic Estimates 1955-1970, Ag. Statistics No. 33. 1973 data was omitted for use in testing the model. 1974 data were used in the analysis since the year was very atypical and therefore broadened the scope of data for the analysis. The following basic independent variables were used: running three, six, and nine day sums of average minimum and maximum temperature values (C°) (N3S, N6S, N9S, X3S, X6S, X9S), estimated soil moisture (E0 in %), preseason precipitation (PP in cm), and location(LOC). The basic variables were used as additional independent variables in the form of the following transformations: square and cube; and cross products of all basic variables. Table 1 shows the statistics for the final step of the anlaysis, with Fig. 1 showing the relationship of the predicted values to the actual values.

The prediction equation (Predicted planting date = 136.7 + 0.0055 (E0 X N9S) - etc.) was tested on daily data not used in the analysis for 1973. An example of the predicted values for one division (represented by dots) is presented in Fig. 2. The curved line is the line of best fit (considering only 1st and 2nd order equations) through the points. The straight line (45°) passes through points where actual and predicted values are equal. The objective of the procedure is to find the date where the value predicted by the equation is equal to the actual Julian date. Thus, the point where the regression line crosses the 45° line is chosen as the predicted planting date. For the Northwest division of North Dakota, the actual date was missed by 8 days using this method. Results for all divisions are as follows:

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Division	Predicted Julian Date	Actual Julian Date
Northwest	123	131
North Central	138	133
Northeast	124	127
West Central	116	124
Central	138	118
East Central	124	111
Southwest	126	126
South Central	100	116
Southeast	126	112
Avg.	124	122

The accuracy of this model is considered satisfactory for the purpose of finding the historic dates (i.e. years when no USDA reports were available) on which to initiate our yield prediction model.

2. Growth rate prediction models have been developed for spring wheat for the first two weeks of the 1974 season. These were developed from analysis of 1974 data from Dickinson, Williston (2 locations), Minot, North Dakota and Clemson, South Carolina. Since observations were not begun on the exact date of emergence at each location, it was necessary to establish a stage of development in common for all locations on which to base the subsequent weekly increments of data for analysis. The stage 2.4 was used as the point in common to represent the end of the first week of development. Successive 7-day increments will be used for the subsequent weekly analyses. Each analysis will combine the current week's data with all previous weeks.

Growth rates were regressed on the following independent variables: maximum air temperature (C°), minimum air temperature (C°), precipitation (cm.), estimated soil moisture (100% by Thornthwaite method), solar radiation (Langleys); at 0, 1, 2, and 3 day lag periods; squared, cubed; and 45 selected cross products of the basic lagged variables; for a total of 93, by the step-up multiple regression procedure. This procedure selects the most highly correlated individual independent variable in the first step, and in successive steps variables are added or removed to maintain significance at a designated level (considering all possible combinations). Tables 2, 3, 4, and 5 present statistics of the steps selected for use as growth prediction models.

B. Overall status and problem areas -

Development of prediction models for spring wheat should be completed shortly and then the models will be subjected to tests on domestic data. Several inquiries have been made without success to obtain weather and yield data on the foreign countries for which there is interest in trial predictions. We have on hand a limited amount of Canadian and USSR data which may be used. Unless a source is found soon for data from China, Argentina, Australia and India it is doubtful that tests will be accomplished on these countries before April 1, 1975.

C. Expected accomplishments during January 1975 -

Analyses will continue on North Dakota spring wheat data and the resulting prediction equations will be applied to test data.

D. Recommendations and summary outlook for future work -

No new recommendations at this time.

E. Travel summary and plans -

A work conference with NASA personnel and other collaborating research parties is scheduled at JSC the week of January 23.

Table 1. Analysis of variance, regression coefficients, and statistics of fit for the dependent variable, day of 50% planted in North Dakota, 1967-72, 1974.

Source	df	MS	F	Prob>F	R^2
Regression	4	1918.5994	59.7372	0.0001	0.8129
Error	55	32.1173			
Corrected total	59				

	Partial regression coefficients	Student's t for H0:B = 0	Prob.>|t|
Intercept	136.6887	54.99	0.0001
Product of E0 and N9S	0.0055	12.84	0.0001
Product of LOC and X9S	-0.1177	-7.54	0.0001
Product of LOC and X3S	0.2777	6.24	0.0001
Product of PP and X3S	-0.0138	-4.71	0.0001

N9S - Running nine day sum of average minimum temperature values (C°)
X3S - Running three day sum of average maximum temperature values (C°)
X9S - Running nine day sum of average maximum temperature values (C°)
LOC - Location (north, central, south)
PP - Preseason precipitation
E0 - Estimated soil moisture

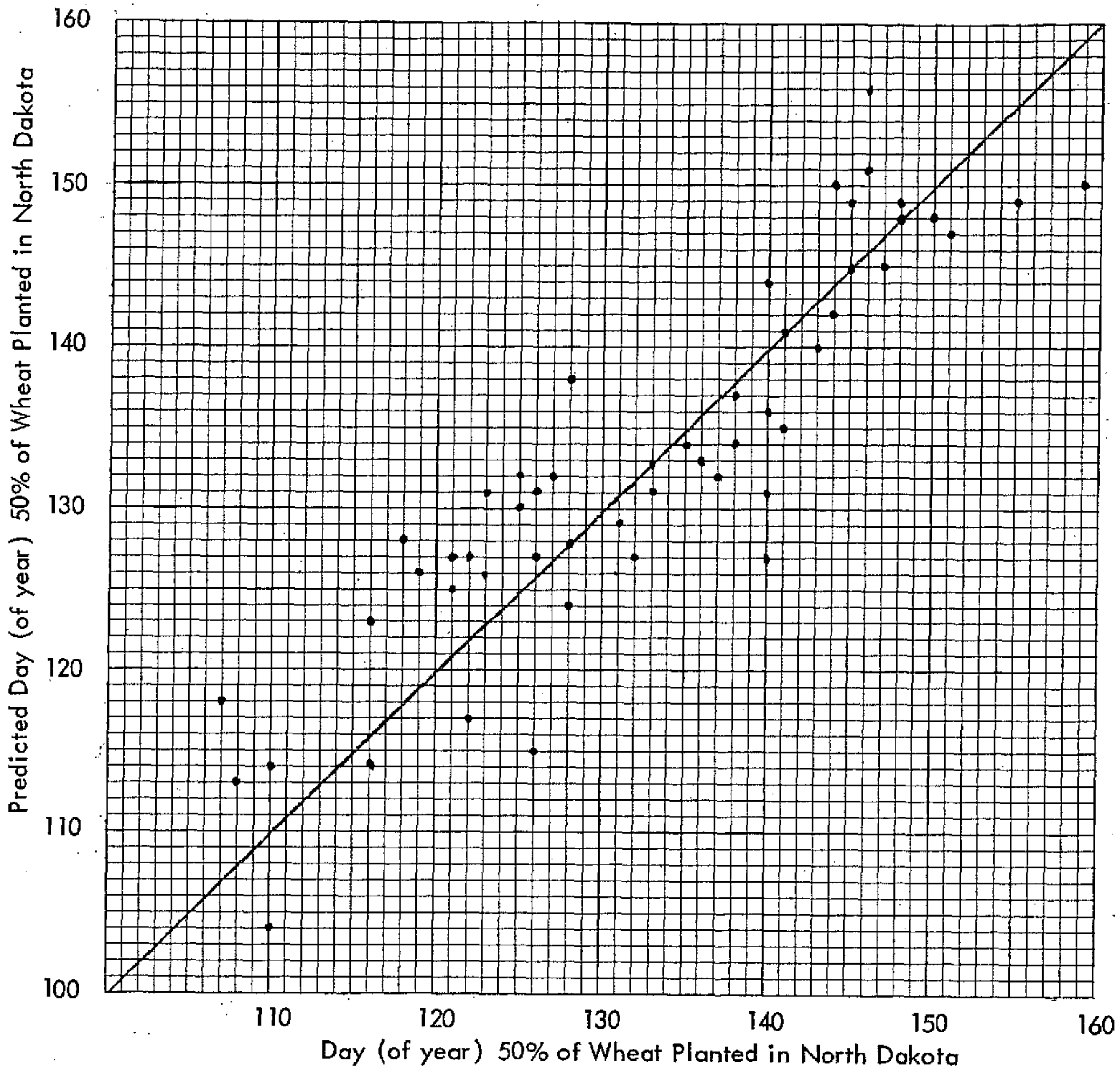

Fig. 1. Relationship of predicted date on which 50% of wheat was planted to actual date for the period 1967-72, 1974, based on equation from Table 1.

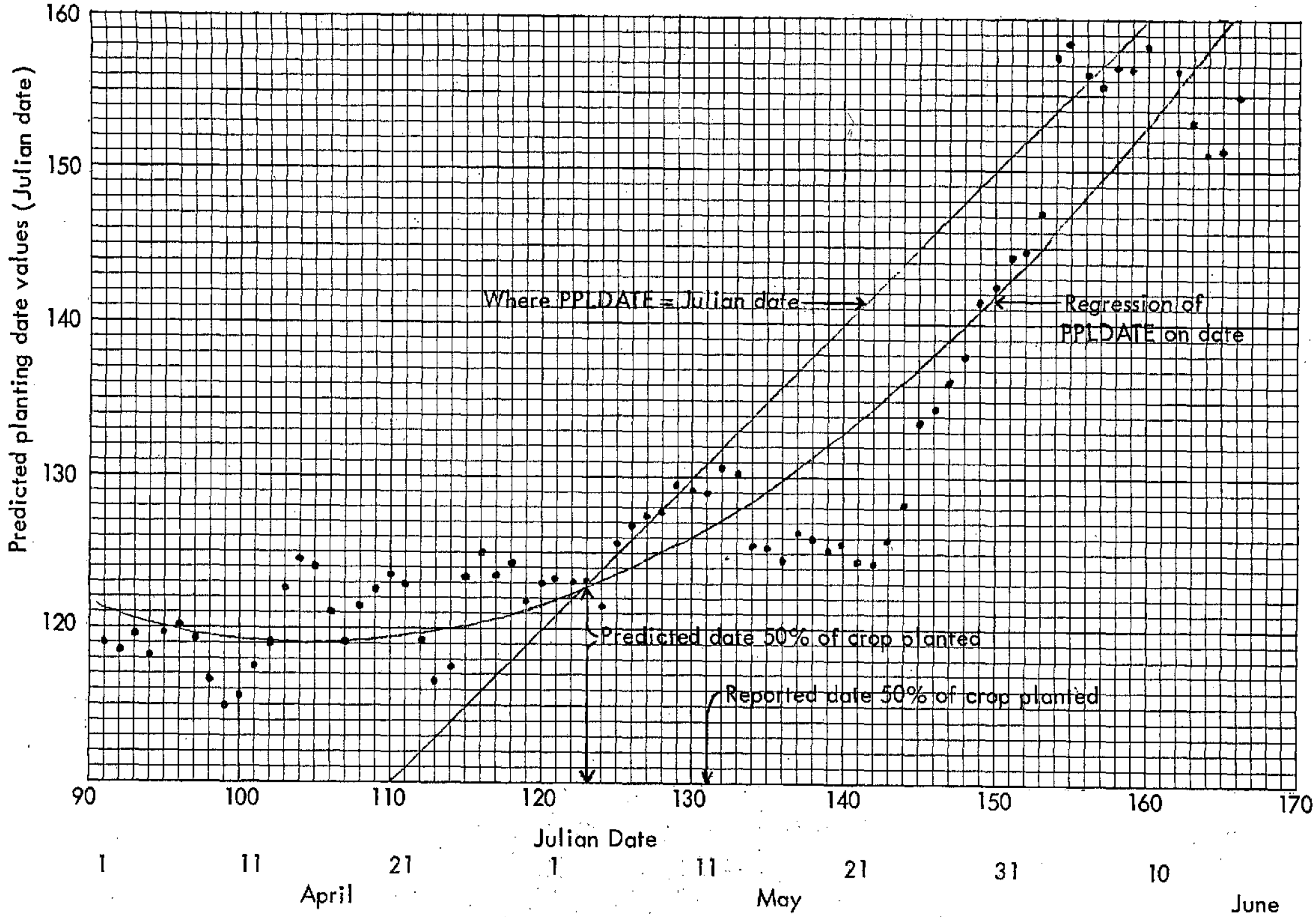

Fig. 2. Predicted planting date (PPLDATE) model applied to all dates from April 1, to June 15 in 1973 for the Northwest Division of North Dakota.

Table 2. Analysis of variance, regression coefficients, and statistics of fit for the dependent variable, growth rate of spring wheat 1974, one week (with Langleys)

Source	df	MS	F	Prob.> F	R^2
Regression	5	0.005458	18.252	0.0001	0.843
Error	17	0.000299			
Corrected total	22				

	Partial regression coefficients	Student's t for H0:B = 0	Prob.> |t|
Intercept	6.971×10^{-2}	3.784	0.0015
TN0	5.575×10^{-3}	5.108	0.0001
P1	7.630×10^{-2}	3.537	0.0025
PSE02	-8.460×10^{-6}	-3.102	0.0065
LSE02/1000	3.262×10^{-5}	7.601	0.0001
L3E02/1000	-6.099×10^{-5}	-6.389	0.0001

The first number following each basic variable indicates the lag period. The second number indicates that the variable is squared (2) or cubed(3). Two variables combined indicate a cross product.
PS - sum of P0, P1, P2, and P3
LS - sum of L1, L2, and L3

Table 3. Analysis of variance, regression coefficients, and statistics of fit for the dependent variable, growth rate of spring wheat 1974, one week (without Langleys)

Source	df	MS	F	Prob.> F	R^2
Regression	8	0.003593	13.862	0.0001	0.888
Error	14	0.000259			
Corrected total	22				

	Partial regression coefficients	Student's t for H0:B = 0	Prob.>|t|
Intercept	-2.252×10^{-1}	-2.44	0.0285
TX2	1.719×10^{-2}	6.01	0.0001
TX3	1.172×10^{-2}	-7.02	0.0001
TX12	-3.526×10^{-4}	-5.44	0.0001
TX22	1.345×10^{-4}	3.69	0.0024
TN0	9.307×10^{-3}	7.17	0.0001
P02	-5.701×10^{-1}	-4.46	0.0005
E3	5.340×10^{-3}	3.23	0.0060
E13/1000	2.332×10^{-4}	-2.49	0.0259

The first number following each basic variable indicates the lag period. The second number indicates that the variable is squared (2) or cubed(3) . Two variables combined indicate a cross product.

Table 4. Analysis of variance, regression coefficients, and statistics of fit for the dependent variable, growth rate of spring wheat 1974, two weeks (with Langleys)

Source	df	MS	F	Prob.> F	R^2
Regression	9	0.01587	25.983	0.0001	0.839
Error	45	0.00061			
Corrected total	54				

	Partial regression coefficients	Student's t for H0:B = 0	Prob.>|t|
Intercept	6.017×10^{-2}	2.61	0.0123
TX33/1000	-2.573×10^{-3}	-4.62	0.0001
TX0P0	1.638×10^{-3}	-4.61	0.0001
TX0L1	4.660×10^{-6}	4.48	0.0001
TX2E0	8.180×10^{-5}	6.31	0.0001
TN0P2	2.280×10^{-2}	9.21	0.0001
TN1P2	4.464×10^{-2}	-12.28	0.0001
P33/1000	3.971×10^{0}	-3.39	0.0015
P1L1	-6.300×10^{-5}	-3.43	0.0013
P2L1	5.605×10^{-4}	10.66	0.0001

The first number following each basic variable indicates the lag period. The second number indicates that the variable is squared (2) or cubed (3). Two variables combined indicate a cross product.

Table 5. Analysis of variance, regression coefficients, and statistics of fit for the dependent variable, growth rate of spring wheat 1974, two weeks (without Langleys)

Source	df	MS	F	Prob.> F	R^2
Regression	10	0.01354	23.013	0.0001	0.839
Error	44	0.00059			
Corrected total	54				

	Partial regression coefficients	Student's t for H0:B = 0	Prob.> |t|
Intercept	2.334×10^{-1}	4.42	0.0001
E1	-2.394×10^{-3}	-2.53	0.0150
E03/1000	2.223×10^{-4}	3.93	0.0003
P22	-8.396×10^{-2}	-8.92	0.0001
P33/1000	-5.747×10^{0}	-4.37	0.0001
P1E0	-3.145×10^{-4}	-3.29	0.0020
TX33/1000	-2.270×10^{-3}	-3.91	0.0003
TX0P2	2.089×10^{-2}	10.22	0.0001
TX0TX2	1.708×10^{-4}	6.47	0.0001
TN1P0	-5.762×10^{-3}	-5.13	0.0001
TN1P2	-3.392×10^{-2}	-9.52	0.0001

The first number following each basic variable indicates the lag period. The second number indicates that the variable is squared (2) or cubed (3). Two variables combined indicate a cross product.