WHEAT YIELD MODELS WITH METEOROLOGICAL PREDICTORS BASED ON PHENOLOGICAL DEVELOPMENT

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.TRODUCTION

wheat yield model was developed for hard ring wheat in North Dakota using historical for crop reporting districts in conjunc- ith meteorological predicter variables on weekly data. The meteorological data ggregated according to observed phenologi- ages. A similar model was developed for red winter wheat in Kansas.

ODEL VARIABLES

r the North Dakota model the reported logical stages were smoothed to determine dian date for each stage in each crop ing district (CRD). The meteorological le for a particular stage was then weighted e three week period centering on the week alf of the crop reached that stage. That received twice as much weight as each of her two weeks. Phenological stages were ng, emergence, jointing, heading, turning, ough, combined, and swathed.

e basic weekly data, which were summarized tation data across each CRD, were done by (1977). A total of 59 stations were used rth Dakota. Meteorological variables con- d for the North Dakota model included: itation, maximum temperature, minimum tem- ure, maximum temperature above 90°F or , minimum temperature less than 40°F or growing degree days, soil moisture, and .

oter (1978) developed the variables for the model. In Kansas 47 stations were used ive the basic weekly data. Data were over reported phenological stages. The ogical stages reported were planting, rg, heading, turning, ripening, and har- The jointing date was missing for much of mple so heading date minus 21 days was Predictors examined for this model included llowing variables defined over selected ogical stages: soil moisture, moisture ratio, maximum temperature between 42°F °F, mean temperature between 68°F and ?, maximum temperature greater than speci- hreshold value, minimum temperature less pecified threshold value, and precipita- reater than a specified threshold value.

In both these models determining the trend or increase due to technological innovations was accomplished by fitting an exponential function to the yield data by least squares. For the trend for crop districts in Kansas a flattening of the curve at 1978 was forced and the inflection point that produced the smallest standard deviation was then determined. In North Dakota a slight modification was used for estimating trend in the crop districts. The trend was a combination of a linear function through 1949 and exponential function in the following years with a forced juncture at 1949.

3. MODEL FORM

The model form is expressed as:

$$y_j = \alpha + \delta YR + \gamma T_j + \sum_{i=1}^{n} \beta_i W_{ij}$$

where j varies for each crop district, n is the number of weather terms, T_j is the trend for crop district j, YR is the year, and W_{ij} is the ith weather variable for crop district j.

All the crop districts in North Dakota were used in a single model thus increasing the number of observations for estimating coefficients. In Kansas that has not been possible. The eastern third of Kansas shows a different response to the weather variables than the rest of the state. Work on a model for this area is proceeding at present.

Truncated models at different phenological stages were also developed. These allow for estimates of final yield earlier in the growing season without making assumptions about future weather. A separate set of coefficients and in some cases different variables are used in the earlier truncations.

4. NORTH DAKOTA MODEL

The predictors included in the model for the final truncation at the milk dough stage include the following variables with coefficient estimates and standard deviations, respectively, in parentheses: trend (.82, .06); year (.30, .05); maximum temperature at planting (.07, .03); minimum temperature at jointing (-.23, .06); number of days the maximum temperature is greater than 90°F at jointing (-1.14, .29); number of days the precipitation is greater than .2 inches at jointing (1.13, .29); number of days the maximum temperature is greater than 90°F at heading (-1.42, .24), maximum temperature at milk dough (-.53, .07); minimum temperature at milk dough (.23, .09). The variables for earlier truncations were the same with the minimum temperature at emergence and the number of days with precipitation greater than .1 inches at planting also included for the model at jointing.

Test results for the North Dakota model for the final truncation are shown in Figure 1.

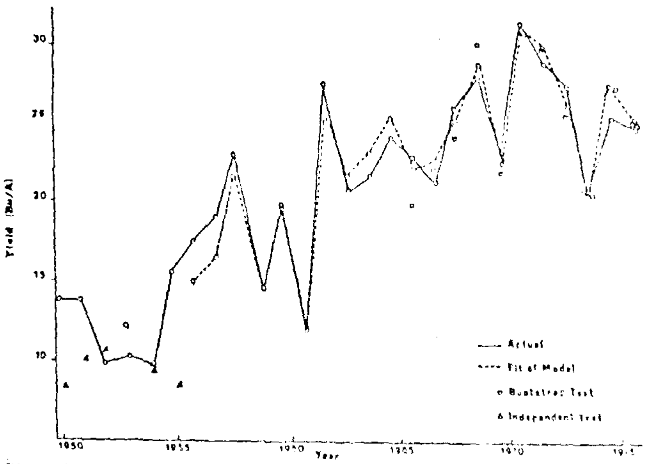

Figure 1. Yields for North Dakota Hard Red Spring Wheat, Actual and Estimated

The early 1950's were an independent test. They were not used in determining variables for the model or in estimating coefficients because the phenological data were rarely reported, if reported at all. To estimate the phenological data necessary for testing the model, reports from the Weekly Weather and Crop Bulletin were used. These estimated dates are likely to be in error. The later test years, indicated as the bootstrap test in the figure, omit that year and all later years when estimating the coefficients. These estimates follow the actual fluctuations very well.

The independent test years 1974-1976 were not used in either the selection of variables for the model or in estimation of the coefficients. The model estimates are in the correct direction although the estimate for 1975 is about 1.9 bushels per acre too high. The estimates from the earlier truncations in 1975 were higher than the final estimate so later estimates were moving in the proper direction. The 1974 yield was low and the model estimated this very well. As in 1975, earlier truncations were higher, starting at 28.3 bushels per acre for the estimate using just trend and decreasing steadily throughout the growing season to a final estimate of 20.7 when the actual was 20.5.

The model for Kansas is still being checked and tested and will be presented when work is completed.

5. RESULTS

Results on the North Dakota model look good especially for the 1974 crop yield which experienced considerable deviation from the normal growth of the crop because of delayed planting. The model did well in assessing the impact of t[illegible] weather. The model for estimating the winter w[illegible] yield may not show such dramatic capabilities because of the fact that winter wheat phenology [illegible] not impacted as dramatically by the weather. T[illegible] is more time to plant in the fall and developme[illegible] then tends to show less variation in the later stages. Any abrupt change in technology due to such things as changes in the farm program, or price/cost considerations will affect the level yield as estimated by the trend function. The model does not have the capability of assessin[illegible] this. Also the impact of severe disease probl[illegible] or insect infestations on yield will be missed.

6. CONCLUSIONS

This type of model has advantages and disad[illegible] vantages. The number of stations required to provide meteorological data at the density used developing the models is greater than the numb[illegible] which presently report in a real-time mode. Co[illegible] lecting the data to provide operational estimat[illegible] from the models thus necessitates either interp[illegible] lation of those stations being received or collection of data from more stations. The former incurs error and the latter takes planning, coo[illegible] eration, and resources at several levels includ[illegible] observing, transmitting, collecting, quality controlling, and using the data. The phenolog[illegible] stage must also be observed or estimated.

All of these steps take resources, especi[illegible] when testing the operation of the models. The largest cost would be in the initial establis[illegible] of the system, including computer, transmission, and programs to make operation of these models automatic as possible. Once established the s[illegible] would require only maintenance and handling of

If models of this type are to provide infor[illegible] tion, that information must be an improvement [illegible] what is presently available. When assessing th[illegible] improvement, several aspects are relevant: Ar[illegible] estimates more accurate? Are estimates more r[illegible] vant for areas the size of crop districts? Can estimates be provided soon enough and at approp[illegible] ate times? The results thus far indicate good information can be provided, but further testi[illegible] is necessary before estimates from this type m[illegible] are operationally provided.

7. REFERENCES

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