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PROJECT TITLE: SEED AND PROTEIN MODELLING OF SOYBEANS

MA SMIT & EL PIPER, IGC, POTCHEFSTROOM

Problem and Objectives

Soybean cropping demonstrates a highly significant interaction between seed yield and environment under South African conditions. There is a whole range of parameters that complicate the prediction of yield and protein such as day and night temperature, photoperiod, humidity, plant available water in the soil, soil fertility, and cropping systems. To account for all the variables in a systematic and calculated way do require a mathematical physiological computer model and multidisciplinary input. An integrated computer model can assist farmers in managerial decisions and safeguard against many of the numerous mistakes that are made each planting season. Strategy analysis applications with a model can determine the best management combinations for each individual field situation in order to achieve optimum grain yield, seed protein, and economic return. The model can be used to estimate potential and water-limited yield and its associated variability throughout South Africa for industry and policy decision making.

The objective of this project was to adapt and validate the SOYGRO/CROPGRO soybean crop model developed by the University of Florida to South African growing conditions, and to develop a subroutine which could predict seed chemical content. The latter objective was given because of the unacceptable range of protein content reported each year for South African grown SOYBEANS.

Methods and Material

Phenological data was gleaned from the National Soybean Cultivar Evaluation Programme. Weather data was acquired from the DEASE data base managed at Cedara, and soil data from a data base created as directed by the Oil Seeds Board specifically for the purpose of crop modelling. This data base contained 15 ecotype characterizations and another six was added to with the assistance of dr M Hensley of ISCW. SOYGRO/CROPGRO version 3 was calibrated for the simulation of seed number, seed size, and seed yield at ten locations. Areas for model improvement such as sensitivity for low temperature and to vapour pressure deficit, was identified and model development was done during and since the visit by drs. Boote and Jones (CROPGRO authors) September 1995.

A new more extensive data set with four cultivars, which includes two locations for model calibration and 11 locations for model evaluation, was created during 1996. The Sept. 95

CROPGRO version was evaluated with this data set.

An attempt to calibrate for plant water relations was aborted because of the lack of accurate and sufficient soil water measurements.

Results and discussion

One of the major achievements of this project was the development and official inclusion of the T_{min} function into the CROPGRO model. This has improved the model's overall prediction for growth phase events considerably and the latest South African results gave a r^2=0.88 for the prediction of flowering date. Research on the T_{min} has once again focussed attention on the need for temperature tolerant cultivars in South Africa. An assay should be developed for screening cultivars for temperature tolerance and (at least for South African conditions) a genetic coefficient should be included when solving for growth and development.

The Sept. 95 CROPGRO version predicted grain yield well with d values of 0.85 (49), 0.80 (90), 0.85 (69), 0.82 (86) for the cultivars Crawford, Prima, A7119, and Impala, respectively. The number of observations is in parentheses. The d values for seed protein were 0.29 (38), 0.44 (52), 0.59 (47), 0.54 (50), for Crawford, Prima, A7119, and Impala, respectively. The major sources of error associated with the prediction of seed protein were the simulation of water stress - temperature interactions on plant growth and from the difficulty in predicting the time and intensity of water stress. More research will have to be done on plant water relations and soil moisture need to be monitored more accurately in general if prediction for protein are to be improved. The assumption that soil fertility and nodulation were adequate could also have contributed to the error.

A Framework was developed to evaluate climatic limitations to soybean yield. The framework will be used for purpose of yield gap analysis and the assistance of farmers in managerial decision making.

Recommendation

South African data pose a real challenge to the model in its current form. Unless such conditions are also experienced elsewhere in the world, the need to develop the model further for aspects such as plant water relations and soil fertility may only be of importance to the South African researcher. South Africa lends itself to studies on plant water relations and an important contribution to the model on this aspect still needs to be done. It is recommended that plant water relations be monitored closely in relation to precipitation and crop performance in order to improve the subroutine for water relations.

There sometimes exists significant differences between predicted and observed yield. Such differences demonstrate the need for Yield Gap research in order to identify managerial constraints limiting soybean yield on individual farms. It is recommended that a study be conducted in order to see how effective real time monitoring can be in assisting production management.

Value of project

Adaptation of the SOYGRO/CROPGRO to accurately predict seed composition have international significance. The soybean database developed at the GCI offers a valuable complement to North American data and an opportunity to cooperate on an international basis.

In calibrating the model for South African conditions valuable lessons were learned. It soon became apparent that the variation in temperature play a significant role in South African agriculture and deserves more attention in cultivar development. Vapour pressure deficit appears to be more important in most South African environments and water relations deserve more research attention.

Indirectly the modelling project has had a significant impact on seed yield and protein content of SOYBEANS produced in Natal over the past four years. Calibrations for the model made researchers aware of managerial constraints and gave a reference for addressing such. Improved protein content has made SOYBEANS from Natal more acceptable to the processing industry. Increased yields have made SOYBEANS more attractive to the Natal farmer.

Application

The model is still very much a research tool only. Aspects such as plant water relations, soil fertility, and row width/plant population still needs to be addressed. Further development should be an integral part of all relevant soybean projects. Its use in the field should be with care and not without expert interpretation.

It is envisioned that the model is linked to a GIS and is used together with short term weather predictor models to assist producers with decision making, and industry with production and quality predictions.

ACKNOWLEDGEMENTS

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APPENDIX

1. Evaluation of the Sept. 95 CROPGRO Version For Grain Yield and Seed Protein. E.L Piper, M.A Smit, K.J Boote and J.W Jones.

2. FCR548 Piper, E.L, Smit, M.A, Boote, K.J, and Jones, J.W. The role of Daily minimum Temperature in Modulating the Development rate to Flowering in Soybean.