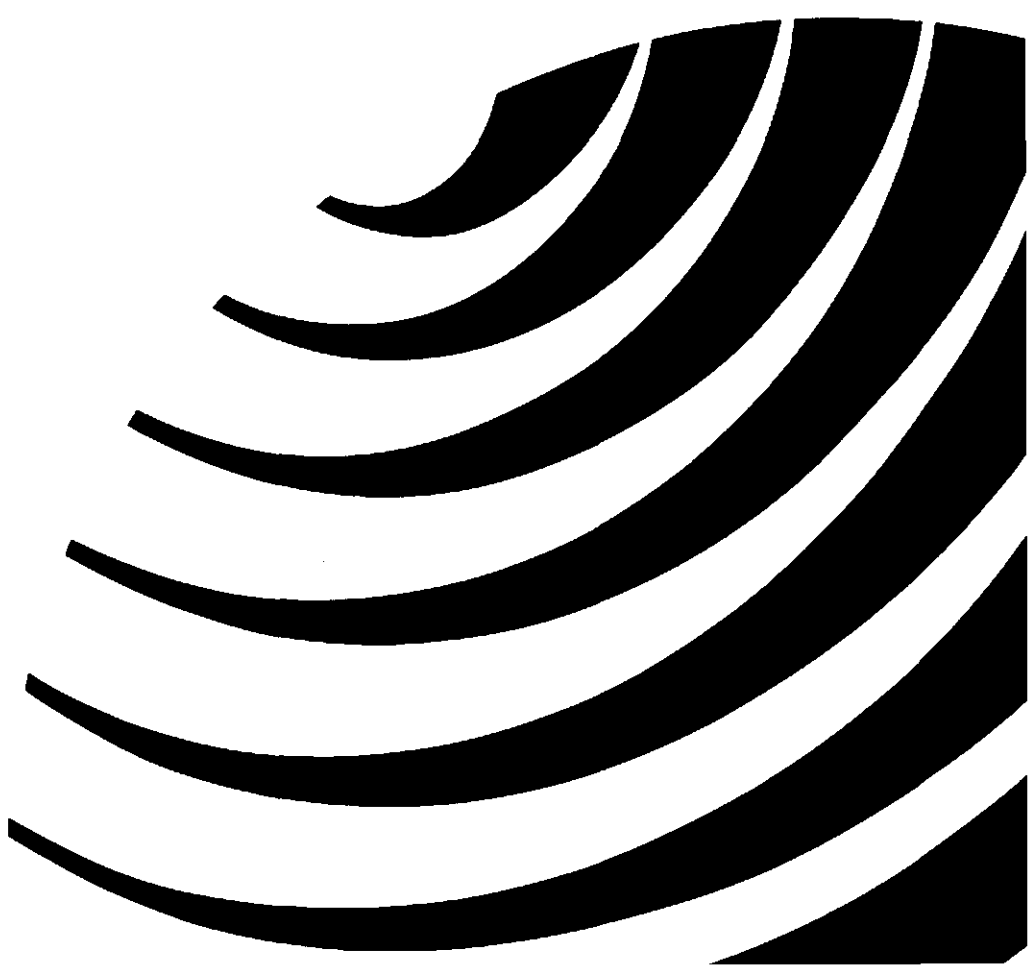
Agricultural Research Department
Research Institute for Agrobiology and Soil Fertility

Tests of performance of SUCROS-Wheat v4.0 with West-European experimental datasets

W. Stol

ab-dlo



Note 55

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ab-dlo

Note 55, Wageningen
April 1997

The DLO Research Institute for Agrobiology and Soil Fertility (AB-DLO) is part of the Dutch Agricultural Research Department (DLO-NL) of the Ministry of Agriculture, Nature Management and Fisheries.
The institute was founded on 1 November 1993 by the amalgamation of the Centre for Agrobiological Research (CABO-DLO) in Wageningen and the institute for Soil Fertility Research (IB-DLO) in Haren.

The DLO organization generates new knowledge and develops and maintains the expertise needed for implementing government policies, for improving the agro-industry, for the planning and management of rural areas and for protecting the environment.

AB-DLO, with locations in Wageningen and Haren, will carry out research into plant physiology, soil science and agro-ecology with the aim of improving the quality of soils and agricultural produce and of furthering sustainable plant production systems.

Key areas of expertise in AB-DLO are: plant physiology, soil biology, soil chemistry and soil physics, nutrient management, crop and weed ecology, grassland research and agrosystems research.

Addresses

Location Wageningen:
P.O. Box 14, 6700 AA Wageningen
The Netherlands
phone (+) 31 317 47 57 00
fax (+) 31 317 42 31 10
e-mail postmaster@ab.dlo.nl

Location Haren:
P.O. Box 129, 9750 AC Haren
The Netherlands
phone (+) 31 50 533 77 77
fax (+) 31 50 533 72 91
e-mail postmaster@ab.dlo.nl

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Summary

This report shows the results of a study to test the performance of the SUCROS-Wheat v4.0 model against crop data obtained in field experiments conducted in the Netherlands and in the United Kingdom. Within DLO-research program 229 there is a continuing effort to update and test dynamic crop growth models. The reason for publication of these intermediate results is to report them as a starting point for other researchers in the same field.

The results obtained with the model on the experimental datasets are presented both in a graphical and numerical form, the latter by meaning of calculated statistical measures. Statistical measures used include: root mean square error, mean absolute error and the coefficient of determination. Root mean square error of the predicted of total above ground dry weights (TADRW) averaged over the reviewed experiments was 1155 kg dry matter per hectare, the mean absolute error was 865 kg dry matter per hectare. Coefficient of determination between simulated and observed values of total above ground dry weight at anthesis was 0.73, at maturity the coefficient of determination yields 0.87. Root mean square error of predicted dry weights of storage organs (WSO) over the reviewed experiments was on average 858 kg dry matter per hectare, the mean absolute error was 770 kg dry matter per hectare. Coefficient of determination between simulated and observed values of grain dry weight at maturity was 0.77. Simulation of the dynamics of leaf area development in these set of experiments was moderate. Root mean square error of the prediction of leaf area index (LAI) over the reviewed experiments was 0.85 m^2/m^2, mean absolute error was 0.65 m^2/m^2.

1. Introduction

Increasing the quality of the crop growth models of AB-DLO is one of the objectives of DLO-research program 229. Several aspects of quality are covered under this objective: scientific quality, model validation, applicability, software quality, user-friendliness. This report shows the results of an evaluation study on the performance of the SUCROS-Wheat v4.0 model against crop data obtained in field experiments conducted in the Netherlands and in the United Kingdom. Within this DLO-research program there is a continuing effort to update and test dynamic crop growth models. The reason for publication of these relatively crude intermediate results is to fix and report them in a suitable format for further use by other researchers in the same field. SUCROS-Wheat v4.0 is the wheat implementation of the generic crop growth model SUCROS, which is an acronym for Simple and Universal CROp growth Simulation model. The analysis includes: (1) a test of model behaviour under West-European meteorological conditions and (2) an assessment of the model accuracy and prediction error. The SUCROS-Wheat v4.0 model will be used for yield prediction purposes across Europe.

Treatments in field experiments that show the most favourable conditions for crop growth, were selected and evaluated by means of graphs of simulated against observed values of state variables. The SUCROS-Wheat v4.0 model was used at the level of potential production, it was assumed that crop growth was not restricted by drought, insufficient fertilisation or biotic stress in all treatments. The only adaptation applied to the model was the change of two model parameters. The value of the model parameter AMX, the actual CO_2 assimilation rate at light saturation for individual leaves was increased from 40. to 40.8, while the model parameter EFF, the initial light use efficiency for individual leaves was decreased from 0.45 to 0.36.

If possible, three graphs were presented per experiment; the observed against the simulated value of the total above ground dry weight (variable TADRW, kg/ha), the dry weight of the storage organs (variable WSO, kg/ha) and the leaf area index (variable LAI, m^2/m^2). Along with the graphs for each state variable, two statistical measures for model performance are given; the root mean square error and the mean absolute error between observed and simulated values.

The site-specific information that was applied to obtain these results was limited to date of sowing, sowing density, latitude and daily weather data.

2. Evaluation of SUCROS-Wheat v4.0 on West-European experimental datasets

Summary output of observations and model outcome will be given for each selected field experiment. On the upper and middle graph, time is plotted on the X-axis and dry weights on the Y-axis, on the graph in which the leaf area index is shown, the units of the Y-axis are m^2/m^2. Along with each graph, the statistical measures root mean square error and mean absolute error will be presented for total above ground dry weight, dry weight of storage organs and leaf area index.

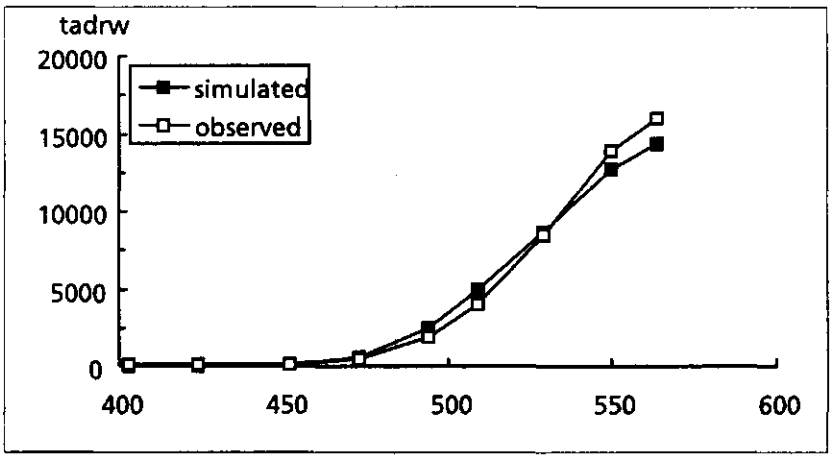
2.1. The Netherlands

2.1.1. Nitrogen fertiliser trial at experimental farm De Bouwing, 1982-1983

Total above ground dry weight

Rt.mn.sq.error 768 kg/ha

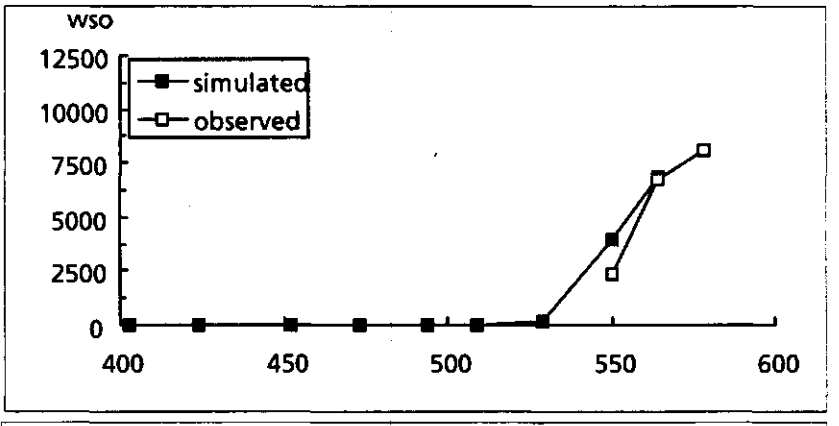
Mn. abs. error 528 kg/ha



Weight of storage organs

Rt.mn.sq.error 1123 kg/ha

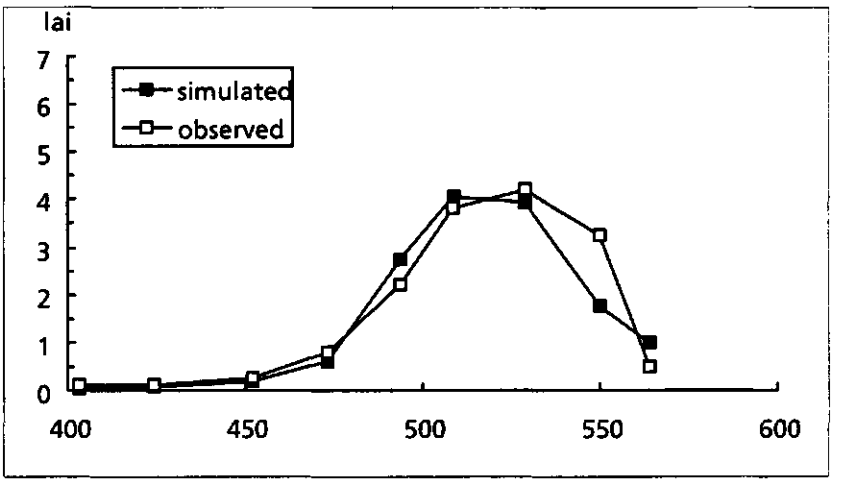
Mn. abs. error = 803 kg/ha



Leaf area index

Rt.mn.sq.error 0.58 m^2/m^2

Mn. abs. error 0.38 m^2/m^2

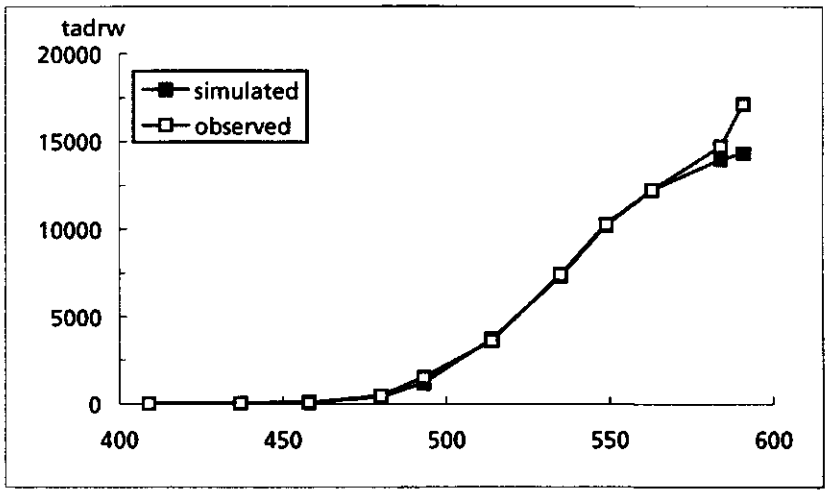


2.1.2. Nitrogen fertiliser trial at experimental farm De Bouwing, 1983-1984

Total above ground dry weight

Rt.mn.sq.error 878 kg/ha

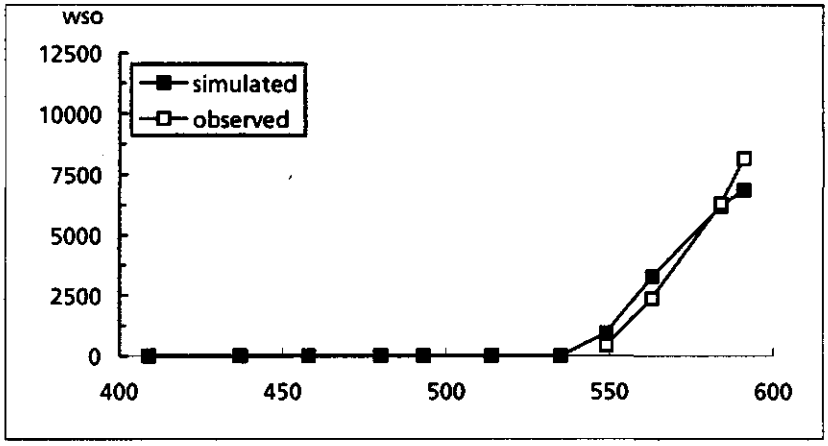
Mn. abs. error 391 kg/ha



Weight of storage organs

Rt.mn.sq.error 836 kg/ha

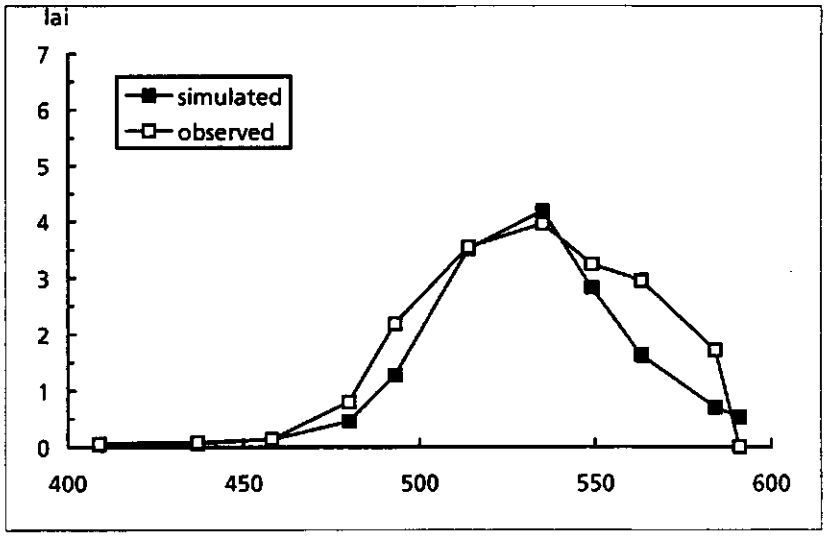
Mn. abs. error 706 kg/ha



Leaf area index

Rt.mn.sq.error 0.62 m^2/m^2

Mn. abs. error 0.44 m^2/m^2

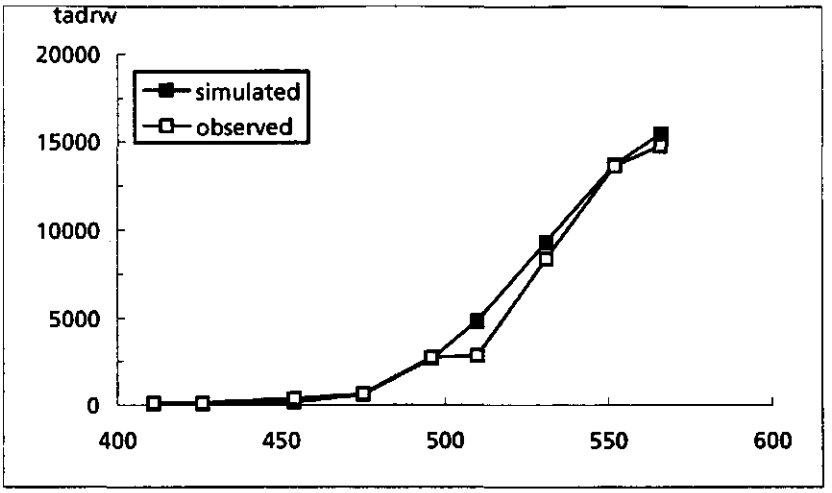


2.1.3. Nitrogen fertiliser trial at experimental farm De Eest, 1982-1983

Total above ground dry weight

Rt.mn.sq.error 774 kg/ha

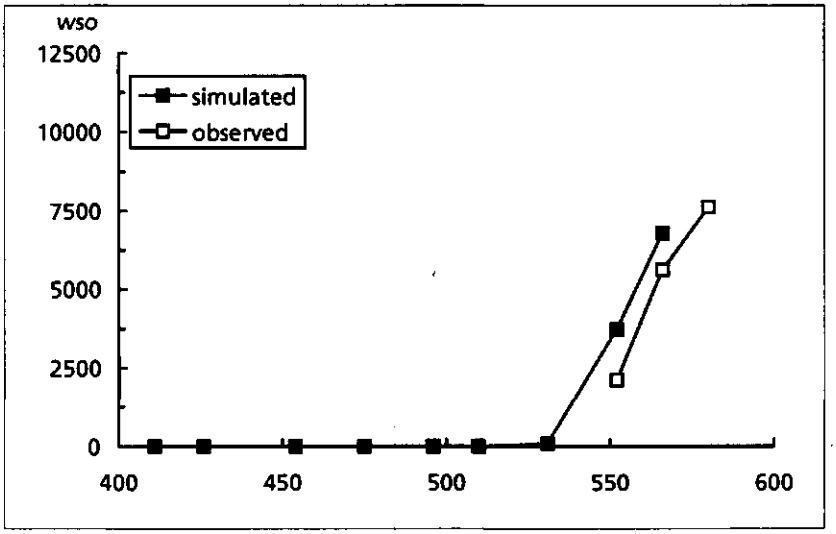
Mn. abs. error 463 kg/ha



Weight of storage organs

Rt.mn.sq.error 1415 kg/ha

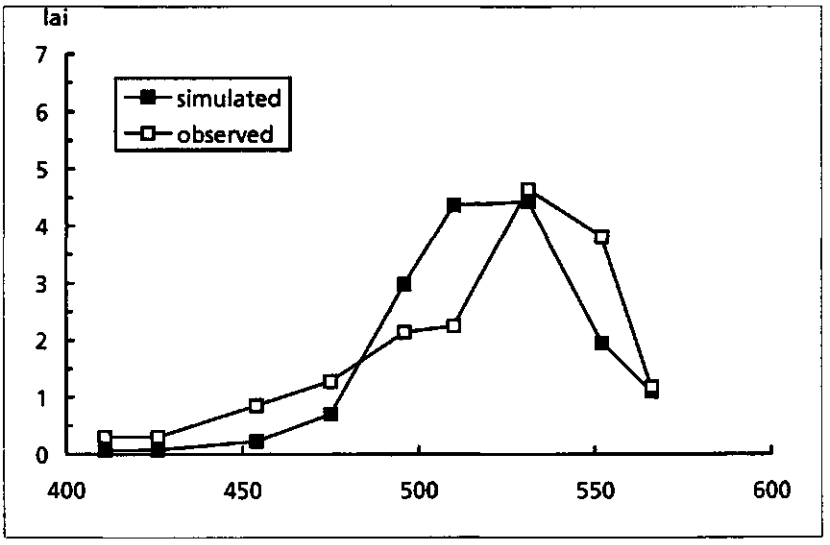
Mn. abs. error 1397 kg/ha



Leaf area index

Rt.mn.sq.error 1.03 m^2/m^2

Mn. abs. error 0.75 m^2/m^2

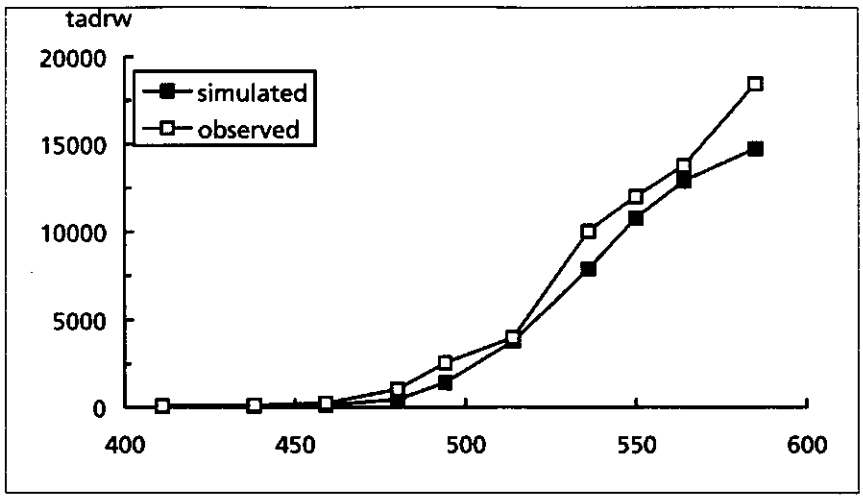


2.1.4. Nitrogen fertiliser trial at experimental farm De Eest, 1983-1984

Total above ground dry weight

Rt.mn.sq.error 1365 kg/ha

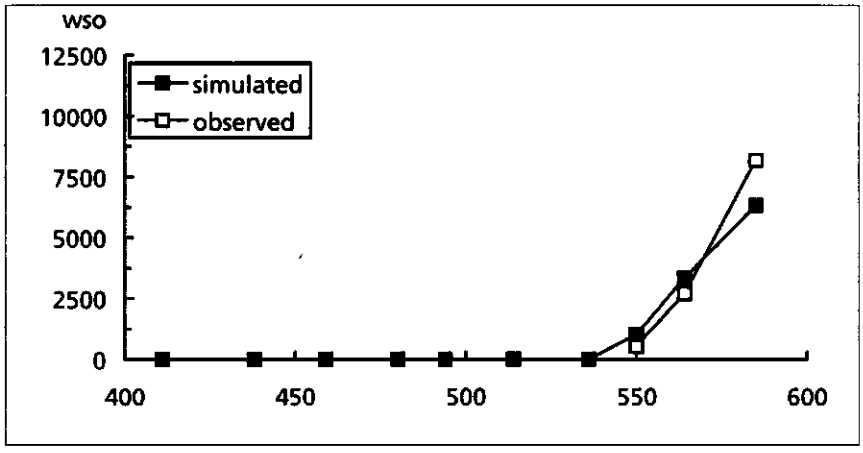
Mn. abs. error 1008 kg/ha



Weight of storage organs

Rt.mn.sq.error 1169 kg/ha

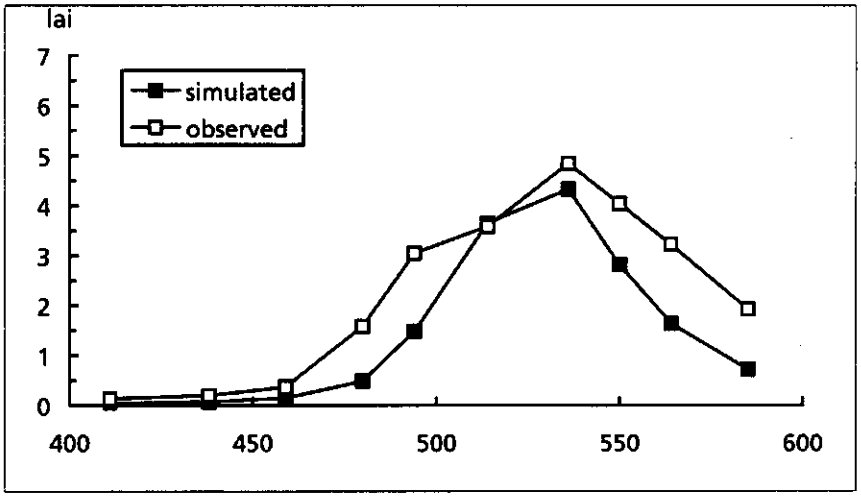
Mn. abs. error = 993 kg/ha



Leaf area index

Rt.mn.sq.error 0.97 m^2/m^2

Mn. abs. error 0.77 m^2/m^2

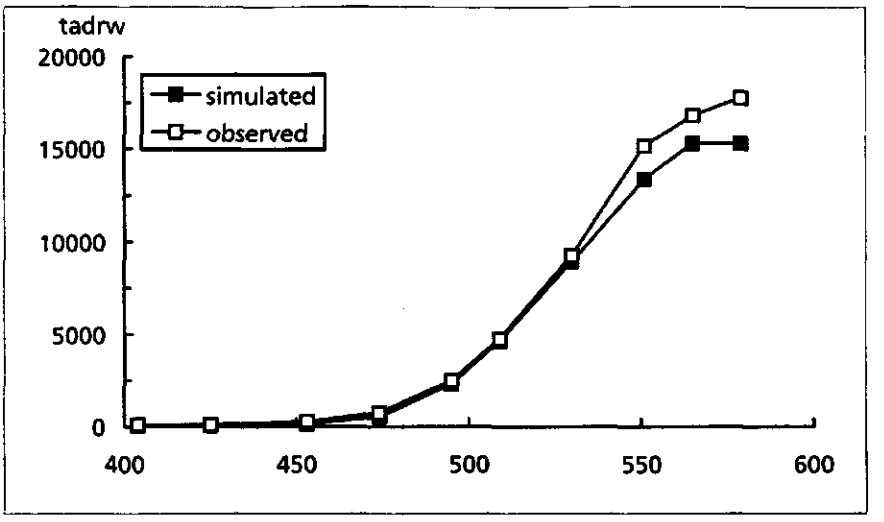


2.1.5. Nitrogen fertiliser trial at experimental farm PAGV, 1982-1983

Total above ground dry weight

Rt.mn.sq.error 1088 kg/ha

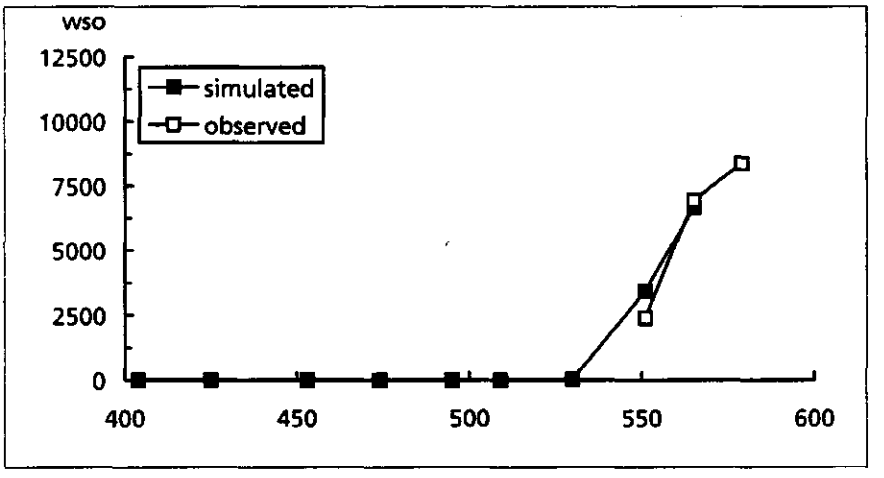
Mn. abs. error 691 kg/ha



Weight of storage organs

Rt.mn.sq.error 1162 kg/ha

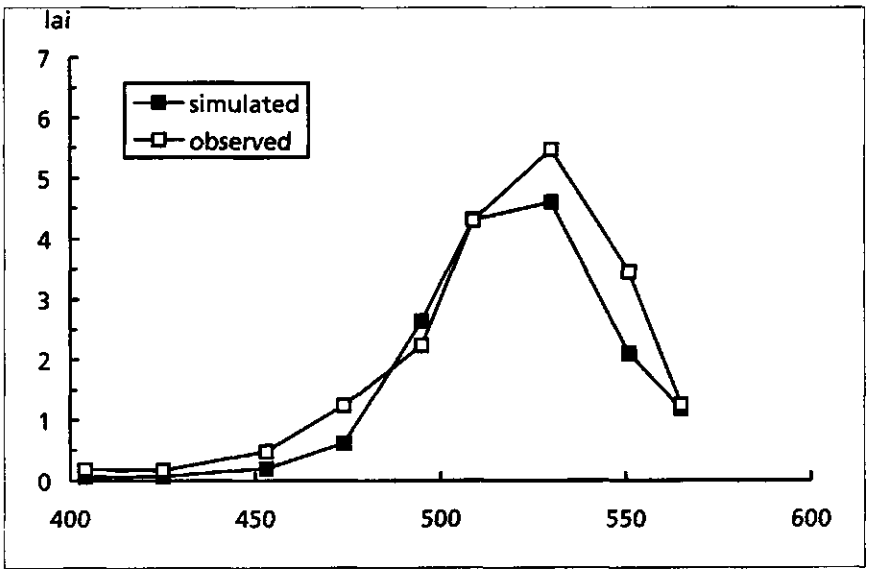
Mn. abs. error = 1003 kg/ha



Leaf area index

Rt.mn.sq.error 0.60 m^2/m^2

Mn. abs. error 0.42 m^2/m^2

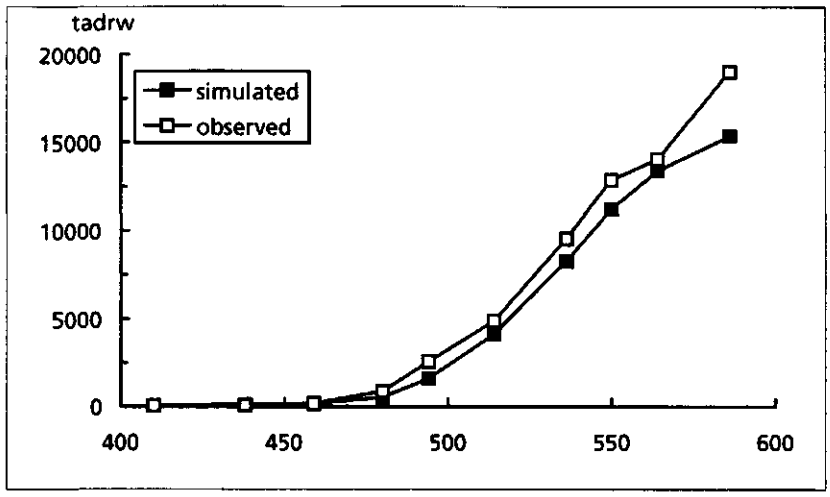


2.1.6. Nitrogen fertiliser trial at experimental farm PAGV, 1983-1984

Total above ground dry weight

Rt.mn.sq.error 1413 kg/ha

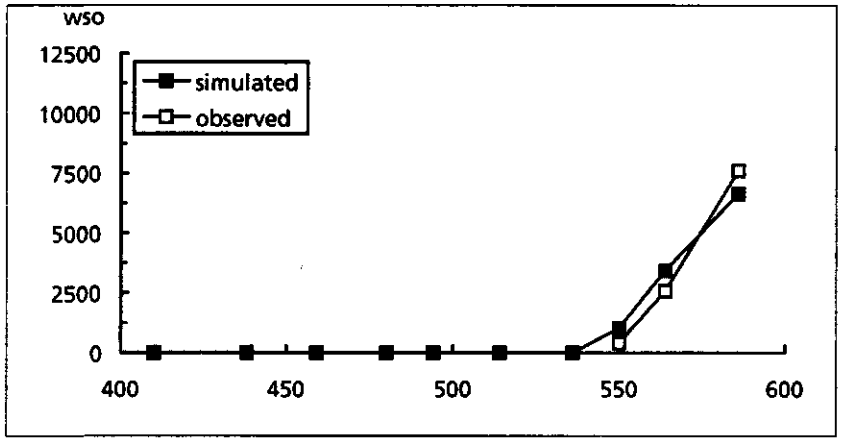
Mn. abs. error 943 kg/ha



Weight of storage organs

Rt.mn.sq.error 826 kg/ha

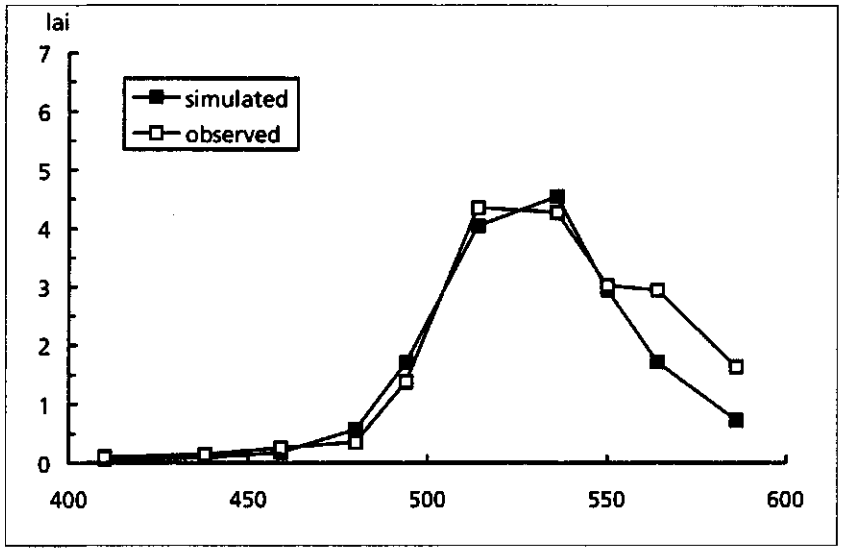
Mn. abs. error = 814 kg/ha



Leaf area index

Rt.mn.sq.error 0.52 m^2/m^2

Mn. abs. error 0.35 m^2/m^2

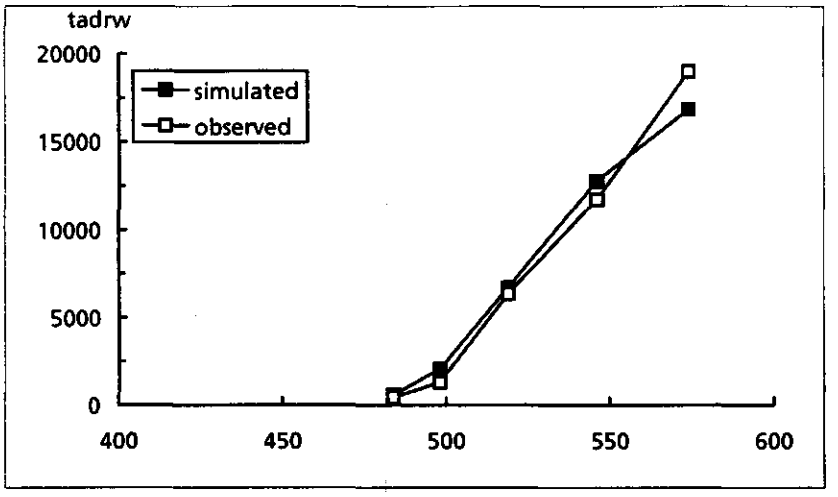


2.1.7. Growth, yield and composition of four winter cereals at experimental farm A.G. Minderhoudhoeve, 1985-1986

Total above ground dry weight

Rt.mn.sq.error 1122 kg/ha

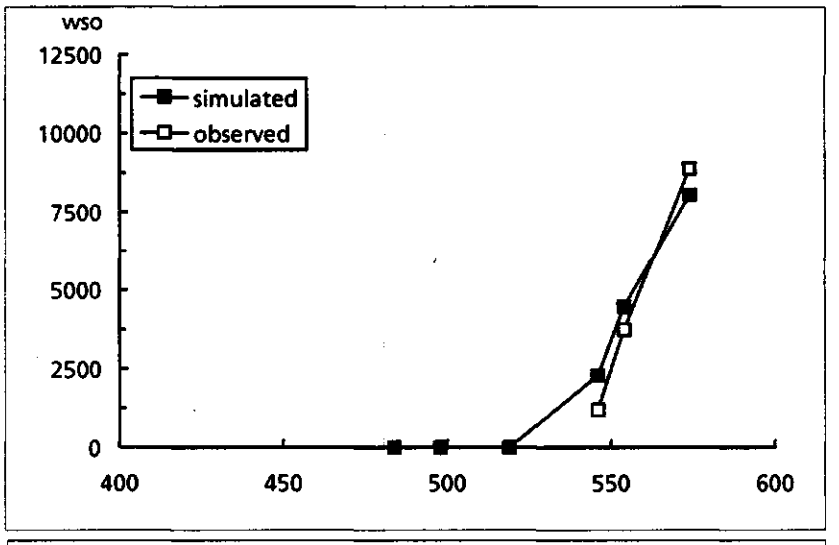
Mn. abs. error 890 kg/ha



Weight of storage organs

Rt.mn.sq.error 894 kg/ha

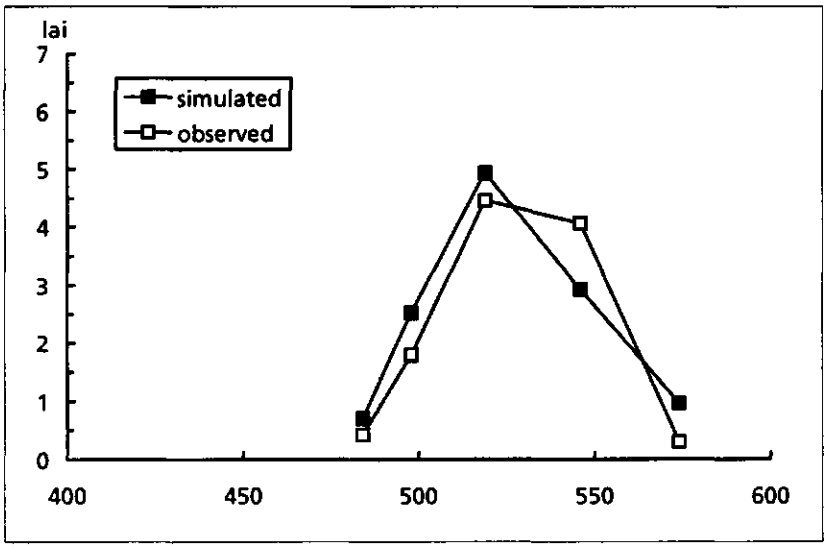
Mn. abs. error 882 kg/ha



Leaf area index

Rt.mn.sq.error 0.72 m^2/m^2

Mn. abs. error 0.66 m^2/m^2



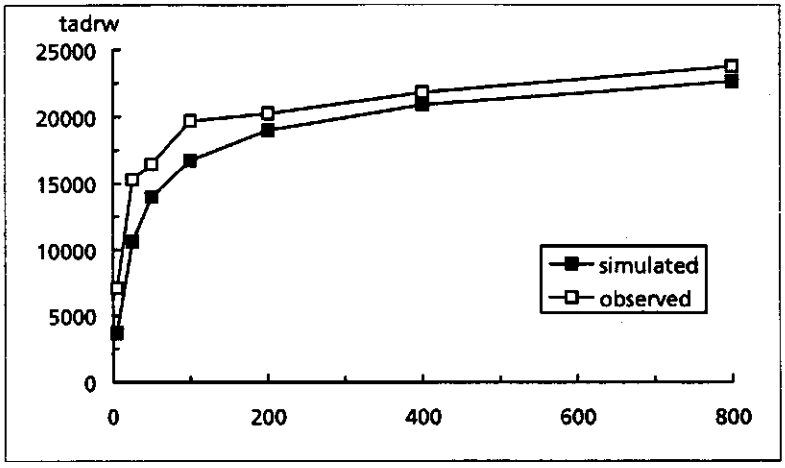
2.1.8. Plant density experiment of winter wheat at experimental farm PAGV, 1976-1977

This experiment conducted by Darwinkel at PAGV in 1976 covers plant densities from 5 to 800 plants per m^2. Plant densities are shown in the X-axis, whereas the graphs of the other trials have time on the X-axis.

Total above ground dry weight

Rt.mn.sq.error 2553 kg/ha

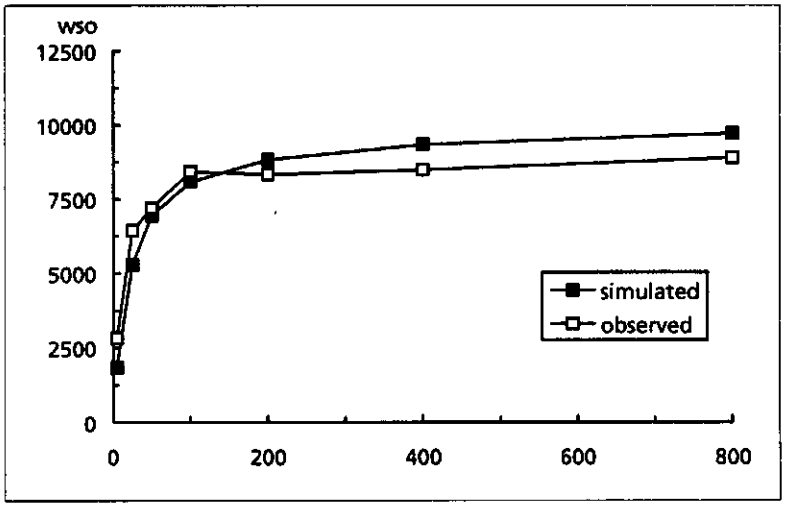
Mn. abs. error 2404 kg/ha



Weight of storage organs

Rt.mn.sq.error 717 kg/ha

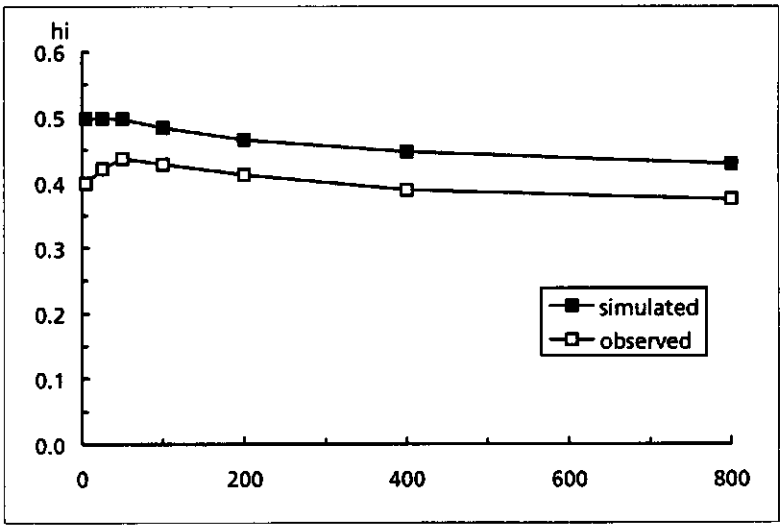
Mn. abs. error 698 kg/ha



Harvest index

Rt.mn.sq.error 0.06 (-)

Mn. abs. error 0.07 (-)



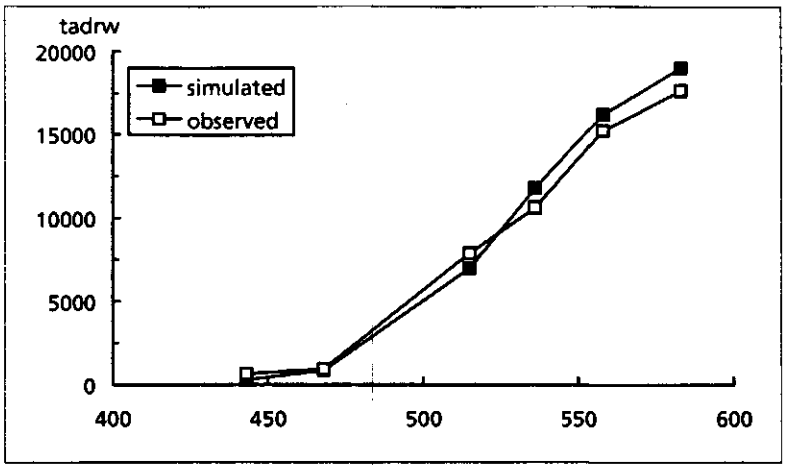
2.2. United Kingdom

2.2.1. Nitrogen fertiliser and irrigation trial at Rothamsted experimental station, 1984-1985

Total above ground dry weight

Rt.mn.sq.error 925 kg/ha

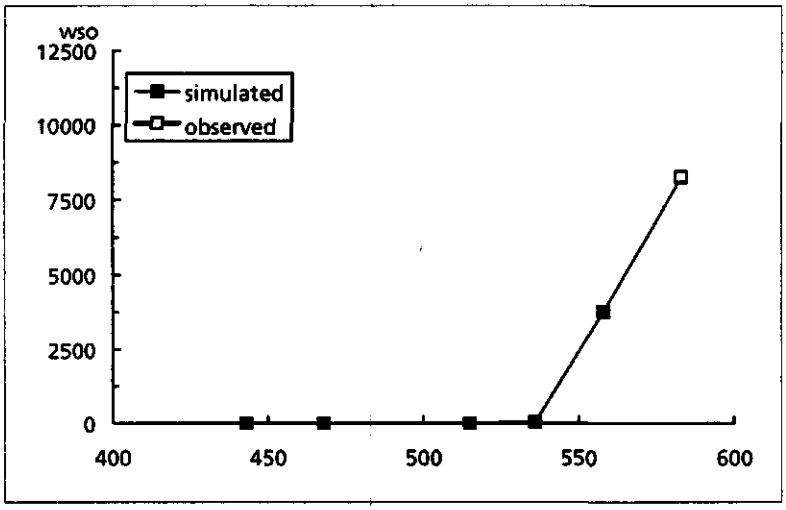
Mn. abs. error 811 kg/ha



Weight of storage organs

Rt.mn.sq.error 29 kg/ha

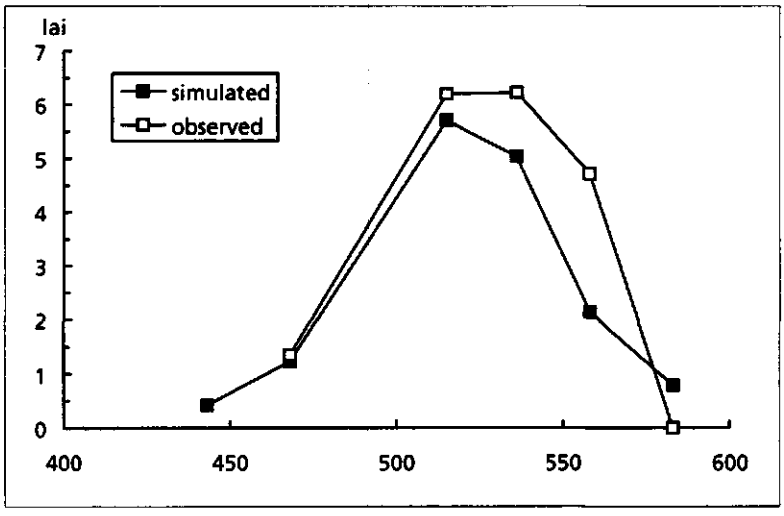
Mn. abs. error ≈ 29 kg/ha



Leaf area index

Rt.mn.sq.error 1.34 m^2/m^2

Mn. abs. error 1.03 m^2/m^2

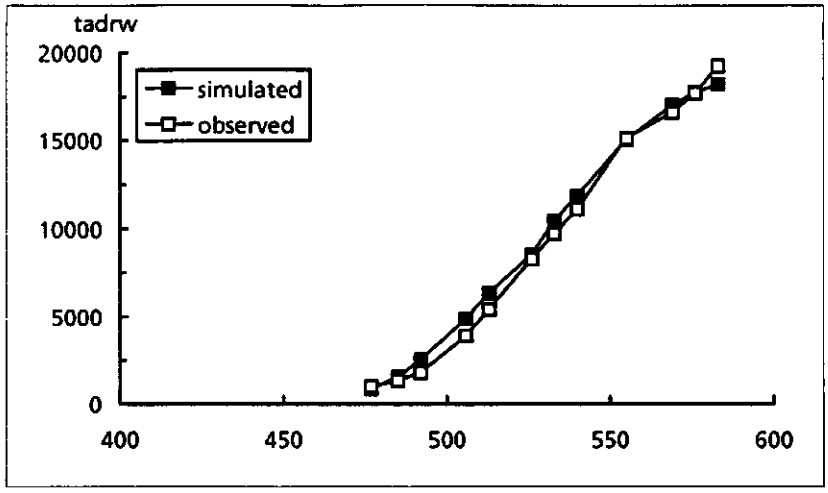


2.2.2. Nitrogen fertiliser and irrigation trial at Rothamsted experimental station, 1985-1986

Total above ground dry weight

Rt.mn.sq.error 663 kg/ha

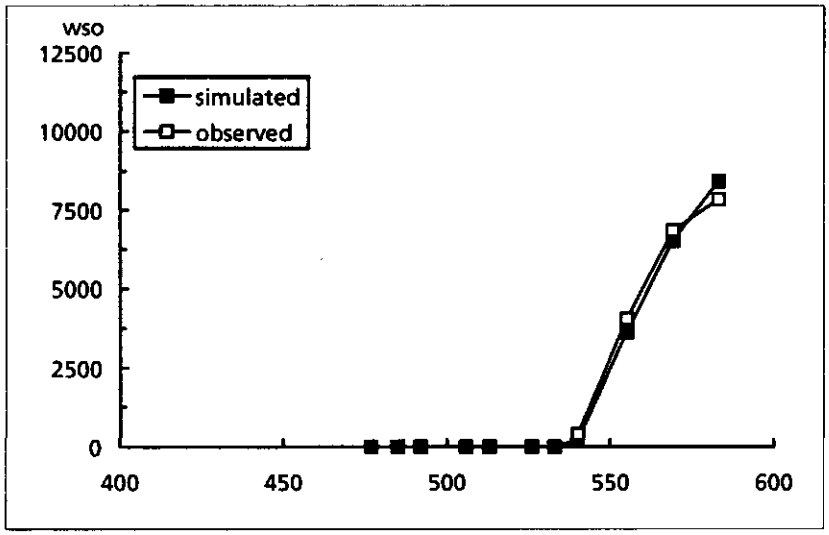
Mn. abs. error 526 kg/ha



Weight of storage organs

Rt.mn.sq.error 407 kg/ha

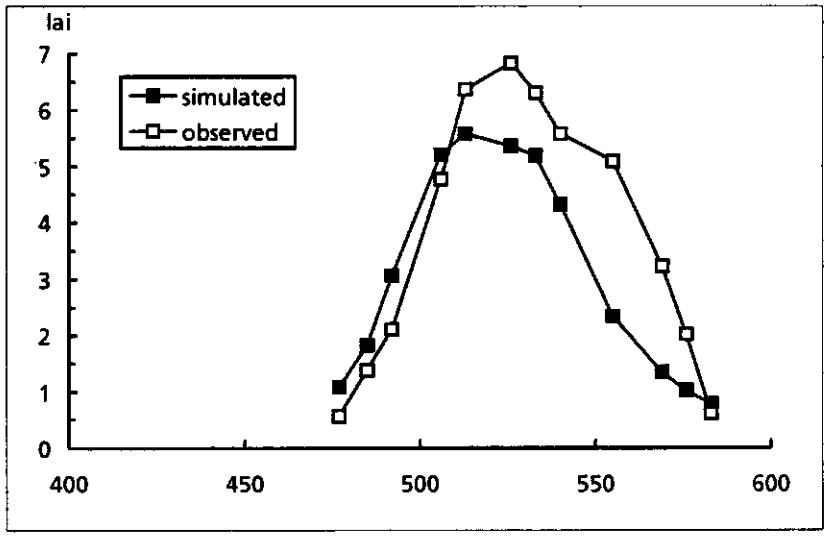
Mn. abs. error = 381 kg/ha



Leaf area index

Rt.mn.sq.error 1.27 m^2/m^2

Mn. abs. error 1.07 m^2/m^2



3. Conclusions

Evaluation of the SUCROS-Wheat v4.0 model and its detailed description of phenology was done with experimental datasets. The results, presented by graphs, show that the above ground dry weight was simulated reasonably well till the last two, three weeks of the growing period. At the end of the post-anthesis period, total biomass was sometimes over and sometimes underestimated. Root mean square error of the prediction of total above ground dry weight (TADRW) over the reviewed experiments was 1155 kg dry matter per hectare, mean absolute error was 865 kg dry matter per hectare. Coefficient of determination (r^2) between simulated and observed values of total above ground dry weight at anthesis was 0.73, at maturity the coefficient of determination yields 0.87, using all observed data.

Table 1 Summary results of the evaluation of the accuracy of SUCROS-Wheat v4.0 to predict winter wheat biomass production, grain yield and leaf area index at 10 experimental sites

State variables	TADRW		WSO		LAI	
Statistical criteria	rt. mn. sq. err.	mn. abs. err.	rt. mn. sq. err.	mn. abs. err.	rt. mn. sq. err.	mn. abs. err.
Nitrogen fertiliser trial at experimental farm De Bouwing, 1982-1983	768	528	1123	803	0.58	0.38
Nitrogen fertiliser trial at experimental farm De Bouwing, 1983-1984	878	391	836	706	0.62	0.44
Nitrogen fertiliser trial at experimental farm De Eest, 1982-1983	774	463	1415	1397	1.03	0.75
Nitrogen fertiliser trial at experimental farm De Eest, 1983-1984	1365	1008	1169	993	0.97	0.77
Nitrogen fertiliser trial at experimental farm PAGV, 1982-1983	1088	691	1162	1003	0.60	0.42
Nitrogen fertiliser trial at experimental farm PAGV, 1983-1984	1413	943	826	814	0.52	0.35
Growth composition trial experimental farm A.G. Minderhoudhoeve, 1985-1986	1122	890	894	882	0.72	0.66
Plant density trial , experimental farm PAGV, 1976-1977	2553	2404	717	698	-	-
Nitrogen fertiliser and irrigation trial experimental farm Rothamsted, 1984-1985	925	811	29	29	1.34	1.03
Nitrogen fertiliser and irrigation trial experimental farm Rothamsted, 1985-1986	663	526	407	381	1.27	1.07

Performance of the model on the experimental data in the Netherlands was reasonably good with respect to weight of storage organs, where behaviour of the model on the datasets in the United Kingdom was good. Root mean square error of the prediction of dry weight of storage organs (WSO) over the reviewed experiments was 858 kg dry matter per hectare, mean absolute error was 770 kg dry matter per hectare. Coefficient of determination (r^2) between

simulated and observed values of grain dry weight at maturity was 0.77, using all observed data. Simulation of the dynamics of leaf area development in these set of experiments was moderate. Root mean square error of the prediction of leaf area index (LAI) over the reviewed experiments was 0.85 m^2/m^2, mean absolute error was 0.65 m^2/m^2.

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Wolf, J. & M.A. Semenov, H. Eckersten, L.G. Evans, A. Iglesias, J.R. Porter, 1995. Effects on winter wheat: A comparison of five models. In: Harrison, P.A., R.E. Butterfield & T.E. Downing (Eds.), Climate Change and Agriculture in Europe, Assessments of Impacts and Adaptations, Environmental Change Unit, University of Oxford, Research Report No. 9, p. 231-280

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