Grain Number of Wheat - A Model Comparison -

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Introduction

A sufficiently accurate prediction of grain number per square meter (GPSM) is of high importance for most wheat crop simulators. It is more closely related to yield than thousand kernel weight (e.g. Brancourt-Hulmel et al. 2003), albeit the role of GPSM for yield via sink limitation is still controversially discussed. We compared the performance of different existing empirical GPSM algorithms using data from field experiments. Furthermore we propose and test a new algorithm, as a synthesis of existing approaches, aiming to improve the predictive power of wheat crop simulators for GPSM.

Material and Methods

Data base for model comparison:

Field trials in Kiel (northern Germany)

- Three years (2003/04 to 2005/06)
- Five cultivars (4 each year)
- Varying N supply (0-320 kg/ha)

Field trial in Wageningen (the Netherlands) (Groot 1987)

- Two years (1983 and 1984)
- One cultivar
- Varying N supply (0-240 kg/ha)

Measured Parameters:

GPSM, yield, shoot dry weight (DM), shoot N concentration, development stages, daily weather data.

The necessary inputs for the models (Tab.1) were generated by fitting curves to the field data:

DM (logistic growth), shoot N concentration (linear interpolation), growth stages (simulated using a fitted model).

The Wageningen dataset was used for a *ceteris paribus* comparison between models using one genotype parameter for each model (G see Tab.1), derived by fitting using observed GPSM.

Literature:

Brancourt-Hulmel, M., Doussinault, G., Lecomte, C., Berard, P., Le Buanec, B., Trottet, M., 2003. Genetic improvement of agronomic traits of winter wheat cultivars released in France from 1946 to 1992. Crop Sci. 43, 37–45.

Demotes-Mainard, S., Jeuffroy, M.H., 2001. Incorporating radiation and nitrogen nutrition into a model of kernel number in wheat. Crop Sci. 41, 415–423.

Groot, J. J. R., 1987. Simulation of nitrogen balance in a system of winter wheat and soil. Simulation Report CABO-TT 69.

Moreno-Sotomayor, A., Weiss, A., 2004. Improvements in the simulation of kernel number and grain yield in CERES-Wheat. Field Crops Res. 88, 157–169

Vos, J.,1981. Effect of temperature and nitrogen supply on post anthesis growth of winter wheat: measurements and simulations. Agric. Res. Rep.811, Pudoc, Wageningen, 164

Hypothesis

Although shoot dry matter, N nutrition index and photothermal quotient are not independent, a model considering all three parameters can enhance the GPSM prediction.

Tab. 1: Overview of model approaches (M1-M4) used for estimation of GPSM

Model	GPSM =	Source
M1	$G_1 \times DM_{65}$	Vos (1981), CERES-Wheat (v. 4)
M2	$G_2 \times \Delta DM_{39\text{-}65}$	Moreno-Sotomayor and Weiss (2004)
M3	$G_3 \times (\alpha + \beta \times \ln(NNI_{60}) + \gamma \times Q45)$	Demotes-Mainard and Jeuffroy (2001)
M4	$G_4 \times \ln(DM_{65} \times NNI_{60} \times Q45)^a$	Newly developed

DM: shoot dry matter [g/m²]; $\Delta DM_{39\text{-}65}$: shoot growth between end of leaf growth and 50% anthesis [g/m²]; **Q45**: photo-thermal quotient 45 days before anthesis [MJ/(m²·d°C)]; **NNI**: N Nutrition Index; **G**: genotypic fit parameter for each dataset. **a**: fit parameter for Kiel only. Corresponding growth stages (BBCH scale) are represented as subscripts

Results

Kiel		M1	M2	M3	M4
Number of fit parameter		1	1	1	2
G*	[see Tab. 1]	16.1	34.2	0.95	149
RMSE	[grains/m²]	1808	1912	2513	1301
rRMSE	[% Mean]	9.3	9.9	13.0	6.7
Wageningen		**M1**	**M2**	**M3**	**M4**
Number of fit parameter		1	1	1	1
G	[see Tab. 1]	20.1	39.9	1.36	193
RMSE	[grains/m²]	3677	2700	2565	1809
rRMSE	[% Mean]	16.6	12.2	11.6	8.2

** no differences between "modern" cultivars (Kiel)*

Tab. 2: Statistical parameters for goodness of fit

RMSE =

$$\left[\frac{1}{n}\sum(sim_i - obs_i)^2\right]^{0.5}$$

rRMSE = RMSE/obs. average

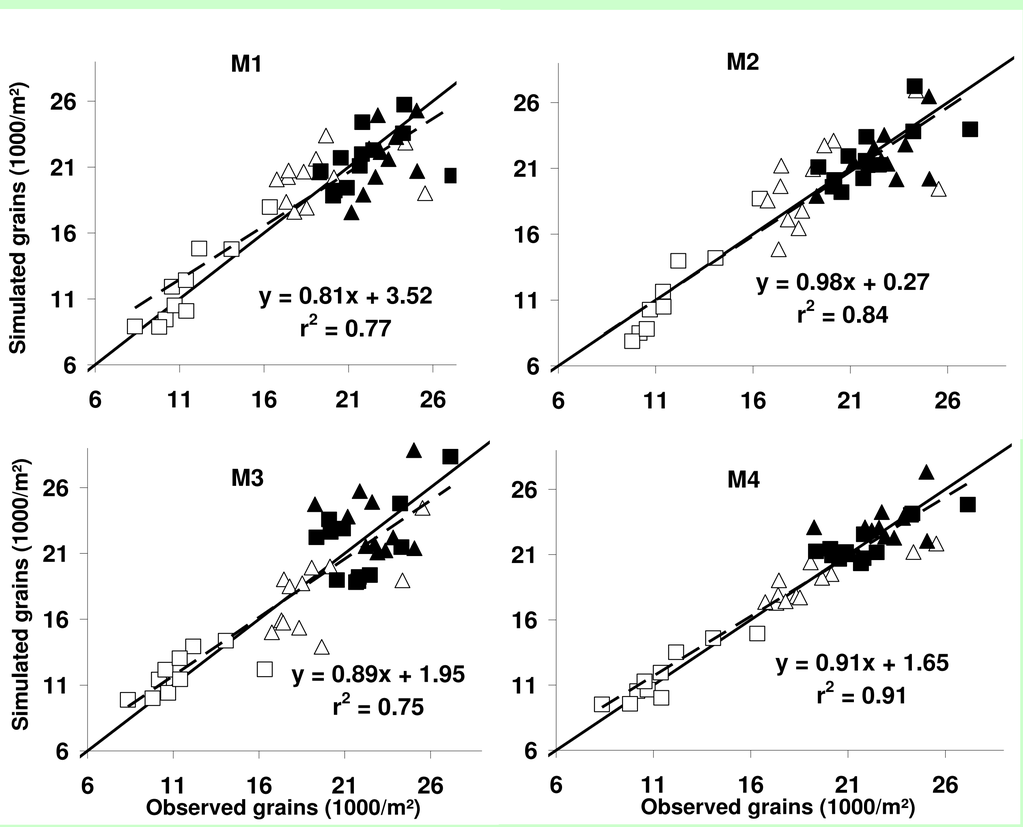

Fig. 1: Simulated vs. observed GPSM (both data sets), obtained from different model approaches (M1-M4) and corresponding linear regression (— —) equations as well as the 1:1 line (——).

N treatments:

[kg N/ha]	Symbol
0	□
60-120	△
140-192	■
240-320	▲

Conclusion

The consideration of all three parameters (DM_{65}, NNI_{60}, Q_{45}) shows best estimates for both datasets.

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