Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Skördetidsprognos i ensilagemajs

Växjö möte 2017-12-06

Forskningsledare
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MAISPROQ – maize growth model

- MAISPROQ - MAIS(z)e PROduction and Quality model
- MAISPROQ is being used in Germany for maize yield and quality forecasting (Herrmann et al. 2005)

- Can predict
  - Biomass growth
  - DM % change
  - Starch % change

Field trials maize

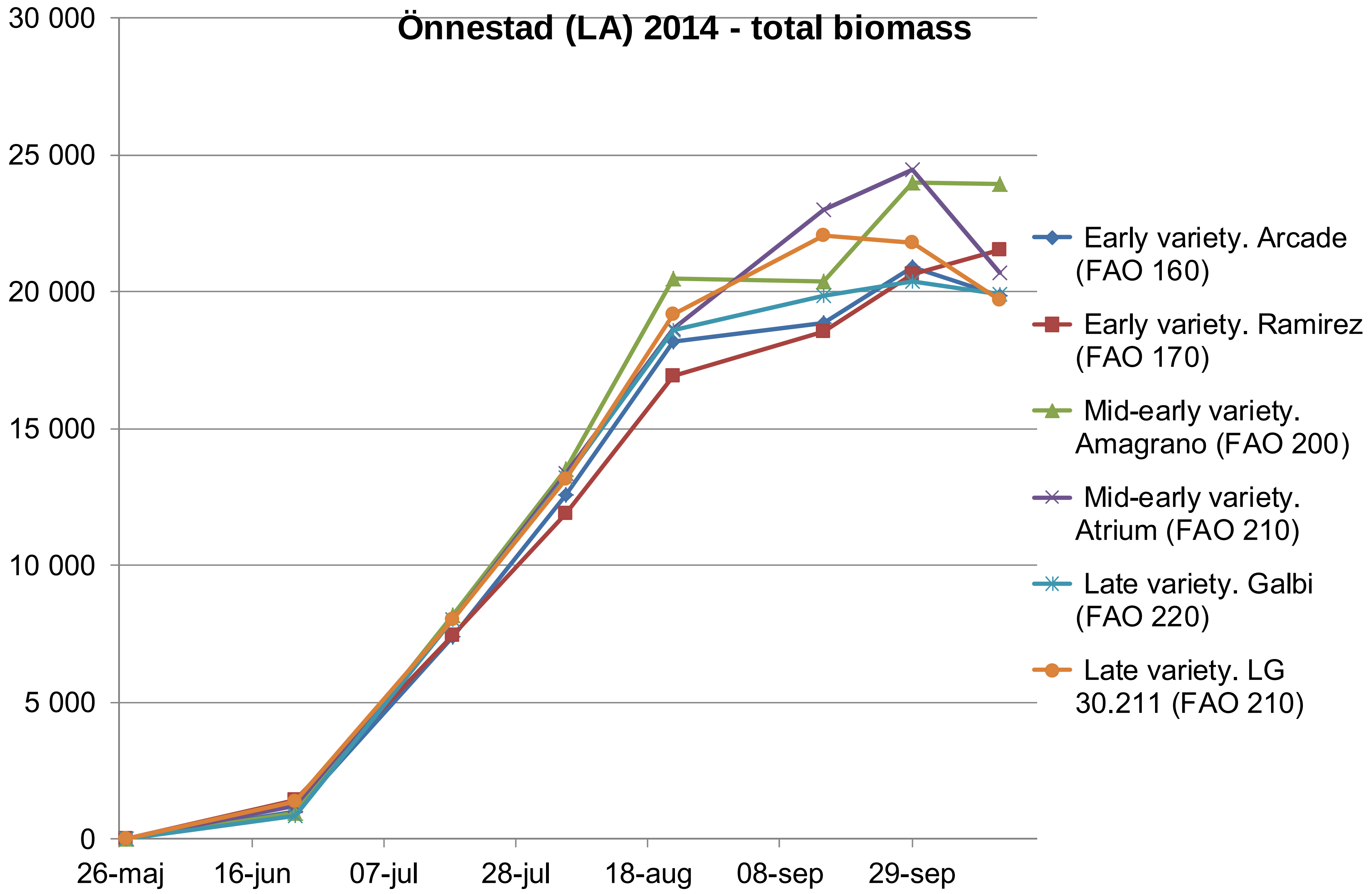
- Sweden
  - Three sites (middle west, south east and south) and
  - Two years (2013 and 2014)
  - Six varieties, pure maize, two replicates
  - Eight samplings from growth onset to start decay

Varieties in Swedish trials 2013-2014

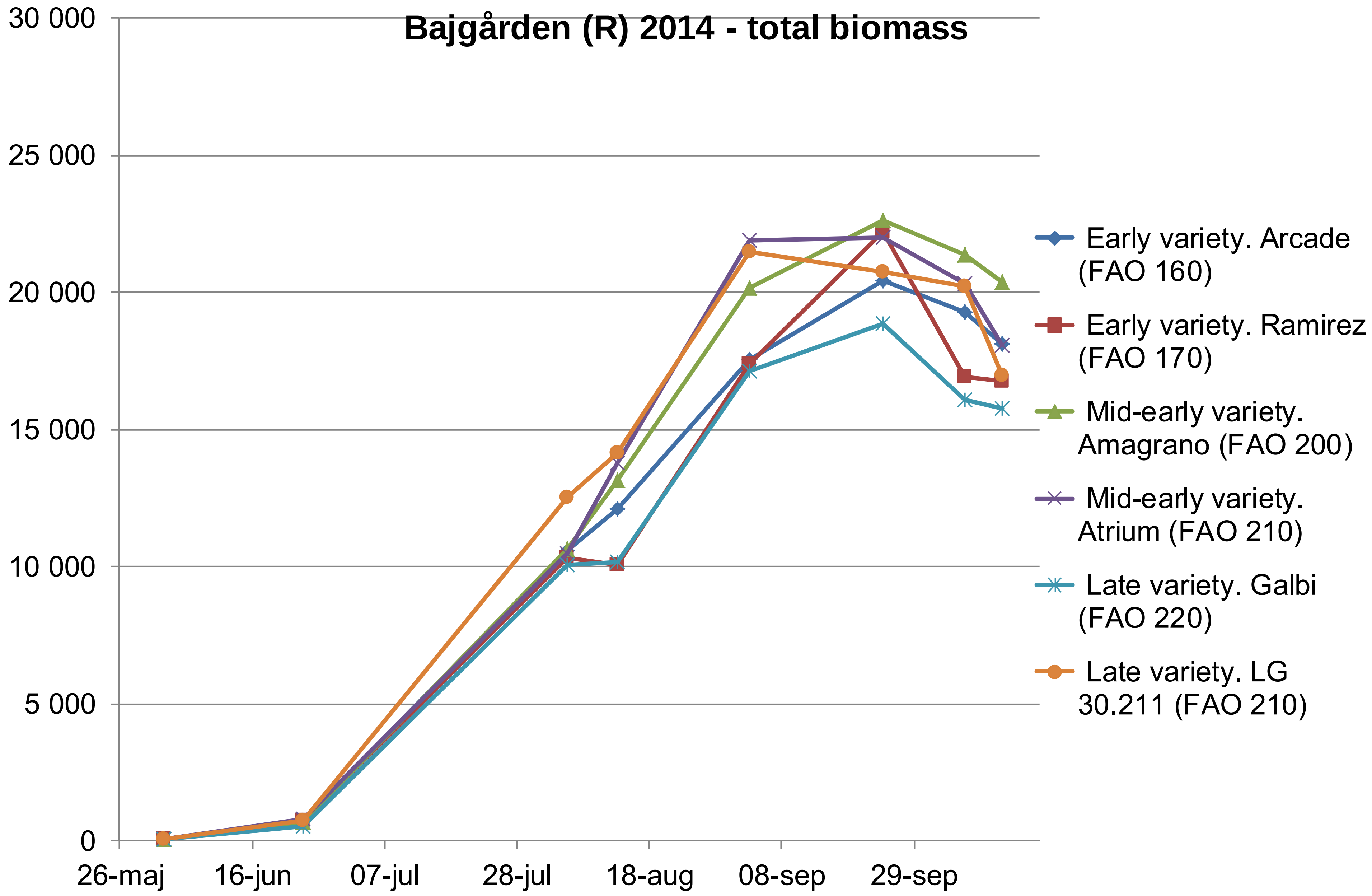
- Early variety. Arcade (FAO 160)
- Early variety. Ramirez (FAO 170)
- Mid-early variety. Amagrano (FAO 200)
- Mid-early variety. Atrium (FAO 210)
- Late variety. Galbi (FAO 220)
- Late variety. LG 30.211 (FAO 210)

- FAO-number.
  - Nine classes (100-900), each ten difference means 1-2 days difference in development or 1-2 % DM.

South Sweden 2014 – Önnestad 7th July.
Seeded 30th April



Önnestad (LA) 2014 - total biomass
30 000
25 000
20 000
15 000
10 000
5 000
0
26-maj
16-jun
07-jul
28-jul
18-aug
08-sep
29-sep
Early variety. Arcade (FAO 160)
Early variety. Ramirez (FAO 170)
Mid-early variety. Amagrano (FAO 200)
Mid-early variety. Atrium (FAO 210)
Late variety. Galbi (FAO 220)
Late variety. LG 30.211 (FAO 210)



Bajgården (R) 2014 - total biomass
30 000
25 000
20 000
15 000
10 000
5 000
0
26-maj
16-jun
07-jul
28-jul
18-aug
08-sep
29-sep
Early variety. Arcade (FAO 160)
Early variety. Ramirez (FAO 170)
Mid-early variety. Amagrano (FAO 200)
Mid-early variety. Atrium (FAO 210)
Late variety. Galbi (FAO 220)
Late variety. LG 30.211 (FAO 210)

Format of weather data to MAISPROQ

Day-number	Percipi-tation, mm	Average tempera-ture, C	Potential evapo-transpiration, mm	Global solar radiation (10kJ/m2 day−1
001	0.0	2.5	0.1	100
002	7.5	3.5	0.1	60
003	1.1	4.6	0.1	60

Growth model

(above ground biomass)

$$dW_t/dt = W_{t-1} \cdot R_s \cdot AGE_t \cdot GI_t \quad \text{g m}^{-2}\,\text{d}^{-1}$$

$$AGE_t = 1/(1+W_{t-1}/a_{Age})^{\wedge}b_{Age}$$

$$GI_t = T_i \cdot R_i \cdot M_{it}$$

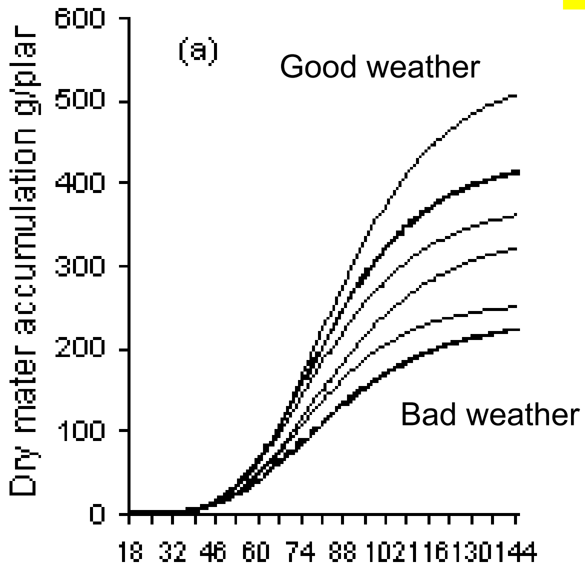
Rs: Initial relative growth rate

aAge: Half maximum biomass

bAge: Age function constant

tk1: Temperature response

rk: Solar radiation response



Temperature, Radiation, Water availability

$$T_i = ½\,[2(1-x)]^{tk1}$$

$$R_i = [1-e^{(-k.Ri/Rmax)}]/(1-e^{-rk})$$

Herrmann et al., 2005

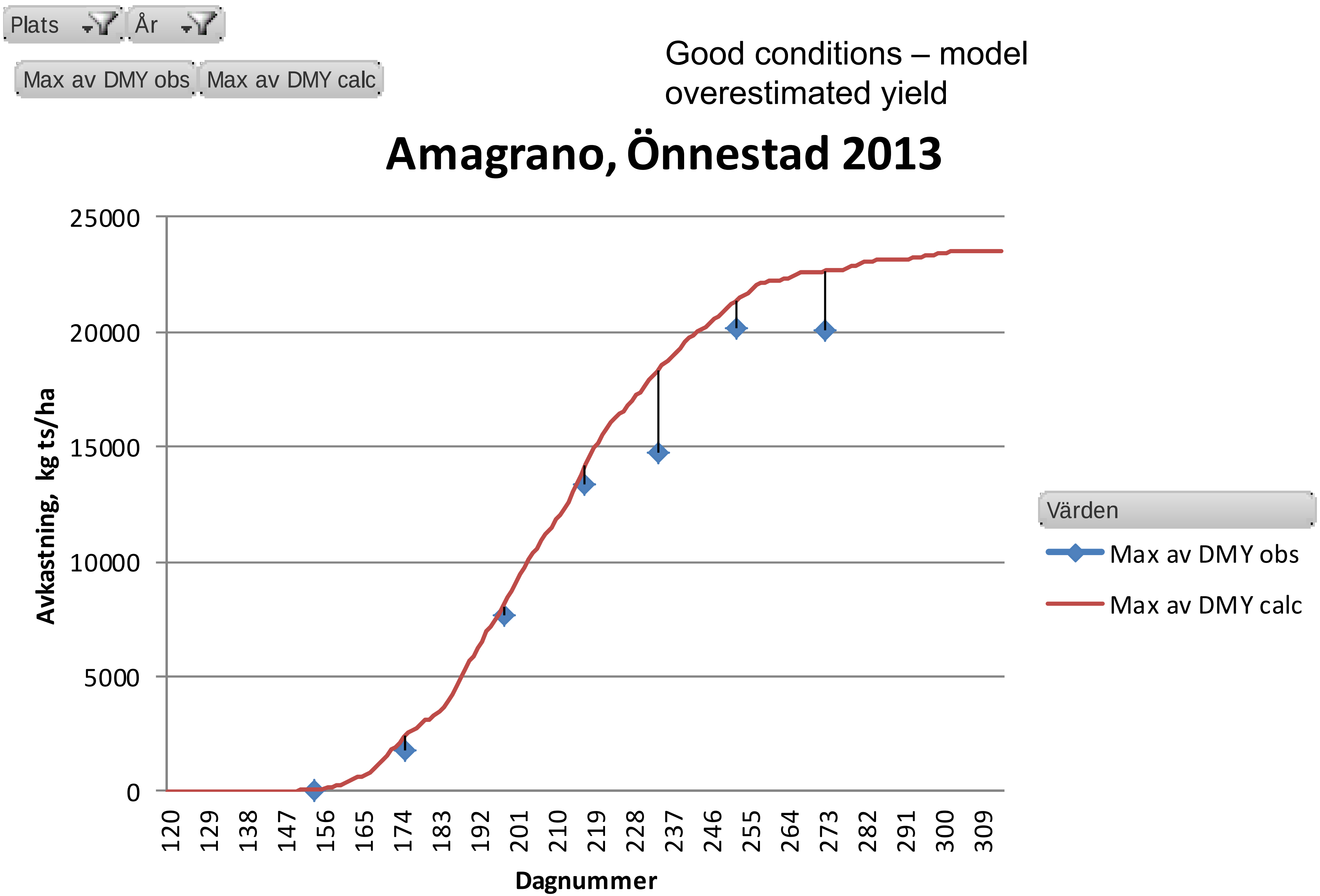
Optimized parameters biomass

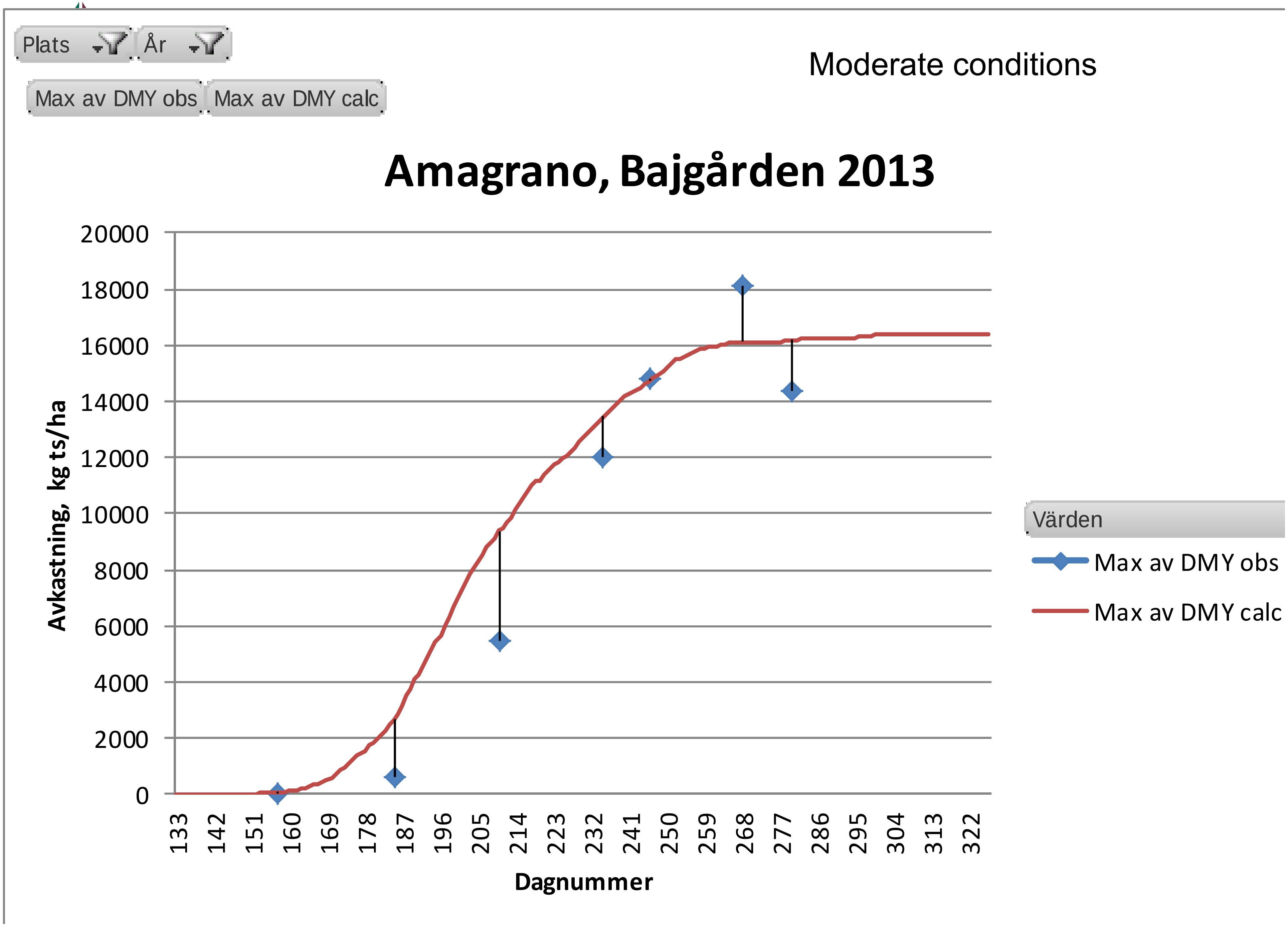
Three sites and two years per variety at optimization

	Variety	Rs	LAI50	ak	tk1	rk	R^2
1	Arcade	0.446	1648.63	1.11	0.1	2	0.91
2	Ramirez	0.447	1536.56	1.10	0.1	2	0.92
3	Amagrano	0.411	2298.50	1.41	0.1	2	0.93
4	Atrium	0.294	5760.56	1.95	0.1	2	0.95
5	Galbi	0.304	4060.00	1.52	0.1	2	0.93
6	Lg 30.211	0.489	1350.54	1.03	0.1	2	0.92

- Rs=initial RGR
- LAI50 (a_{Age}) = half maximum LAI
- ak (a_{Age}) = age function constant
- tk1 = constant in TI-function - temperature response
- rk = constant in RI-function - solar radiation response

Good conditions – model overestimated yield





Plats
År
Max av DMY obs
Max av DMY calc
Moderate conditions
Amagrano, Bajgården 2013
Avkastning, kg ts/ha
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
133
142
151
160
169
178
187
196
205
214
223
232
241
250
259
268
277
286
295
304
313
322
Dagnummer
Värden
Max av DMY obs
Max av DMY calc

DM Yield observed-calculated - Amagrano

Site, year	Day-number	Yield, kg/ha observed	Yield, kg/ha calculated	Difference, kg/ha	Difference %
Önnestad 2013	154	70	85	15	21
Önnestad 2013	175	1 806	2 423	617	34
Önnestad 2013	198	7 705	8 071	366	5
Önnestad 2013	217	13 379	14 206	827	6
Önnestad 2013	234	14 748	18 297	3 549	24
Önnestad 2013	252	20 184	21 325	1 141	6
Önnestad 2013	273	20 104	22 652	2 548	13
Färjestaden 2013	158	6	36	30	503
Färjestaden 2013	178	361	992	631	175
Färjestaden 2013	210	8 459	8 437	-22	0
Färjestaden 2013	224	12 392	12 232	-160	-1
Färjestaden 2013	242	18 310	15 430	-2 880	-16
Färjestaden 2013	260	19 884	17 520	-2 364	-12
Färjestaden 2013	277	21 426	17 923	-3 503	-16

Quality model

(dry matter and starch contents)

tkq: Constant in temperature function

rkq: Constant in radiation function

Qmin: Minimum quality

Qmax: Maximum quality

v: Specific change rate of quality at half of Qmax

c: Quality function constant

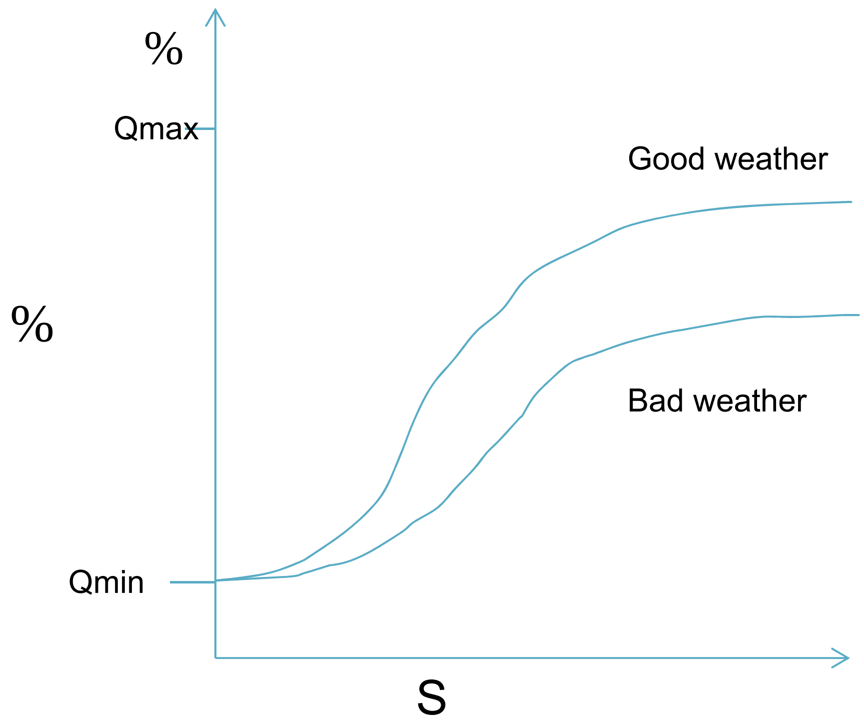
$$Q_t = Q_{min} + (Q_{max} - Q_{min}) \cdot f_{Qt}$$

$$f_{Qt} = (S_t/v)^c/(1+(S_t/v)^c)$$

$$S_t = \sum_{i=0}^{t} Tcr.Rcr.Wcr$$

$$T_{cr} = 1 - e^{-tkq(td-tthr)}$$

$$Rcr = 1 - e^{-rkq(rd-rthr)}$$

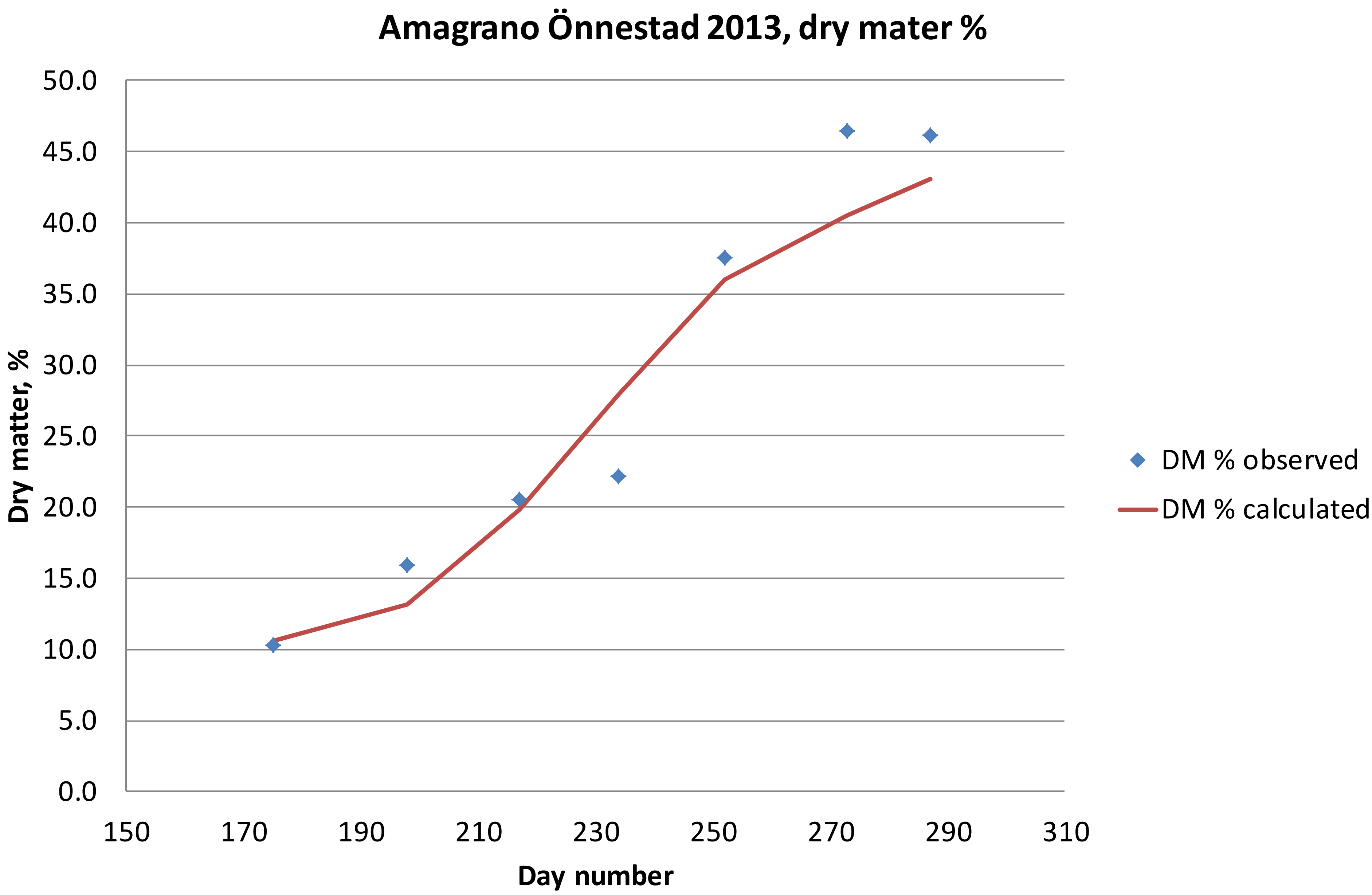


Optimized parameters DM-content %

Three sites and two years per variety at optimization

	sort	rkq	schr50	chrk	Qmin	Qmax	R^2
1	Arcade	4.250	78.10	4.78	10.16	59.99	0.93
2	Ramirez	4.500	77.26	5.82	10.66	59.37	0.92
3	Amagrano	3.393	83.48	4.65	9.75	59.78	0.92
4	Atrium	3.037	82.09	4.53	9.66	60.51	0.93
5	Galbi	3.888	86.42	5.00	10.07	60.12	0.89
6	Lg 30.211	1.936	83.68	4.68	10.15	60.94	0.89

- rkq = constant in radiation function RCH
- schr50 (v) = switch-on/off at half specific change rate of quality at half of Qmax
- chrk (c)= constant S switch-on/off function
- Qmin = minimum quality content at the onset of growth
- Qmax = maximum quality content at maturity



Amagrano Önnestad 2013, dry mater %
Dry matter, %
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
150
170
190
210
230
250
270
290
310
Day number
DM % observed
DM % calculated

DM % observed-calculated - Amagrano

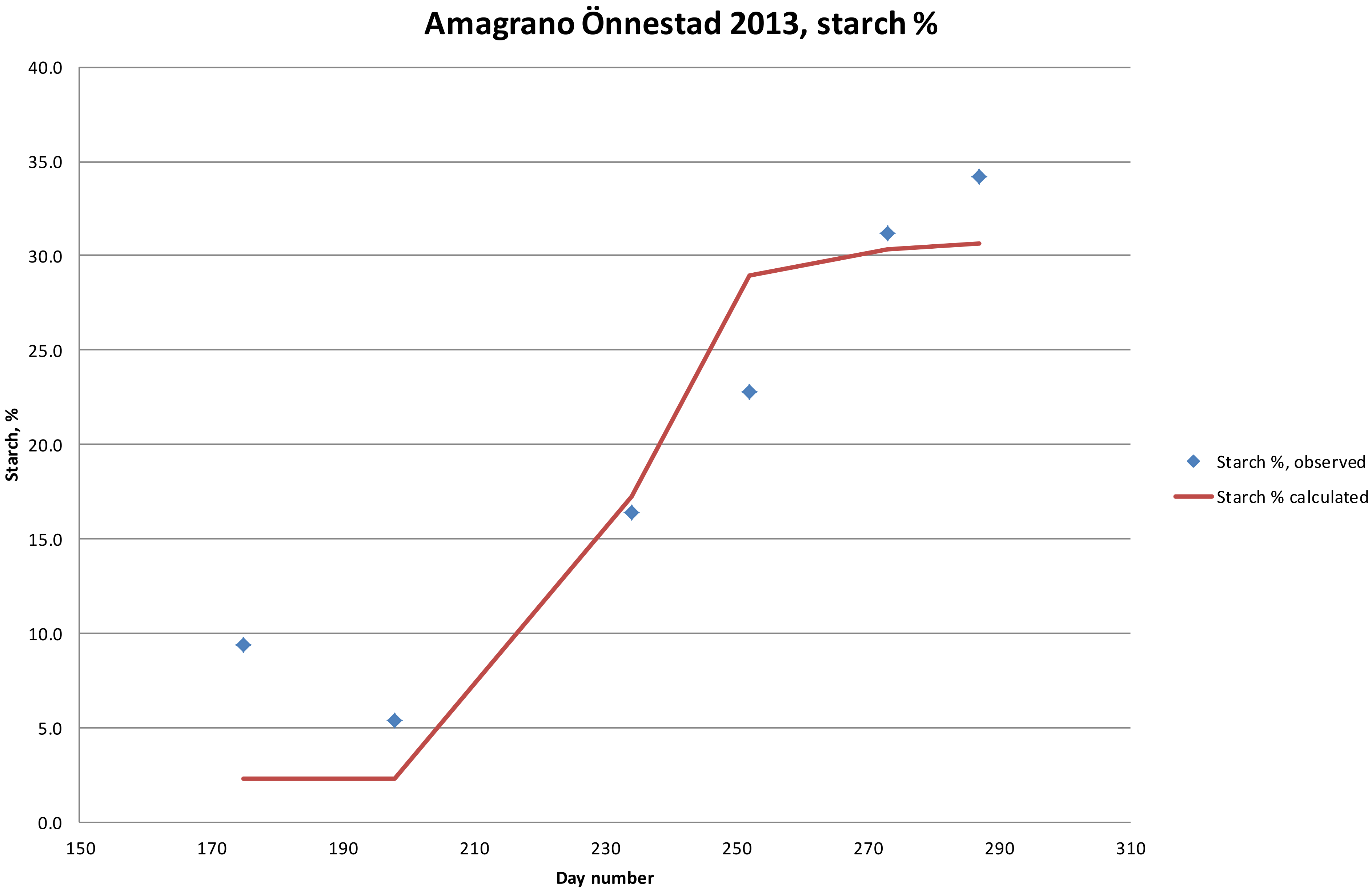
Site	Day-number	DM % observed	DM % calculated	Difference, abs %	Difference rel %
Önnestad 2013	175	10.3	10.6	0.3	3.3
Önnestad 2013	198	15.9	13.2	-2.7	-17.0
Önnestad 2013	217	20.5	19.8	-0.7	-3.5
Önnestad 2013	234	22.2	27.9	5.7	25.8
Önnestad 2013	252	37.5	36.0	-1.5	-4.1
Önnestad 2013	273	46.5	40.5	-6.0	-12.9
Önnestad 2013	287	46.2	43.1	-3.1	-6.7
Färjestaden 2013	178	10.4	10.4	0.0	0.3
Färjestaden 2013	210	15.1	14.2	-0.9	-5.8
Färjestaden 2013	224	18.9	19.0	0.1	0.5
Färjestaden 2013	242	27.3	26.6	-0.7	-2.5
Färjestaden 2013	260	29.6	33.2	3.6	12.2
Färjestaden 2013	277	39.2	35.5	-3.7	-9.4
Färjestaden 2013	288	39.8	37.1	-2.7	-6.8

Optimized parameters starch-content %

Three sites and two years per variety at optimization

	sort	rkq	schr50	chrk	min	max	R^2
1	Arcade	1.88	25.12	19.17	2.31	30.92	0.91
2	Ramirez	3.52	25.35	15.19	1.75	33.41	0.93
3	Amagrano	3.52	25.33	14.94	1.81	33.41	0.89
4	Atrium	3.03	25.29	12.34	1.8	33.79	0.94
5	Galbi	6.50	26.30	13.46	1.6	35.75	0.85
6	Lg 30.211	9.03	25.74	13.66	2 .20	34.8	0.86

- rkq = constant in radiation function RCH
- schr50 (v) = switch-on/off at half specific change rate of quality at half of Qmax
- chrk (c)= constant S switch-on/off function
- Qmin = minimum quality content at the onset of growth
- Qmax = maximum quality content at maturity


Amagrano Önnestad 2013, starch %
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Starch, %
150
170
190
210
230
250
270
290
310
Day number
Starch %, observed
Starch % calculated

Starch % observed-calculated - Amagrano

Site, year	Day-number	Starch %, observed	Starch % calculated	Difference, abs %	Difference rel %
Önnestad 2013	175	9.4	2.3	-7.1	-75.4
Önnestad 2013	198	5.4	2.3	-3.1	-57.2
Önnestad 2013	234	16.4	17.3	0.9	5.2
Önnestad 2013	252	22.8	29.0	6.2	27.1
Önnestad 2013	273	31.2	30.4	-0.8	-2.7
Önnestad 2013	287	34.2	30.7	-3.6	-10.4
Färjestaden 2013	178	4.6	2.3	-2.3	-49.8
Färjestaden 2013	210	2.5	2.3	-0.2	-6.8
Färjestaden 2013	224	3.9	3.0	-0.9	-22.8
Färjestaden 2013	242	18.3	13.4	-4.9	-26.8
Färjestaden 2013	260	29.9	26.1	-3.8	-12.8
Färjestaden 2013	277	33.3	28.1	-5.2	-15.6
Färjestaden 2013	288	36.9	29.0	-7.9	-21.3

Validation of the model

Site	FAO-number	Validation (V) DM %	Validation (V) Date	Simulation (S) DM %	Simulation (S) Date	Variety trial (O) DM %	Variety trial (O) Date	Differences Date, O-S	Differences Date, V-S	Differences DM, O-S	Differences DM, V-S
Kristianstad	220	32.0	05-sep	34.5	09-sep	42.2	21-sep	12	-4	7.7	-2.5
Lidköping	200	32.2	29-sep	34.2	27-sep	39.1	17-okt	20	2	4.9	-2.0
Öland	170	32.2	14-sep	34.2	12-sep	37.5	21-sep	9	2	3.3	-2.0
Öland	220	32.2	14-sep	34.1	11-sep	36.6	21-sep	10	3	2.5	-1.9
Öland	210	33.1	14-sep	34.0	17-sep	34.7	21-sep	4	-3	0.7	-1.0
Gotland	170	33.2	15-sep	34.2	15-sep	35.4	18-sep	3	0	1.2	-1.0
Kristianstad	170	34.0	05-sep	34.5	10-sep	48.8	21-sep	11	-5	14.3	-0.5
Kristianstad	210	34.5	05-sep	34.1	14-sep	44.2	21-sep	7	-9	10.1	0.4
Gotland	180	35.3	15-sep	34.4	27-sep	36.3	18-sep	-9	-12	2.0	0.9
Kristianstad	200	35.4	05-sep	34.2	19-sep	43.3	21-sep	2	-15	9.1	1.1
Lidköping	180	35.7	29-sep	34.0	26-sep	46.7	17-okt	21	3	12.7	1.7
Lidköping	170	35.8	29-sep	34.6	16-sep	41.8	17-okt	31	13	7.3	1.2
Öland	180	35.9	14-sep	34.1	22-sep	39.1	21-sep	-1	-8	5.0	1.8
Mean		*34.8*	*15-sep*	*34.2*	*18-sep*	*41.2*	*27-sep*	*9*	*-3*	*6.2*	*-0.3*
Stdav		*1.1*	*9.3*	*0.2*	*5.6*	*5.1*	*11.9*	*10*	*7*	*4.4*	*1.5*

Skillnader i skördetid och ts-halt

	Datum			TS-halt	
År	Simulering (S), 34 %	Skörd sortförsöket (O)	Skillnad dagar O-S	Sort-försöket (O)	Skillnad O-S
2008	2008-09-25	2008-10-09	14	36.8	2.8
2009	2009-09-20	2009-10-01	11	33.4	-0.6
2010	2010-10-09	2010-10-13	4	33.5	-0.5
2011	2011-09-12	2011-10-11	29	35.8	1.8
2012	2012-09-30	2012-10-17	17	34.7	0.7
2013	2013-09-13	2013-09-26	13	37.7	3.7
2014	2014-09-11	2014-09-29	18	38.6	4.6
2015	2015-10-09	2015-10-21	12	33.0	-1.0
2016	2016-09-15	2016-09-21	6	47.2	13.2
Medel	22-sep	06-okt	14	36.7	2.7

Slutsatser

- MAISPROQ-modellen kan ge tillförlitliga skördeprognoser i ensilagemajs under svenska förhållanden
- Sortförsök i ensilagemajs skördas ofta sent

References

- Eckersten, H., Kornher, A. (2012). Klimatförändringars effekter på jordbrukets växtproduktion i Sverige (Climate change impacts on crop production in Sweden – scenarios and computational framework). *Report from the Department of Crop Production Ecology* (VPE), 14. Uppsala.
- Herrmann, A., Kornher, A., Taube, F. (2005). A new harvest time prognosis tool for forage maize production in Germany. *Agricultural and Forest Meteorology* 130:95-111. DOI: 10.1016/j.agrformet.2005.02.005.
- Nkurunziza, L. Kornher, A., Hetta, M., Halling, M., Weih, M & Eckersten, H. (2014). Crop genotype-environment modeling to evaluate forage maize cultivars under climate variability. *Acta Agriculturae Scandinavica section B-soil and plant science* 64, 56-70.
- Pimentel, D., Heichel, G. (1991). Energy efficiency and sustainability of farming systems. In: Lal, R., Pierce, F. 1991. *Soil Management for Sustaibability*. ISBN 0-935734-23-6

South Sweden 2014 – Close to Önnestad (east
Grantinge, Hässleholm) 24th September – maiz