Evaluating grass growth models to predict grass growth in Ireland

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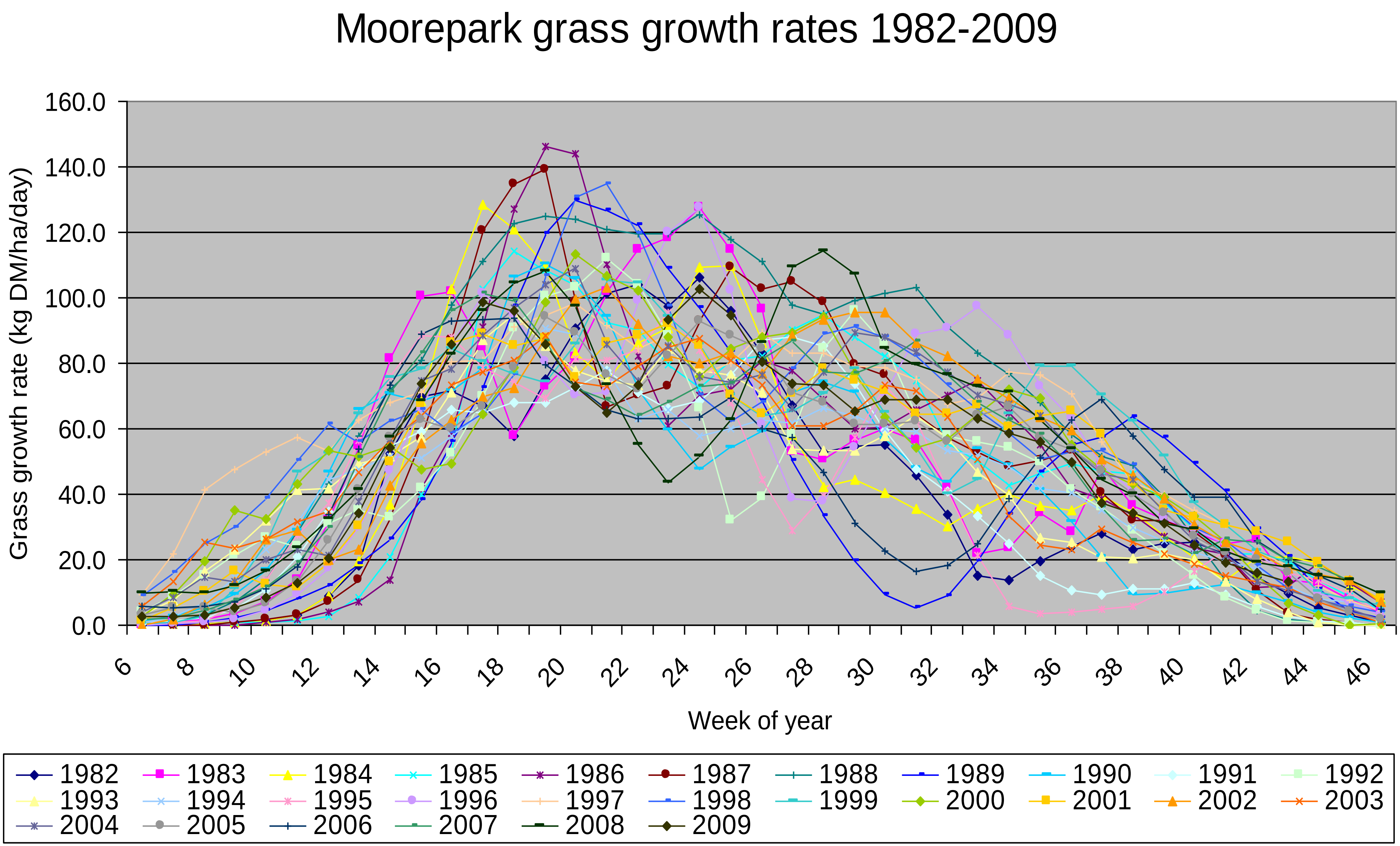
Background

- Dairy production in Ireland is primarily grass-based with spring calving
- Grazing season – Feb. to Nov.
- 8 – 16 t DM/ha/year
- Proportion of grazed grass in the diet of dairy cows is approximately 60%
- Beef and sheep production is also predominantly grass based
- Grass growth in Ireland is quite variable

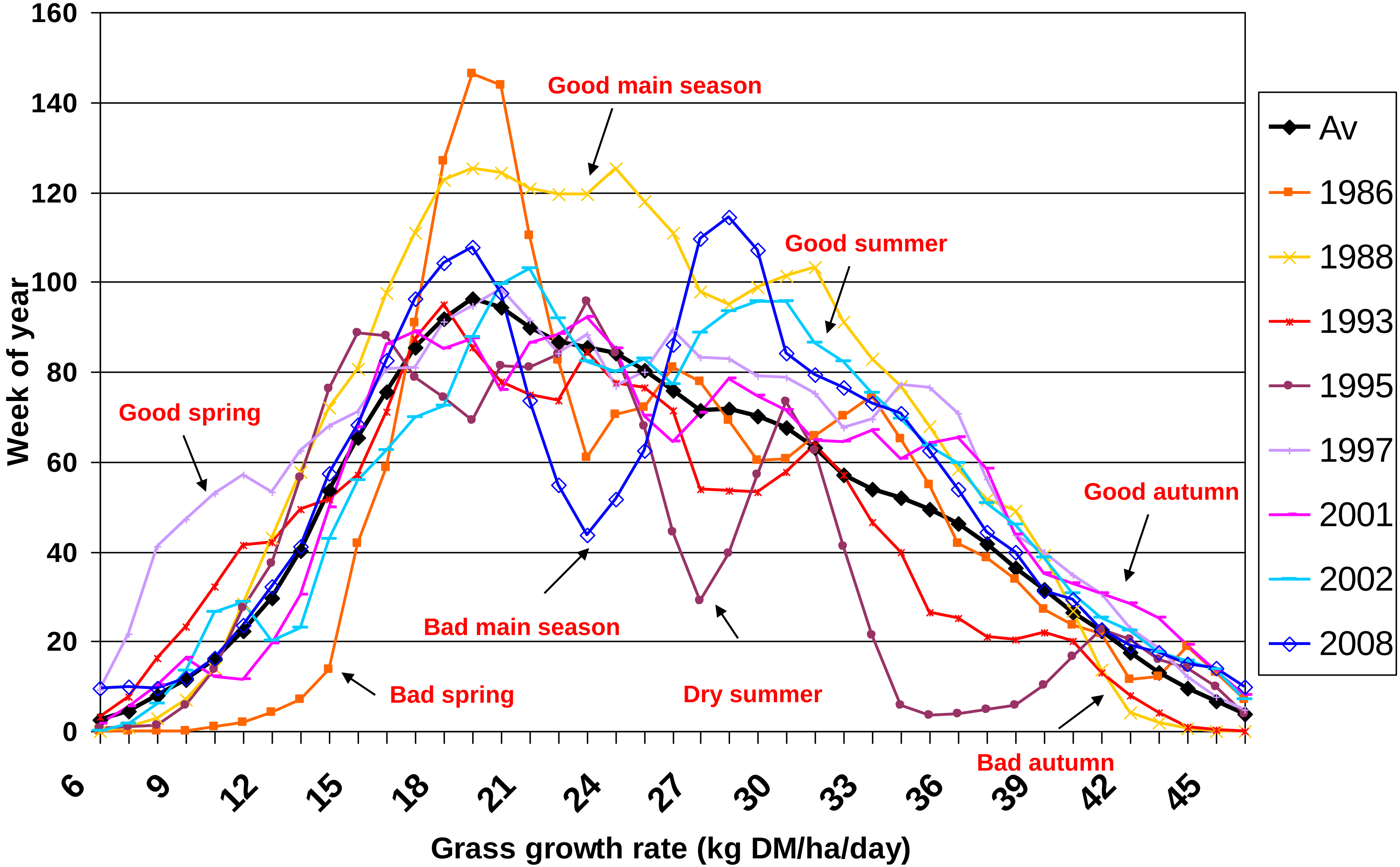
Background

- As a result of variable grass growth throughout the year, the prediction of grass growth is difficult.
- There is a lack of development of models to accurately forecast grass growth
- A grass growth predictor would be invaluable to forecast feed supply
- Why grass growth models?
  - management tools (decision making)
  - research (developing an understanding grass growth)

Grass growth variation



Grass growth variation




Materials and Methods

Materials and Methods

- Three grass growth models were evaluated:
  - Johnson and Thornley (1983) (J&T Model)
  - Jouven *et al.* (2006) (J Model)
  - Brereton *et al.* (1996) (B Model)
- Models were developed for perennial ryegrass swards in temperate climates
- Inputs to the models were meteorological data from Moorepark (2005-2009)
- Modelled data was compared to grass growth data measured at Moorepark (years 2005 to 2009)

Materials and Methods

- Corral and Fenlon methodology (1978) was used to calculate modelled grass growth
- Grass growth estimated on a four week harvest interval.
- The general equation for growth rate in week *t* is

Rate = (7/16 Y_t+ 5/16 Y_{t+1}+ 3/16 Y_{t+2}+ 1/16 Y_{t+3})/28

Where Y_t, Y_{t+1}, Y_{t+2} and Y_{t+3} are the harvested yields at the end of weeks *t*, *t*+1, *t*+2 and *t*+3.

Model description

J&T model

- Mechanistic model
- Objective: to simulate the time course of DM and leaf area development for crops that are exposed to a constant environment, a seasonally varying environment, and are defoliated
- Innovative aspects:
  - a new approach to the problem of leaf area expansion: leaf area index being as an independent state variable
  - the storage pool is used to control incremental specific leaf area (buffer against environment)
- Total above-ground structural crop weight:
  - Growing leaves
  - First fully expanded leaves
  - Second fully expanded leaves
  - Senescing leaves

J model

- Mechanistic dynamic model
- Objective: to investigate seasonal and annual interactions between management and grassland dynamics. Designed to respond to various defoliation regimes, perform multiple-year simulations and produce simple outputs that are easy to use as inputs for a model of ruminant livestock production
- The J model combines functional and structural aspects of grass growth
- Structural compartments:
  - Green vegetative
  - Green reproductive
  - Dead vegetative
  - Dead reproductive

Functional groups:

- Group A (fertile sites, frequent defoliation)
- Group B (medium to fertile sites, infrequent defoliation)
- Group C (medium to poor sites, resistant to defoliation)
- Group D (poor sites, infrequent defoliation)

B model

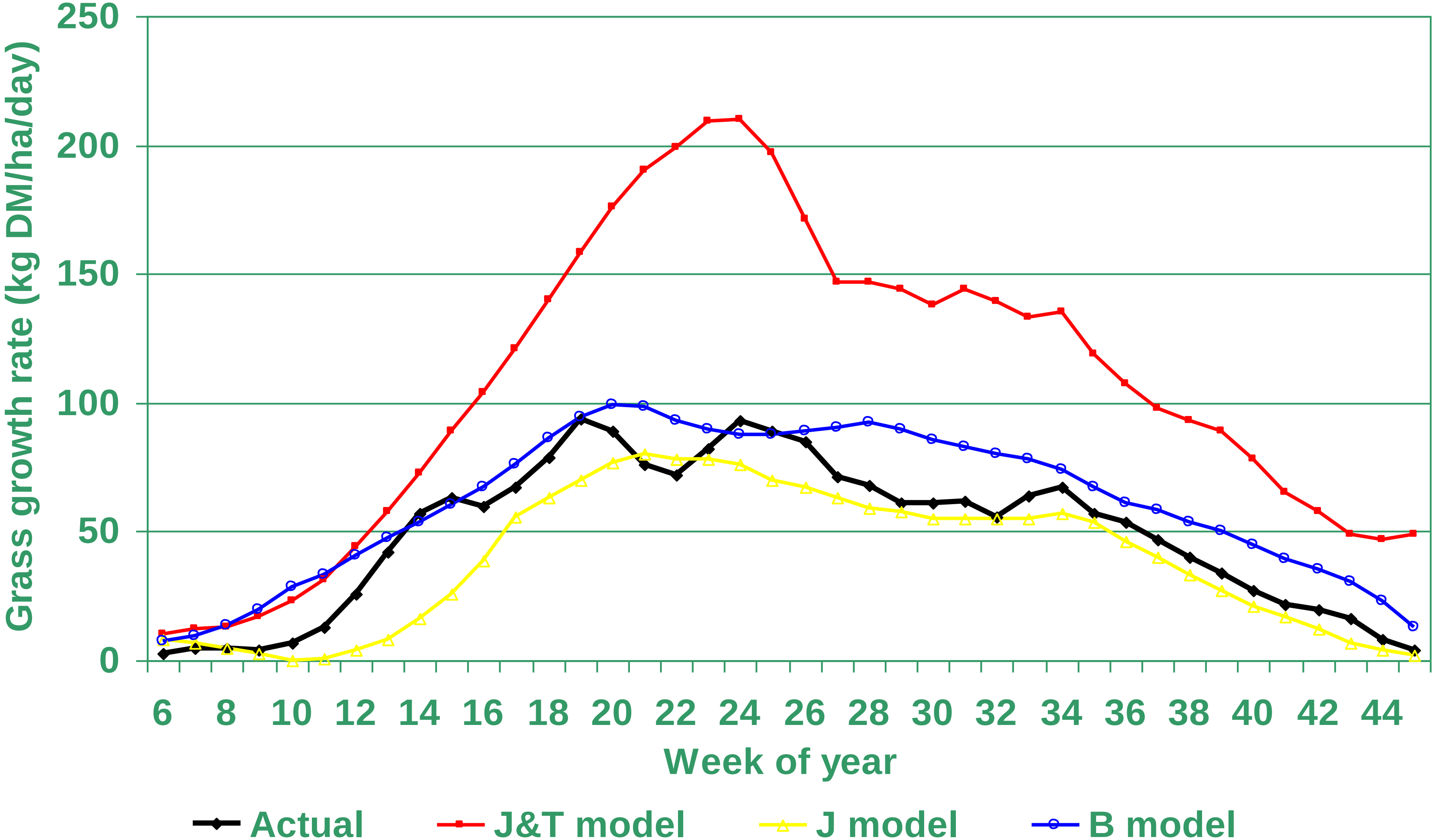
- Static and empirical model
- Objective: to evaluate the gross effects of year-to-year differences in weather conditions on herbage production in grazing systems
- It does not explain the nature of grass growth
- From the mean radiation received at the crop surface herbage mass production is calculated during a regrowth period, and yield is only calculated at the end of this period

Testing the models

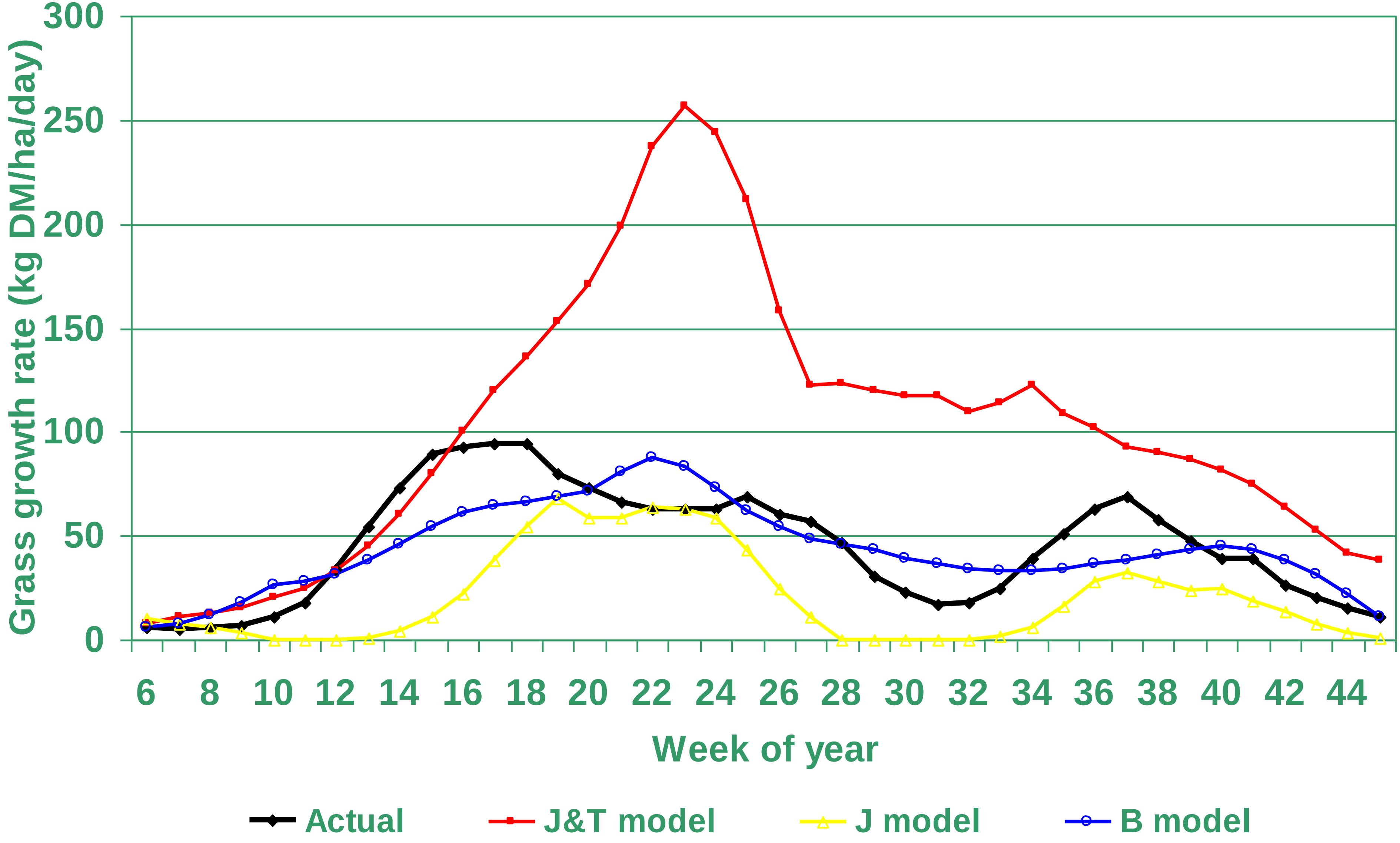
- To test the accuracy of the models
  - Mean percentage error (MPE)
  - Root mean square error (RMSE)
  - Mean square prediction error (MSPE)
    - Mean bias
    - Line bias
    - Random variation
  - Mean prediction error (MPrE)


Results

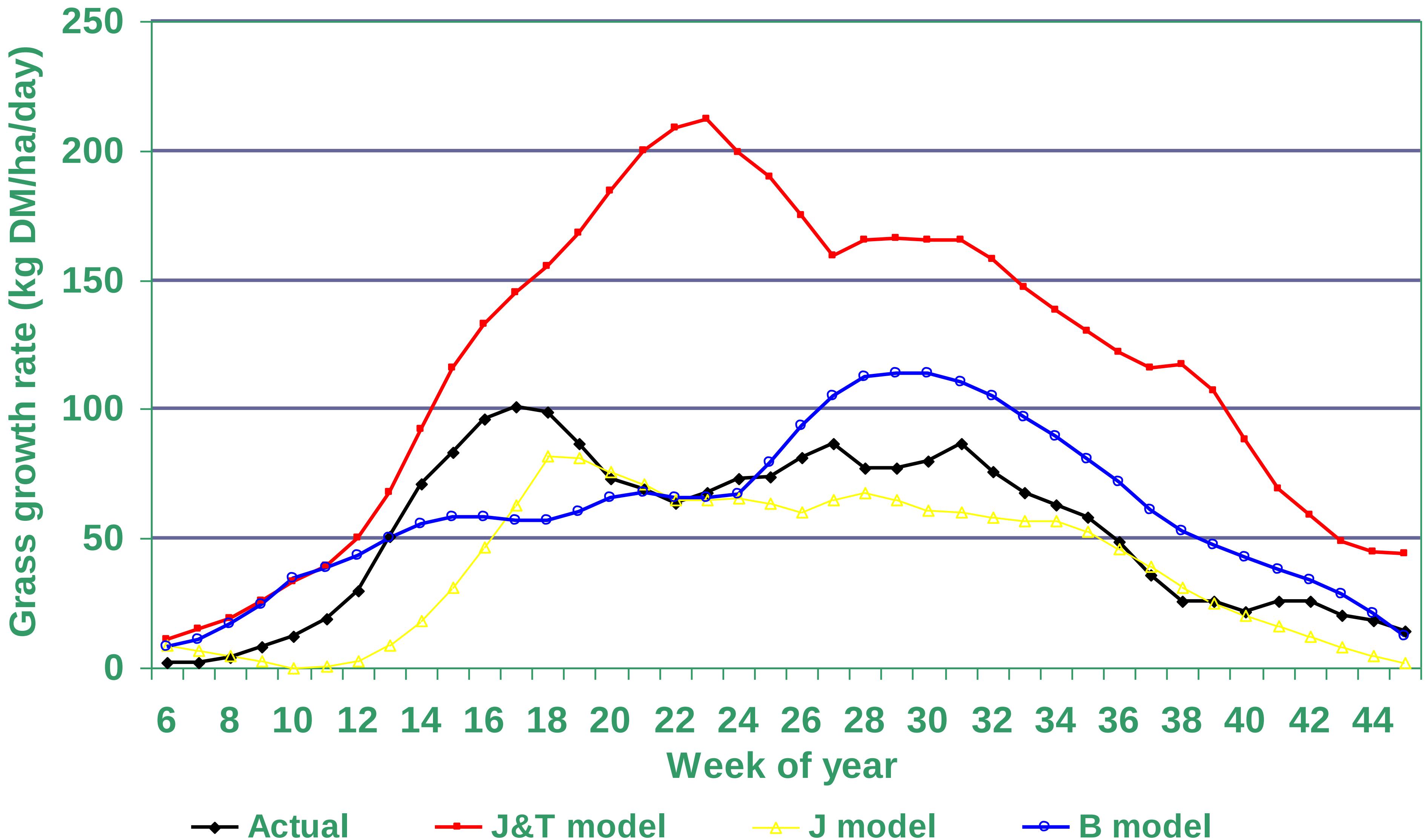
Models predictions for 2005



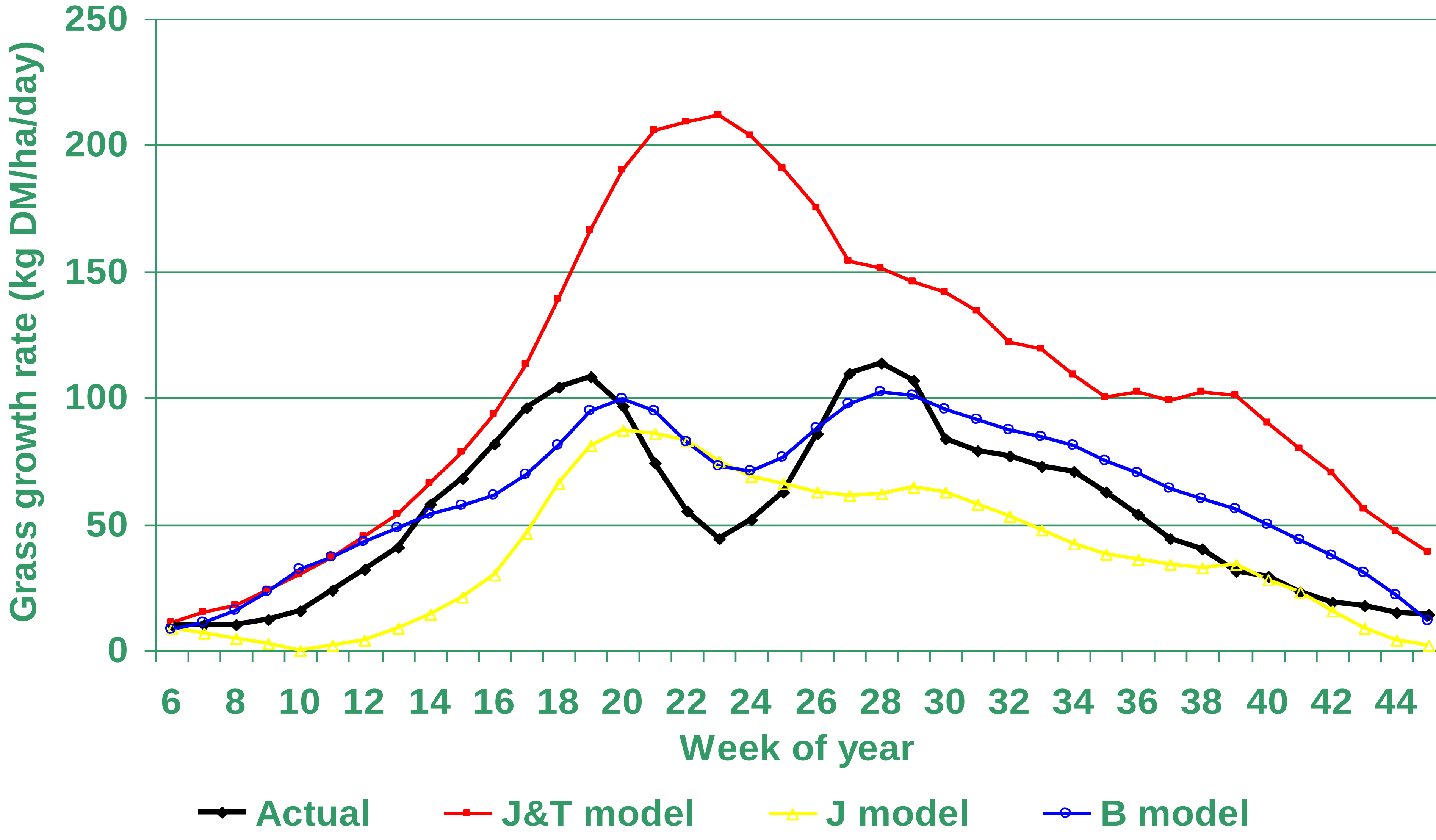
Models predictions for 2006



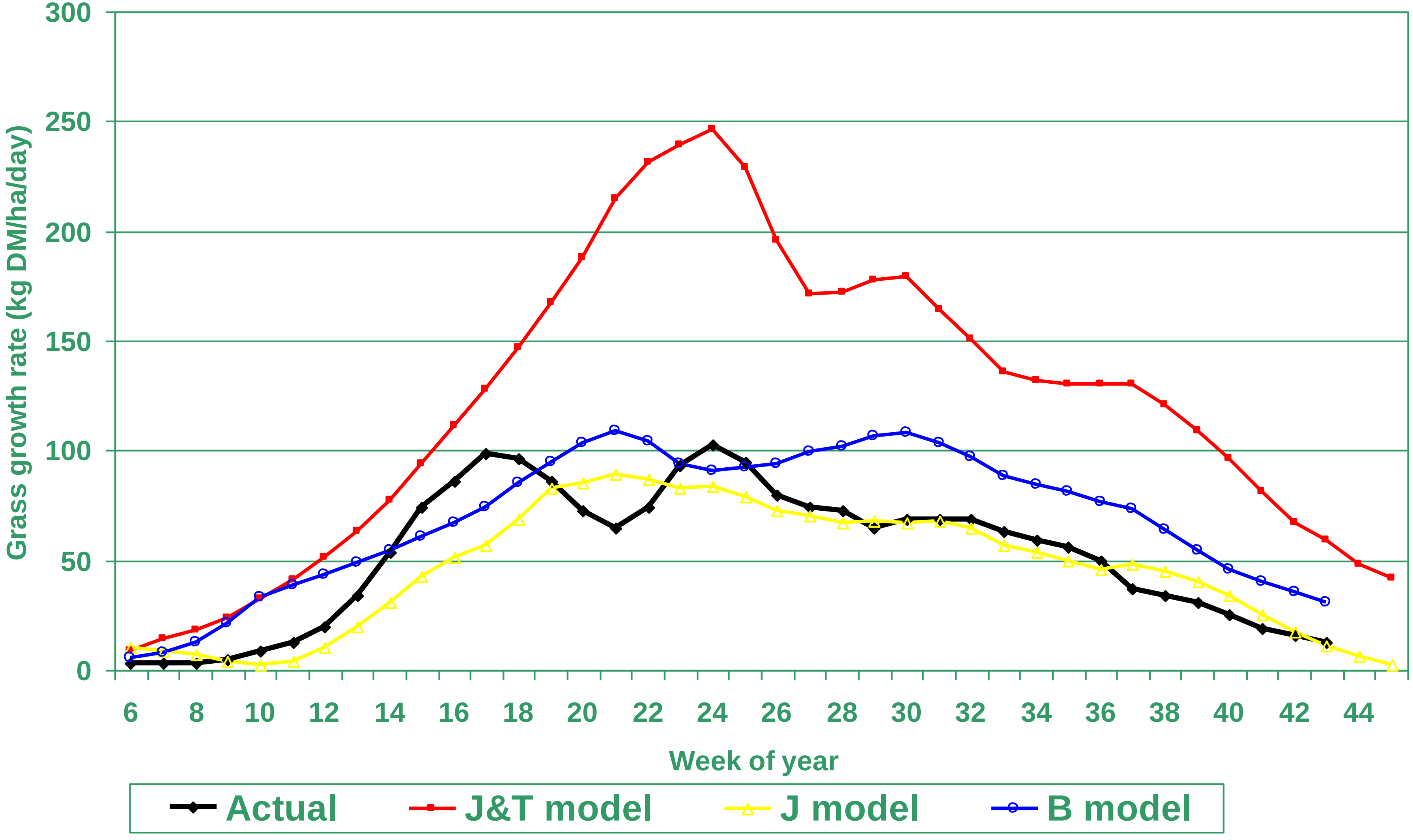
Models predictions for 2007



Models predictions for 2008



Models predictions for 2009



Mean Square Prediction Error (MSPE) and Mean Prediction Error (MPrE)

Average MSPE and MPrE for Spring (weeks 6-18), Summer (weeks 19-32) and Autumn (weeks 33-45)

Period	Model	Mean bias	Line	Random	MSPE	MPrE	R^2
Spring	J&T model	0.827	0.017	0.156	343.0	1.201	0.730
	J model	0.328	0.051	0.621	319.1	1.158	0.000
	B model	0.589	0.034	0.377	174.9	0.857	0.668
Summer	J&T model	0.876	0.097	0.027	11005.0	1.367	0.014
	J model	0.508	0.153	0.339	735.4	0.353	0.164
	B model	0.014	0.336	0.650	401.2	0.261	0.126
Autumn	J&T model	0.920	0.051	0.029	5461.0	1.847	0.650
	J model	0.423	0.067	0.510	230.4	0.379	0.743
	B model	0.629	0.001	0.370	311.6	0.441	0.747

Mean Percentage Error (MPE)

MPE for each year and average of 5 yrs (2005 - 2009)

	J & T Model	J Model	B Model
2005	207	-22	63
2006	161	-55	18
2007	208	-14	56
2008	145	-33	27
2009	228	9	76
2005-2009	189	-23	48

MPE for Spring (Feb – Apr.), Summer (May – Aug.) and Autumn (Aug. – Nov.) (average of 5 years)

	J & T Model	J Model	B Model
Spring	207	-9	133
Summer	140	-25	7
Autumn	237	-29	49

Root Mean Square Error (RMSE)

RMSE for each year and average of 5 years (2005 – 2009)

	J & T Model	J Model	B Model
2005	79.8	14.4	14.6
2006	78.4	32.2	16.2
2007	89.5	20.3	22.0
2008	78.6	26.6	15.4
2009	100.8	14.6	23.8
2005-2009	85.7	22.8	18.7

RMSE for Spring (Feb – Apr.), Summer (May – Aug.) and Autumn (Aug. – Nov.) (average of 5 years)

	J & T Model	J Model	B Model
Spring	19.45	17.65	13.23
Summer	110.07	29.58	20.74
Autumn	74.89	14.68	18.81

Results

- The J&T model repeatedly over predicted grass growth. This was most apparent from mid April to late summer
- The B model over predicted grass growth during the winter period but it closely followed the observed trend during the remainder of the year
- The J model under predicted mostly for the spring period


Thank you