Calibration and Validation of Rice (*Oryza sativa*) Potential Growth Process in Central Punjab of India by Utilizing WOFOST Model

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Title

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Need of Study

- Crop models are important tools to asses the effect of environmental parameters on crop production potentials and for policy planning in agriculture.
- Use of crop simulation model provides a suitable tool to evaluate crop growth as affected by various management practices and environmental factors and their interactions.

METERIALS AND METHODS

Field Experiments:-

- **Crop: Rice (*Oryza sativa*)**
- **Cultivars: PR 116 and PR 118**
- **Season :**

  Kharif **(May – October 2006, 2007 and 2008)**
- **Station: Research Farm, PAU, Ludhiana**

  (30^{o}54’ N, 75^{o}48’ E, 247m above mean sea level)

WOFOST Model

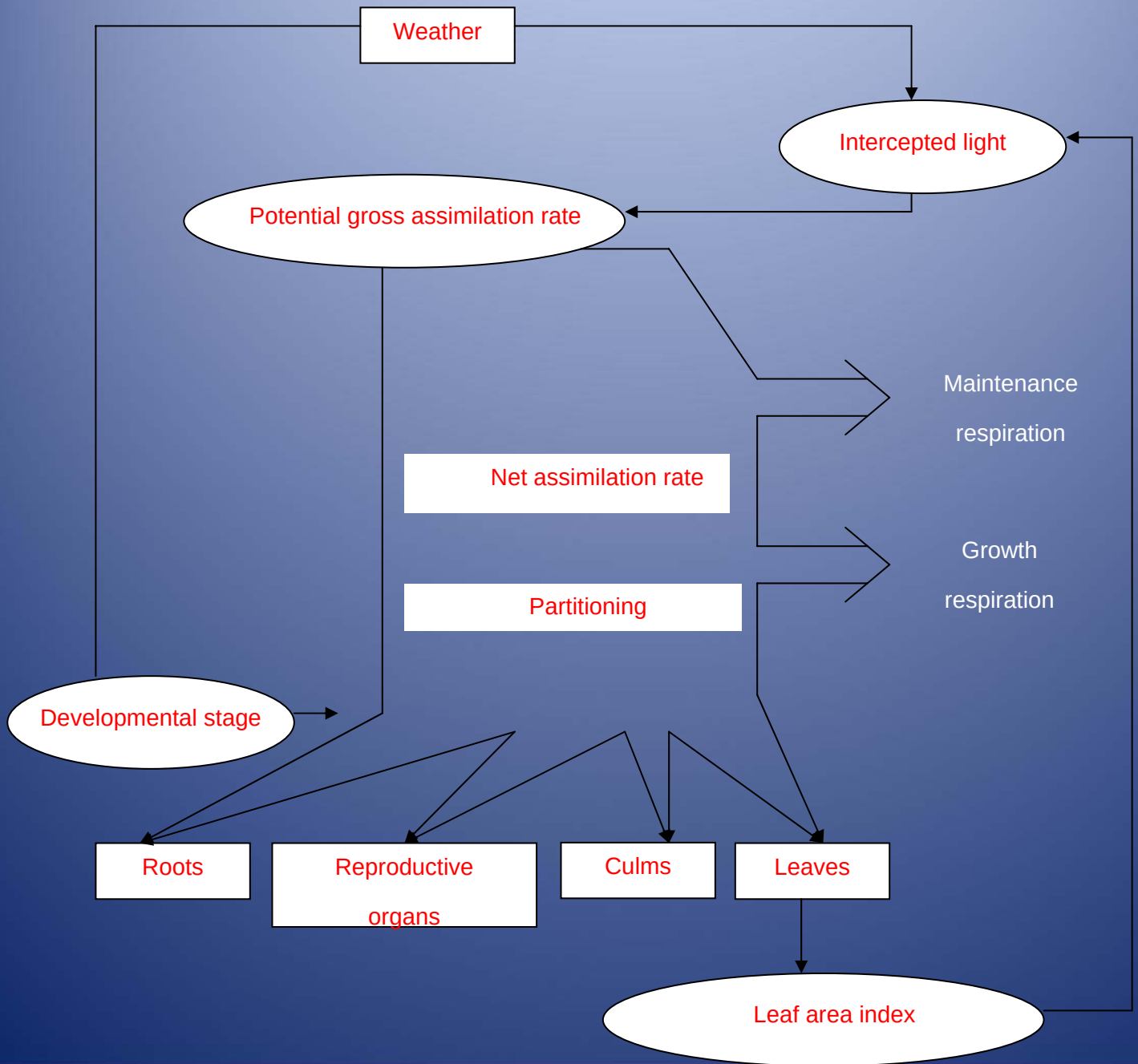
WOFOST (WOrld FOod STudies) is a dynamic, explanatory model. It simulates annual crop growth with time steps of one day. The simulation is based on eco-physiological processes, mainly including phenological development, CO_2-assimilation, transpiration, respiration, partitioning of assimilates to the various organs, and dry matter formation

(Thorsten, 2004)

Development of WOFOST

WOFOST originated in the framework of an interdisciplinary study on the potential world food production by the Centre for World Food Studies (CWFS) in cooperation with the Wageningen Agricultural University, Department of Theoretical Production Ecology (WAU-TPE) and the DLO-Centre for Agrobiological Research (currently Plant Research International), Wageningen, the Netherlands. After cessation of the CWFS in 1988, model development has been carried out at the DLO-Winand Staring Centre (currently Alterra) in cooperation with PRI and WAU-TPE.

Simplified general structure WOFOST model



Model Calibration

Table 1: Physical characteristics of soil

Horizon	Depth (cm)	Bulk Density g cm^{-1}	Field Capacity cm^3 cm^{-3}	Wilting point Cm^3 cm^{-3}	Sand (%)	Silt (%)	Clay (%)	Texture (%)
A_p	0-15	1.44	0.228	0.047	88.0	1.4	10.6	SL
C_1	15-30	1.50	0.257	0.047	76.0	7.9	16.1	SL
C_2	30-60	1.55	0.277	0.063	73.0	8.9	17.3	SL
C_3	60-90	1.60	0.300	0.018	73.2	8.9	17.9	SL
C_4	90-120	1.60	0.300	0.114	73.5	8.8	17.7	SL

Chemical characteristics of soil

Horizon	Depth (cm)	PH	EC Ds m^{-1}	O.C (%)	CEC	Extractable bases		
					Ca	Mg	Na	K
					----------cmol kg^{-1}----------			
A_p	0-15	8.2	0.12	0.15	4.18	3.69	0.37	0.12
C_1	15-30	8.2	0.12	0.18	7.31	6.69	0.23	0.11
C_2	30-60	8.1	0.18	0.10	7.31	7.02	0.21	0.08
C_3	60-90	8.2	0.17	0.02	7.26	6.57	0.26	0.07
C_4	90-120	8.2	0.17	0.02	8.40	8.07	0.26	0.07

Calibrated genetic coefficients selected for cultivar PR 116 and PR 118

S.No	Genetic coefficient*	PR116	PR118
1.	TSUM1	2150	2150
2.	TSUM2	860	840
3.	LAIEM	0.2000	0.2300
4.	RGRLAI	0.0035	0.0039
5.	CVL	0.7300	0.7590
6.	CVO	0.6500	0.7000
7.	CVR	0.7040	0.7040
8.	CVS	0.7000	0.7450
9.	RML	0.0180	0.0180
10.	RMO	0.0140	0.0120
11.	RMR	0.0100	0.0100
12.	RMS	0.0090	0.0090

*TSUM1-temperature sum from emergence to anthesis, TSUM2-temperature sum from anthesis to maturity, LAIEM-leaf area emergence at emergence, RGRLAI-maximum relative increase in LAI, CVL- efficiency of conversion into leaves, CVO- efficiency of conversion into storage org., CVR- efficiency of conversion into roots, CVS- efficiency of conversion into stem, RML-maint. Resp. rate leaves, RMO-maint. Resp. rate storage org., RMR-maint. Resp. rate roots,

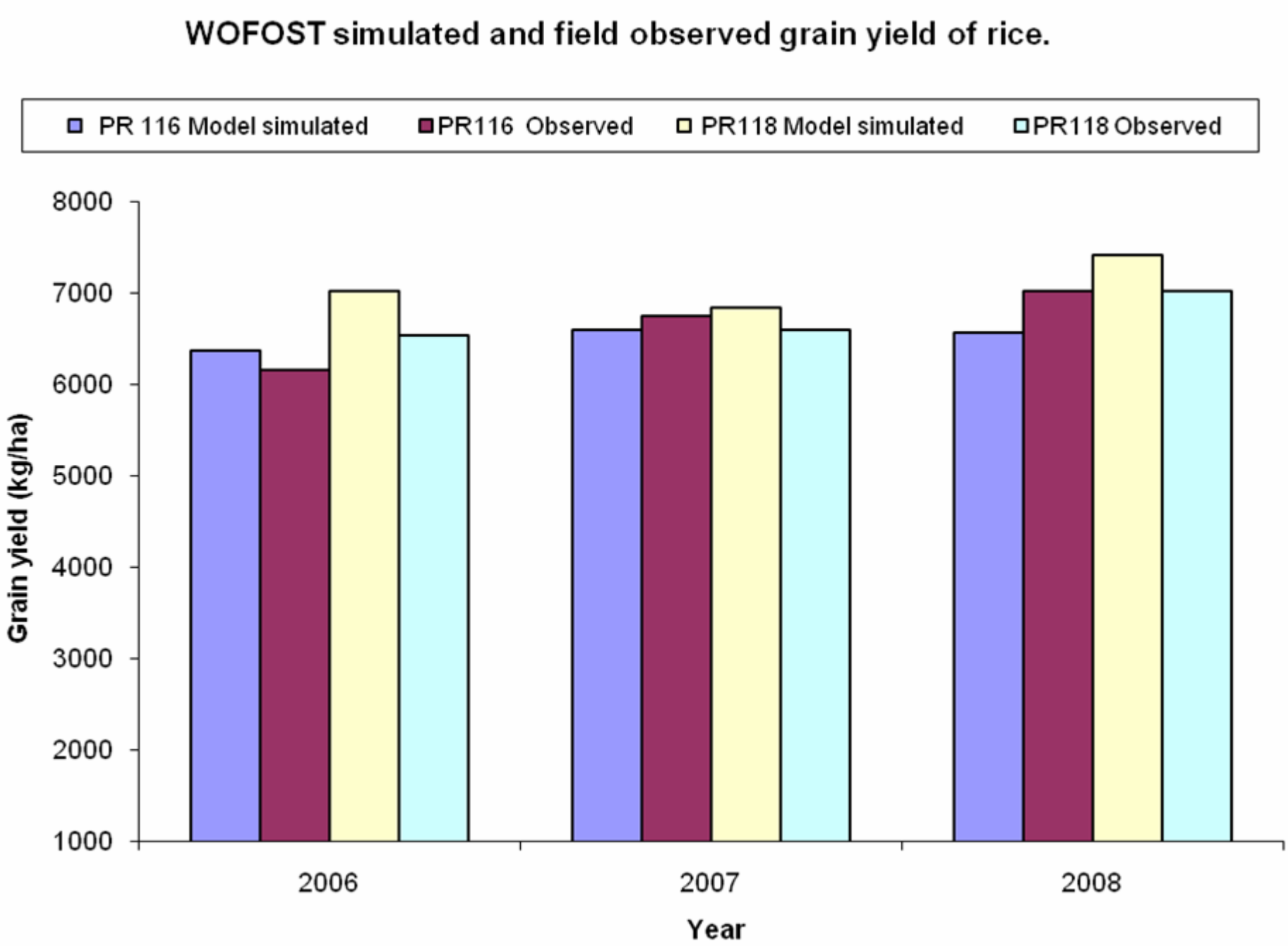
RESULTS AND DISCUSSION

Observed and WOFOST simulated phenology of rice

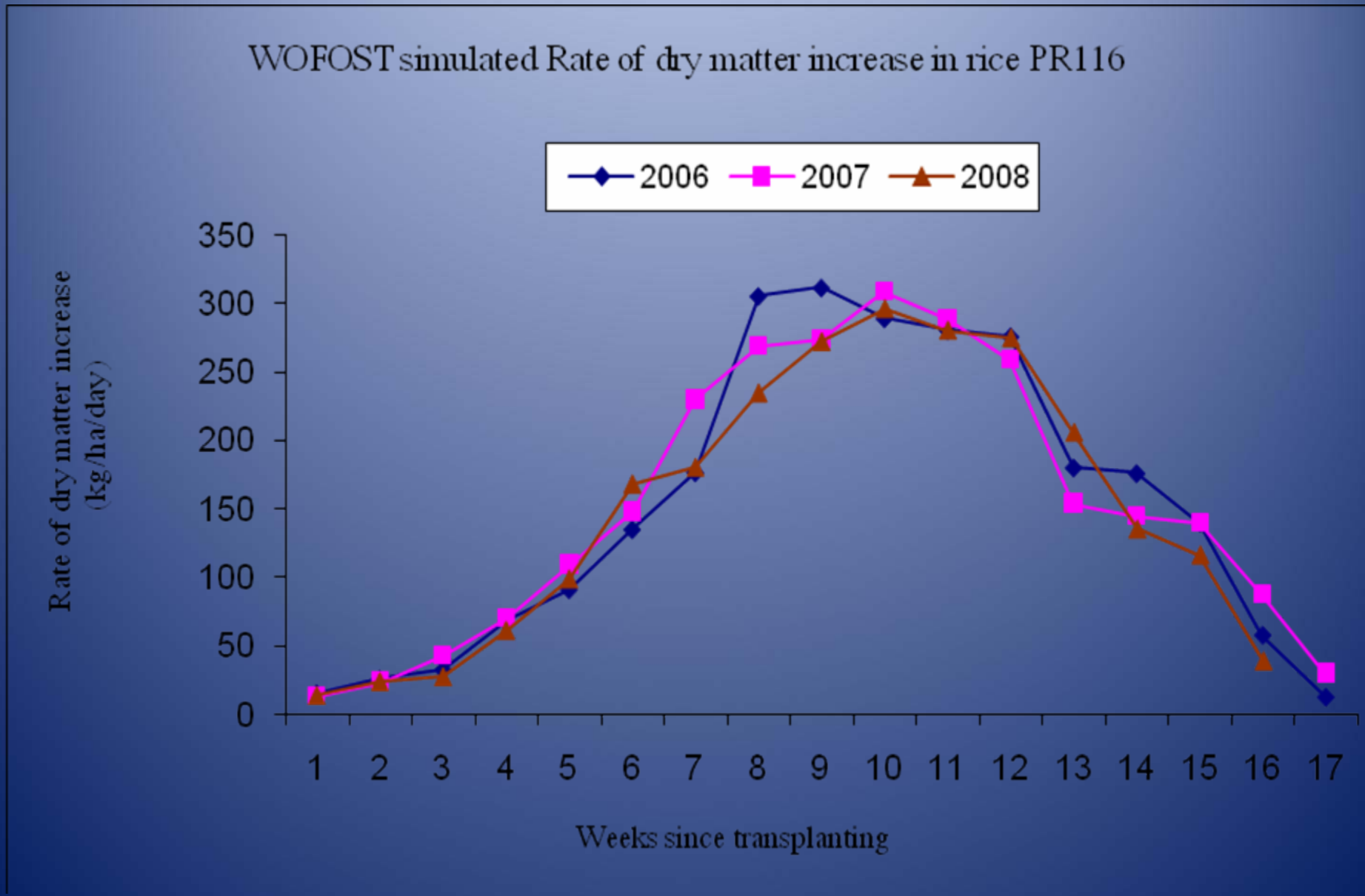
Cultivar	Phenological stage	2006			2007			2008		
		Simulated	Observed	Deviation	Simulated	Observed	Deviation	Simulated	Observed	Deviation
PR 116	Tillering	43	40	+3	39	37	+2	44	41	+3
	Heading	73	78	-5	69	73	-4	72	70	+2
	Anthesis	77	81	-4	75	78	-3	76	78	-2
	P.Maturity	117	118	-1	119	113	+6	115	111	+4
PR 118	Tillering	34	36	-2	35	40	-5	32	38	-6
	Heading	73	70	+3	71	75	-4	71	68	+3
	Anthesis	77	73	+4	75	77	-2	74	73	+1
	P.Maturity	116	119	-3	116	112	+4	113	117	-4

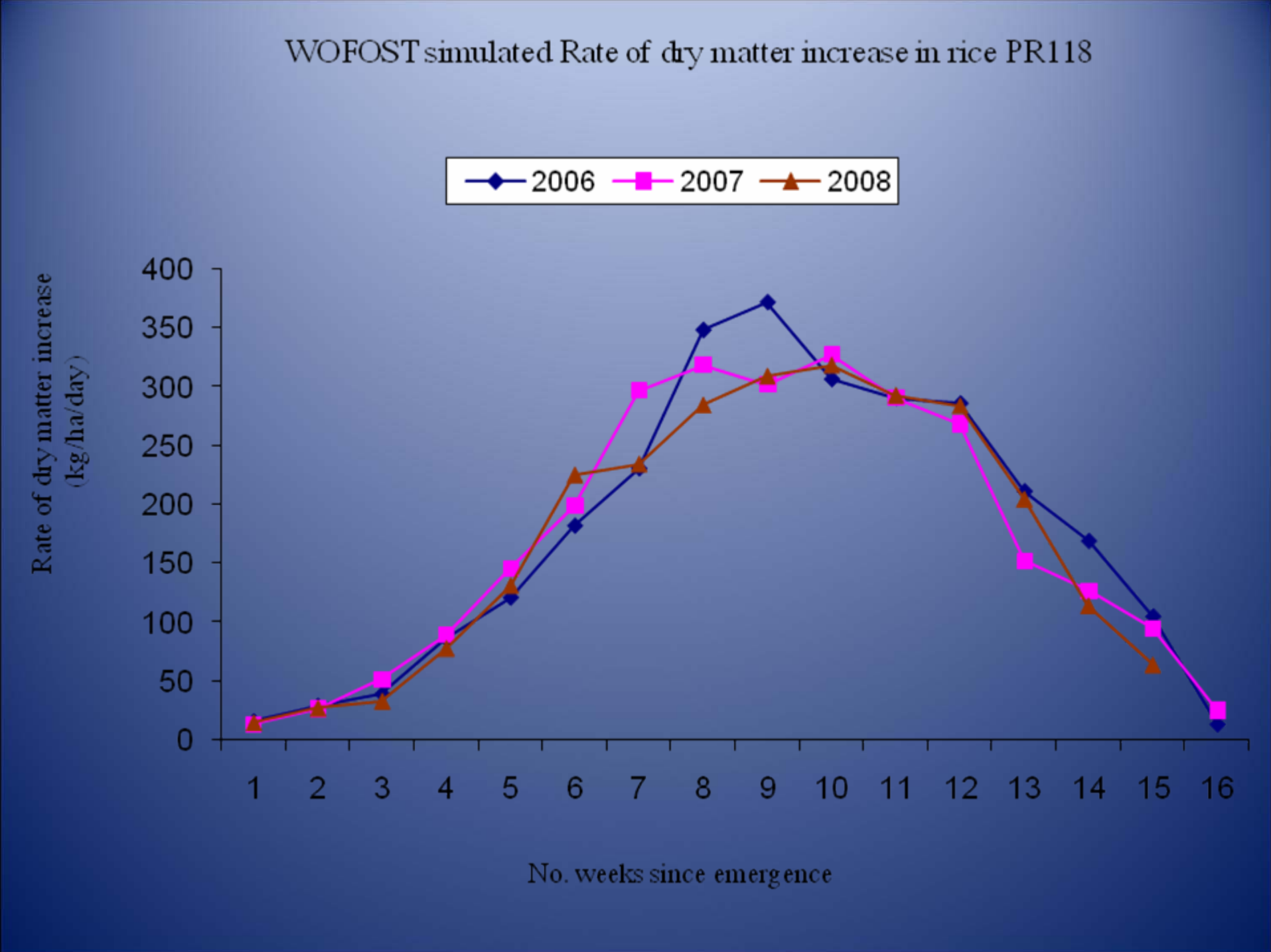
Observed and simulated LAI of rice

Crop growth stages		Year					
		2006		2007		2008	
		Sim.	Obs.	Sim.	Obs.	Sim.	Obs.
Tillering	PR116	1.97	1.53	1.60	1.94	1.91	1.77
	PR118	1.48	1.78	1.66	1.27	1.09	2.68
Heading	PR116	5.48	3.64	5.34	3.71	4.80	3.96
	PR118	6.23	3.77	6.14	4.45	5.42	4.11
Anthesis	PR116	5.53	4.27	5.39	4.92	4.86	5.06
	PR118	6.38	4.89	6.28	5.23	5.44	5.08
P. Maturity	PR116	0.73	2.24	0.24	2.09	0.71	2.21
	PR118	0.33	1.67	0.31	1.98	0.31	2.04
Correlation Coefficient (r^2)	PR116	0.78		0.82		0.80	
	PR118	0.89		0.87		0.91	

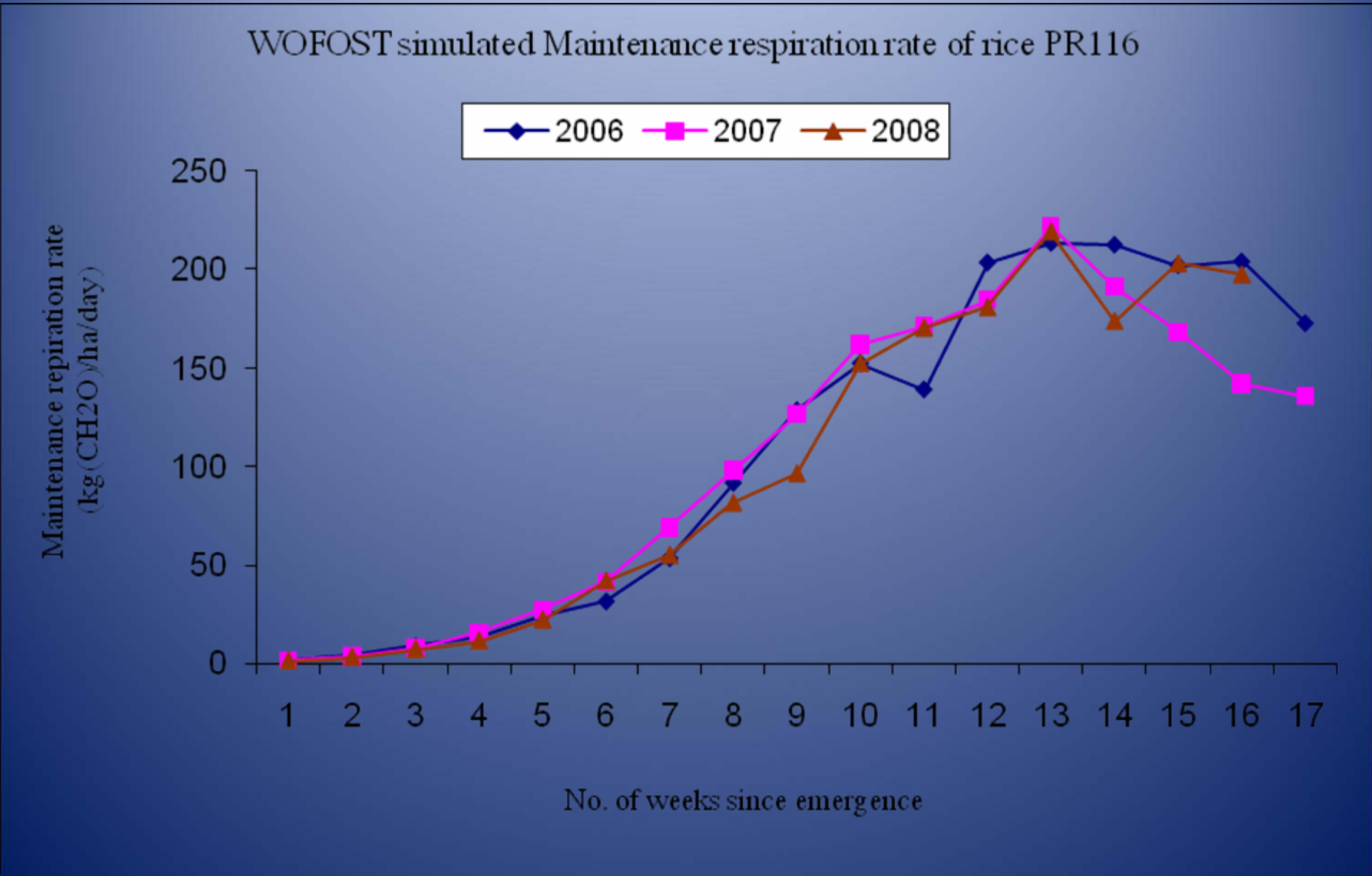

WOFOST simulated and field observed grain yield of rice.
PR 116 Model simulated
PR116 Observed
PR118 Model simulated
PR118 Observed
8000
7000
6000
5000
4000
3000
2000
1000
Grain yield (kg/ha)
2006
2007
2008
Year

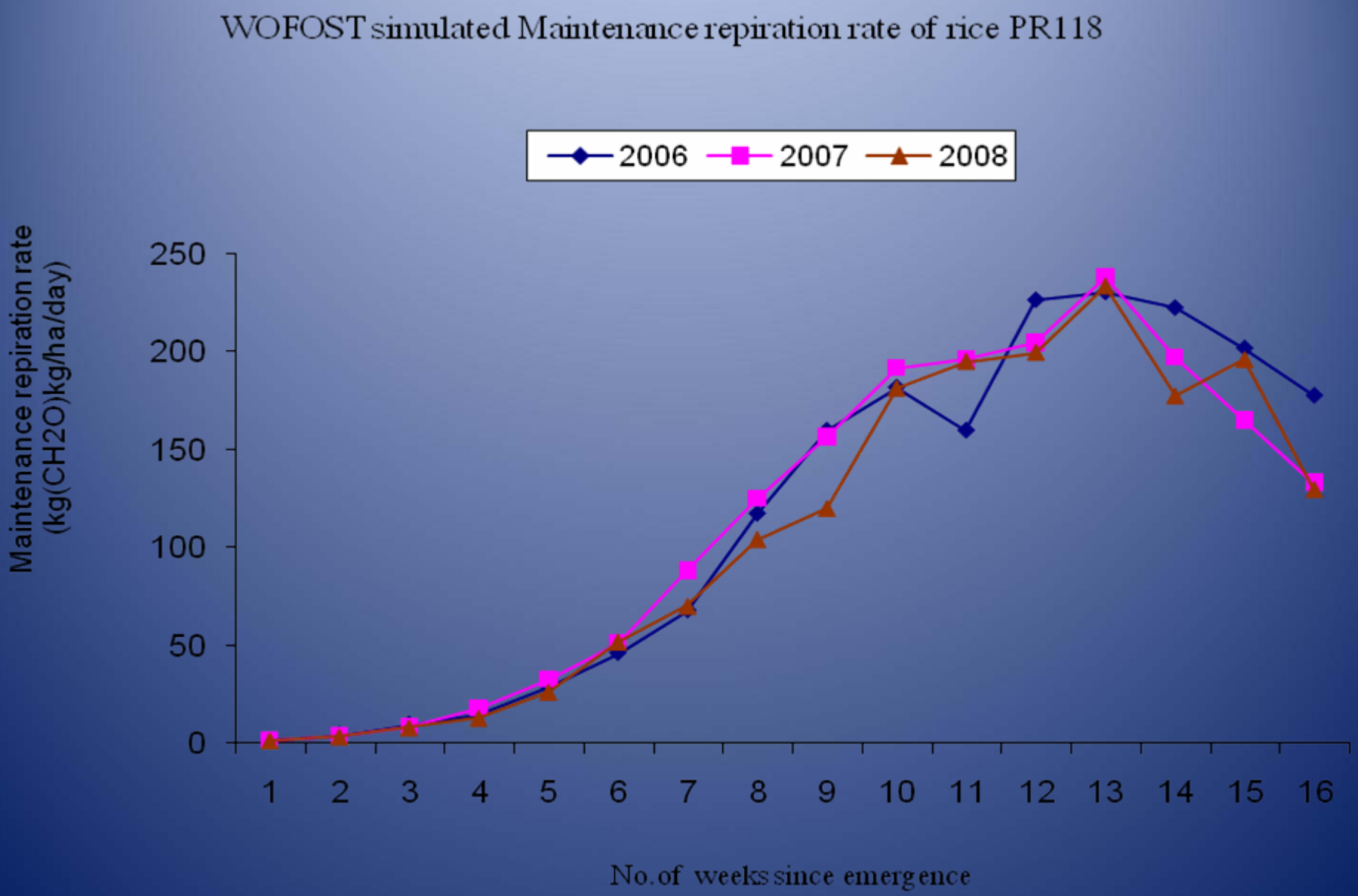
WOFOST simulated rate of dry matter increase for PR 116 and PR118 cultivars



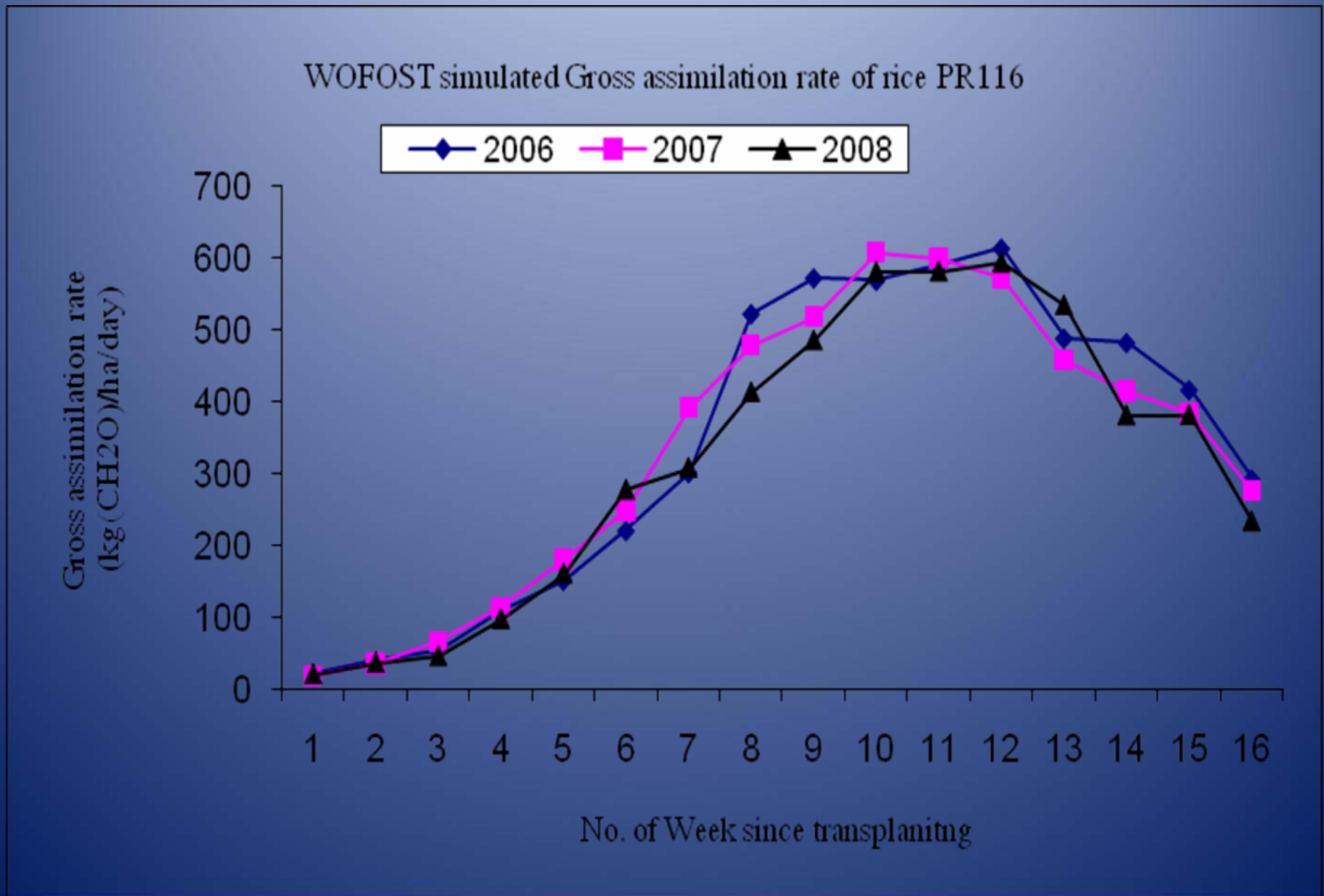

WOFOST simulated Rate of dry matter increase in rice PR118
2006
2007
2008
Rate of dry matter increase (kg/ha/day)
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
No. weeks since emergence

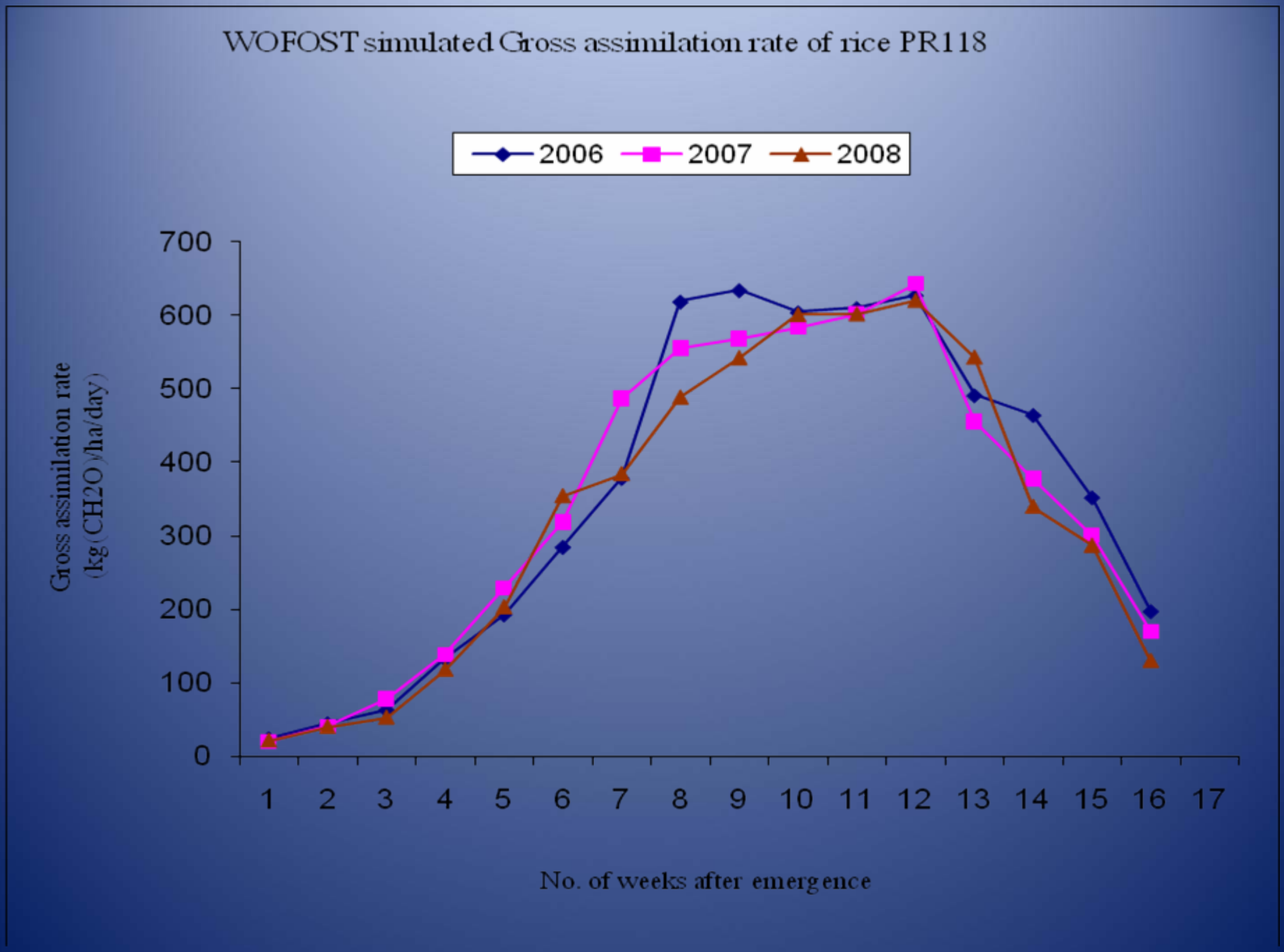
WOFOST simulated Maintenance respiration rate of Rice




WOFOST simulated Maintenance repiration rate of rice PR118
2006
2007
2008
Maintenance repiration rate (kg(CH2O)kg/ha/day)
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
No. of weeks since emergence

WOFOST simulated Gross assimilation rate of Rice




WOFOST simulated Gross assimilation rate of rice PR118
2006
2007
2008
Gross assimilation rate (kg (CH2O)/ha/day)
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
No. of weeks after emergence

Thank You