Use of DSSAT models for climate change impact assessment:

Calibration and validation of CERES-Wheat and CERES-Maize in Spain

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Contribution to:

CGE Hands-on Training Workshop on
V&A Assessment of the Asia and the Pacific Region
Jakarta, 20-24 March 2006-03-21

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1. CERES-Wheat model

1.1. Model description

The CERES-Wheat model (Godwin *et al*., 1990; Ritchie and Otter, 1985) is a simulation model for maize that describes daily phenological development and growth in response to environmental factors (soils, weather and management). Modelled processes include phenological development, i.e. duration of growth stages, growth of vegetative and reproductive plant parts, extension growth of leaves and stems, senescence of leaves, biomass production and partitioning among plant parts, and root system dynamics. The models include subroutines to simulate soil and crop water balance and nitrogen balance, and they have the capability to simulate the effects of nitrogen deficiency and soil water deficit on photosynthesis and pathways of carbohydrate movement in the plant.

Phenology

The primary variable influencing phasic development rate is temperature. The thermal time for each phase is modified by coefficients that characterize the response of different genotypes. The timing of crop phenological stages can be calibrated by modifying the coefficients that characterize vernalization (P1V), photoperiod response (P1D), duration of grain filling (P5) and phillochron interval (PHINT) of a particular variety.

Growth

Potential dry matter production is a linear function of intercepted photosynthetically active radiation (PAR). The percentage of incoming PAR intercepted by the canopy is an exponential function of leaf area index (LAI). The dry matter allocation is determined by partitioning coefficient according to phenological stages and water stress. Final grain yield is the product of plant population, kernels per plant and weight of kernel. The number of kernels per plant is a linear function of stem weight and coefficients that accounts for the variation between genotypes of the number of grains per ear (G1) and spike number (G3). The maximum kernel growth rate is an input coefficient depending on the genotype of wheat (G2).

Water Balance

The model includes a water balance routine where precipitation is an daily input; runoff is a function of soil type, soil moisture and precipitation; infiltration is precipitation minus runoff; drainage occurs when the soil moisture is greater than the soil water holding capacity of the bottom layer. Potential evaporation is calculated by the Priestley-Taylor relation; total evaporation is a function of potential evaporation, LAI and time as described by Ritchie (1972); and transpiration is modified by LAI, soil evaporation and soil water deficit. Daily soil moisture is calculated as precipitation minus evaporation minus runoff minus drainage.

Input data

The model requires daily weather values of solar radiation, maximum and minimum temperatures and precipitation. Soil information needed includes drainage, runoff, evaporation and radiation reflection coefficients, soil water holding capacity amounts, and rooting preference coefficients foe each soil layer and initial soil water content.

1.2. Calibration and validation sites

The field data are from the Agricultural Experimental Station of Tomejil (+37.40^{o}N; -5.80^{o}W); this Station is part of the Red Andaluza de Experimentacion Agraria (RAEA). It is located in the province of Sevilla at 30 Km from Sevilla (capital). The site represents one of the main agricultural regions of Spain (Valle del Guadalquivir). Wheat is the a main crop in the region (accounts for about 40% of the national wheat production). The cultivars grown are winter wheat that require little vernalization, sown in the late winter and non-irrigated.

The experiments are dryland and nitrogen fertilized. Potential production was estimated based on the largest reported production in the area when the water balance for the wheat growing season showed no stress for the crop (RAEA, 1989, 1991).

The calibration is based on the 1988-89 field experiments (RAEA, 1989) and the validation on the 1990-91 field experiments (RAEA, 1991).

The data for the calibration correspond to field experiments performed during 1987-88 and include: daily weather data (maximum and minimum temperatures, precipitation and solar radiation); soil data; and crop and management data (dates of the main phenological stages, final yield, and fertilizer applications).

The model was validated with an independent experimental data set in Tomejil (1990-1991) and in Las Tiesas (1990-1991).

1.3. Field experiments

The calibration os the CERES-Wheat model in Tomejil is based on field data from 1988-1989 (RAEA, 1989); the validation in Tomejil is based on field data from 1990-1991 (RAEA, 1991) and the validation in Las Tiesas (Albacete) is based on field data from 1990-1991 (ITAP, 1991). All experiments were nitrogen fertilized to cover completely crop needs. In Tomejil the experiments are dryland (water-limited production) and in Las Tiesas are dryland and irrigated (water-limited and potential production). Potential production in the southern site (Tomejil) was estimated based on the largest reported production in the area when the water balance for the wheat growing season showed no stress for the crop (RAEA, 1989, 1991).

Table 1. Field data. Sevilla. 1988-89. Sowing date 7 December 1988 (day 341). Sowing rate 360 seeds m^2. Emergence 24 December 1988 (day 358). Dryland. Nitrogen fertilized.

	Wheat CULTIVARS (*)											
OBSERVED DATA	1	2	3	4	5	6	7	8	9	10	11	12
Plants m^{-2}	380	335	320	425	270	360	310	330	425	335	290	295
Tillering (day)	25	25	25	25	25	25	25	25	25	25	25	25
Stem elongation (day)	69	73	69	69	73	75	73	73	69	73	69	73
End spike growth (day)	103	100	98	99	100	109	103	99	98	100	93	99
Anthesis (day)	108	108	105	105	107	110	107	105	105	108	100	105
Spikes m^{-2}	547	557	672	557	485	697	602	640	662	575	570	602
Physiological maturity (day)	147	147	143	143	147	147	147	147	148	149	143	148
kg ha^{-1}	5948	5891	6877	6001	5790	4428	5946	6821	6227	6032	6321	6444
	Wheat CULTIVARS (*)											
OBSERVED DATA	13	14	15	16	17	18	19	20	21	22	23	24
Plants m^{-2}	280	175	220	475	325	265	360	480	305	325	390	295
Tillering (day)	25	25	25	25	25	25	25	25	25	25	25	25
Stem elongation (day)	69	69	69	69	69	73	69	69	73	73	73	73
End spike growth (day)	97	97	95	103	95	97	95	95	97	93	93	97
Anthesis (day)	106	106	101	110	101	103	101	101	103	100	100	106
Spikes m^{-2}	475	417	517	615	432	507	545	542	452	702	502	555
Physiological maturity (day)	144	144	145	149	145	146	145	145	147	142	142	144
kg ha^{-1}	6179	6450	6960	6616	6071	6071	6548	6488	6430	6699	5450	5512

(*) Wheat CULTIVARS: ADALID (1), ADONAY (2), ABANTO (3), ALBARES (4), ALCALA (5), ALDEANO (6), ANZA (7), ARGANDA (8), BETRES (9), CARDENO (10), CAJEME (11), CARTAYA (12), JABATO (13), LACHIS (14), MEXA (15), NIVELO (16), PESUDO (17), ROQUEÑO (18), TAURO (19), TRIANA (20), VITRON (21), YECORA (22), RINCONADA (23), CIBELES (24).

Table 2. Field data. Sevilla. 1990-91. Sowing date 29 November 1990 (day 333). Sowing rate 450 seeds m^{-2}. Emergence 14 December 1990 (day 348). Dryland. Nitrogen fertilized.

	Wheat CULTIVARS (*)											
OBSERVED DATA	1	2	3	4	5	6	7	8	9	10	11	12
Plants m^{-2}	395	446	424	419	376	355	348	424	389	435	380	420
Tillering (day)	11	11	10	8	8	7	9	10	12	14	11	9
Stem elongation (day)	46	46	46	45	46	41	41	46	46	46	46	44
End spike growth (day)	101	101	101	98	102	98	103	103	101	98	100	103
Anthesis (day)	107	107	107	100	106	99	109	108	107	100	107	108
Spikes m^{-2}	328	452	460	512	372	504	324	531	408	496	380	560
Physiological Maturity (day)	148	148	148	141	147	146	150	149	148	141	148	149
kg ha^{-1}	5517	5453	4991	5552	6806	5743	4614	6013	5867	5631	6664	6079

	Wheat CULTIVARS (*)												
OBSERVED DATA	13	14	15	16	17	18	19	20	21	22	23	24	25
Plants m^{-2}	355	383	350	395	405	393	445	400	397	364	353	353	353
Tillering (day)	10	11	8	8	10	8	8	8	9	8	8	8	8
Stem elongation (day)	46	46	44	44	46	45	45	45	46	44	44	44	44
End spike growth (day)	98	98	95	99	100	93	88	89	93	95	99	99	99
Anthesis (day)	105	105	103	105	107	99	95	95	99	101	108	108	108
Spikes m^{-2}	248	400	288	368	316	372	344	508	440	400	456	320	320
Physiological Maturity (day)	146	146	144	146	148	140	136	136	140	142	149	149	149
kg ha^{-1}	5581	5392	5591	6312	5279	5592	5309	4597	5992	6497	6034	5402	5122

(*) Wheat CULTIVARS: ABANTO (1), ADONAIS (2), ALCALA (3), ALDURA (4), AMPUERO (5), ANGRE (6), ANTON (7), ANZA (8), BETRES (9), CAJEME (10), CARTAYA (11), DARTAGNAN (BRIO) (12), DURADERO (13), GRANIZO (14), JABATO (15), MEXA (16), OSONA (17), PESUDO (18), RINCONADA (19), SEVILLANO (20), TAURO (21), TRIANA (22), VALIRA (23), VITRON (24), YECORA (25).

Table 3. Wheat field tests in Tomejil (Sevilla) (1988-89; 1990-91). Dryland; Nitrogen fertilized. Average values and standard deviations.

Observed data	1988-89	1990-91
Sowing (day)	341±0	333±0
Seeds m^{-2}	360±0	450±0
Emergence (day)	358±0	348±0
Plants m^{-2}	332±73	390±31
Tillering (day)	25±0	9±2
Stem elongation (day)	71±2	45±1
End Spike growth (day)	98±4	98±4
Anthesis (day)	105±3	104±4
Spikes m^{-2}	559±79	402±80
Physiological maturity (day)	146±2	145±4
Grain yield (kg ha^{-1})	6175±547	5665±559
Potential grain yield (kg ha^{-1})		

Table 4. Field data from a wheat irrigation experiment in Las Tiesas (Albacete) (1990-1991). Nitrogen fertilized (no nitrogen stress). Wheat variety: BETRES.

Observed data	Irrigation	Rainfed
Sowing (day)	349	349
Seeds m^{-2}	500	400
Plants m^{-2}	350	210
End spike growth (day)	136	136
Physiological maturity (day)	181	181
Grain yield (kg ha^{-1})	7165	1842

1.4. Weather

Single year files, with the extension ". w**" (** indicates the last two digits of the year, i.e. 88 for 1988).

The following is an example of the weather file "tome00112.w88" for Tomejil (1988):

```
TOME  37.40  -5.80 12.07   .00
TOME 88   1  4.35  16.1   7.8   4.3    .00
TOME 88   2  7.44  15.6  10.0    .5    .00
TOME 88   3  6.10  13.3   5.6    .0    .00
TOME 88   4  9.07  12.8   2.2    .0    .00
TOME 88   5  3.76   9.4   2.8   3.3    .00
TOME 88   6  9.61  11.7   2.2    .0    .00
TOME 88   7  3.80   8.9    .6  18.3    .00
TOME 88   8  3.85   9.4   5.0   5.3    .00
```

First line: four letter code for the station, latitude, longitude, PAR conversion.
First column: four letter code of the station
Second column: last two digits of the year (88 for 1988)
Third column: day of year (1 to 365)
Fourth column: Solar radiation (MJ m^{-2} day^{-1})
Fifth column: maximum temperature (^{o}C)
Sixth column: minimum temperature (^{o}C)
Seventh column: precipitation (mm)
Eighth column: no meaning (.00)

The following table presents monthly means of temperature, precipitation and solar radiation in Tomejil and Las Tiesas during the years of the field experiments.

Table 5. Monthly means of temperature (^{o}C), precipitation (mm) and solar radiation (MJ m^{-2} day^{-1}) in Tomejil (Sevilla) (+37.40^{o}N; -5.80^{o}W) (1987-91) and Las Tiesas (+38.95^{o}N;-1.85^{o}W) (1990-1991).

Site/Year	Month	Temp °C	Precip mm	Solar Rad MJ m^{-2} day
Tomejil/1987	1	8.6	126.9	8.4
	2	10.8	92.1	11.0
	3	14.5	11.7	16.2
	4	16.8	65.0	19.8
	5	19.7	4.7	25.6
	6	24.3	0.3	28.9
	7	26.4	45.8	27.0
	8	26.7	31.3	22.1
	9	26.1	9.0	19.1
	10	17.4	107.2	10.9
	11	12.5	86.9	9.6
	12	12.4	238.7	6.7
Tomejil/1988	1	8.8	47.9	8.3
	2	9.8	101.8	8.6
	3	12.8	39.4	16.4
	4	12.2	48.4	18.4
	5	21.3	14.5	23.8
	6	23.8	17.5	26.9
	7	27.4	1.0	26.1

	8	26.3	0.0	25.2
	9	25.4	0.0	17.0
	10	18.9	132.0	13.4
	11	14.5	118.0	10.4
	12	9.3	0.0	6.8
Tomejil/1989	1	9.0	33.0	10.3
	2	11.4	64.0	12.0
	3	13.7	19.0	13.4
	4	13.7	55.0	16.0
	5	19.4	18.0	23.0
	6	24.2	0.0	24.7
	7	29.0	0.0	24.9
	8	29.2	0.0	21.9
	9	24.7	20.3	17.9
	10	19.5	43.2	12.8
	11	13.4	49.5	10.9
	12	8.7	31.8	8.3
Tomejil/1990	1	8.8	47.9	9.0
	2	9.5	93.7	11.2
	3	12.7	47.5	15.0
	4	12.1	48.4	18.0
	5	21.2	14.5	21.8
	6	23.7	17.5	23.9
	7	27.3	1.0	24.7
	8	26.5	0.0	22.3
	9	24.7	20.3	17.6
	10	19.5	90.4	13.4
	11	12.9	71.5	9.8
	12	9.3	15.3	7.7
Tomejil/1991	1	8.1	12.8	8.8
	2	7.6	113.5	11.4
	3	13.4	99.5	15.4
	4	14.1	40.5	19.0
	5	17.8	21.0	22.1
	6	23.6	17.0	25.0
	7	27.0	0.0	26.0
	8	28.8	0.0	22.8
	9	24.7	20.3	18.3
	10	19.5	43.2	13.8
	11	13.4	49.5	10.4
	12	8.7	31.8	8.3
LasTiesas/1990	1	4.0	30.3	8.1
	2	9.0	58.0	10.8
	3	8.8	31.4	12.8
	4	9.2	67.2	15.2
	5	14.1	51.6	17.8
	6	20.3	16.2	23.5
	7	22.5	31.4	22.6
	8	23.9	1.8	22.2
	9	21.0	55.0	14.0
	10	14.3	36.8	11.8
	11	8.6	17.2	8.4
	12	4.1	11.6	6.0
LasTiesas/1991	1	4.2	8.2	8.6
	2	5.7	16.1	11.4

	3	9.5	51.2	15.2
	4	9.6	94.5	16.6
	5	13.0	30.1	20.4
	6	21.2	71.0	24.2
	7	23.6	48.8	23.4
	8	23.7	18.2	21.6
	9	20.2	29.2	17.0
	10	12.0	30.8	11.8
	11	7.9	62.6	9.0
	12	5.9	13.0	5.9

1.5. Soils

An accurate description of the soil profile is ESSENTIAL in the case of water-limiting simulations. The characteristics of the soil profile are described in the input file "sprofile.wh2", and include: albedo, soil drainage, limits of water content for each layer (lower limit, drained upper limit, field capacity, etc), pH, organic mater, nitrogen content. The following information can be used as a guideline in the elaboration of the soil input file:

Soil surface Albedo (SALB)

Appropriate values for SALB can be obtained from the colour of the soil surface layer as according to the following table.

Table 6. Values of SALB according to soils colour

Colour	SALB
Brown	0.13
Red	0.14
Black	0.09
Grey	0.13
Yellow	0.17

When colour is not known, use a default value of 0.13. If the soil is sandy, slightly higher values may be used (up to 0.17). If there is substantial organic matter present, lower values to 0.10 should be used.

First Stage Evaporation Coefficient (U)

Generally in the range 5 to 12 mm/day. Values are determined from texture of the surface horizon. Typical values are presented in the following table.

Table 7. Values of first stage evaporation coefficient of the soil according to soil texture

Texture	Value
Coarse textured (sandy)	5 - 8
Medium Textured (loams)	8 - 11
Medium to Heavy Textured soils (30 to 50% clay)	10 - 12

Whole Profile Drainage Rate Coefficient (SWCON)

This is a zero to unity number which reflects the rate of drainage from the layer in the profile which most impedes drainage. Suitable values can be obtained from drainage class information used in soil classification is presented in the following table.

Table 8. Values of SWCON according to soil drainage class

Drainage Class	SWCON
Excessively	0.8
Somewhat Excessively	0.8
Well	0.6
Moderately Well	0.4
Somewhat poorly	0.2
Poorly	0.05
Very Poorly	0.005

If drainage information is not available, a value of 0.5 could be used but with caution.

Runoff Curve Number

This coefficient which has a value between 60 and 100 is used in runoff calculations. It is based on the USDA Soil Conservation Service Runoff Curve Number technique for estimating runoff. This technique recognizes four soil groups.

Soil Group: Description

A: Lowest Runoff Potential. Includes deep sands with very little silt and clay, also deep, rapidly permeable loses.

B: Moderately Low Runoff Potential. Mostly sandy soils less deep than A, and losses less deep or less aggregate than A, but the group as a whole has above-average infiltration after thorough wetting.

C: Moderately High Runoff Potential. Comprises shallow soils and soils containing considerable clay and colloids, though less than those of group D. The group has below-average infiltration after pre-saturation.

D: Highest Runoff Potential. Includes mostly clays of high swelling percent but the group also includes some shallow soils with nearly impermeable sub-horizons near the surface.

Slope also affects runoff curve number greatly. Given the above soil groups, SWCON can be estimated using slope information presented in the following table.

Table 9. Definition of soil groups according to runoff potential

Soil Group/ Slope	0 to 5 %	5 to 10 %	> 10%
A	64	68	71
B	76	80	83
C	84	88	91
D	87	91	94

Lower Limit Volumetric Moisture Content of layer L (LL)

This is the lowest limit to which plants can extract water in a soil layer. The units of measure are volume fraction of soil. The range is 0.02 to 0.50. If this is not known, it can be reliably estimated from soil texture information. The INPUTS program will estimate lower limit from sand, silt clay and organic matter. Further description of lower limit can be found in Ritchie (1981).

Drained Upper Limit Moisture Content of Layer L (DUL)

This refers to the volumetric moisture content which occurs after a wetted soil drains. This moisture content defines the upper limit of water availability in the soil. It has values in the range 0.10 to 0.60. If values are not known, they can be estimated from soil texture information (see LL).

Field Saturated Moisture Content (SAT)

This refers to the volumetric moisture content of a soil layer at saturation. Typical values can be estimated from soil texture information (see LL).

Rooting Preference Function (WR)

The root distribution weighing factor (WR) is used to estimate the relative root growth in all soil layers in which roots actually occur. In deep well-drained soils with no chemical or physical barriers to root growth, the following equation can be used to estimate WR for any soil layer:

$$WR(I) = EXP(-4.*Z(I)/200.)$$

where Z(I) is the depth (cm) to the center of the layer I.

In the top soil layer, WR can be set to 1.0. The user should reduce WR(I) to reflect physical or chemical constraints on root growth in certain soil layers. For example, WR(I) could be reduced to half the value estimated from the preceding equation when soil strength or aluminium toxicity produces moderate restrictions in root growth. When these constraints are severe, calculated values of WR(I) can be reduced by 80% to 90%.

Soil pH

Soil pH as measured in a 1:1 soil water slurry. Default value is 7.0.

Nitrogen measurements

The soil nitrogen concentration (nitrate and ammonium) have to be included if the model is run with the nitrogen balance routine. The % of organic carbon is also necessary in this case because its value initialises the soil organic nitrogen pools. In all our field experiments the nitrogen levels were adequate, no nitrogen stress occurred and therefore the nitrogen balance was NOT be simulated.

Initial soil water content

It is essential to specify the initial soil water content in water-limiting simulations. This parameter is imputed in FILE 5. In Tomejil the initial soil water in 6 Dec 1988 and 29 Nov 1990 was equal to field capacity. The water balance routine of the CERES model was run starting two months before sowing to check if this value was correct. In Las Tiesas the initial soil water content in 15 December 1990 was 70% of the field capacity.

Table 10. Description of the soil profile "Tomejil" (order VERTISOL, suborder XERERTS, group CHROMOXERERTS, subgroup ETNIC, series CARMONA; deep clay). See methods for description of the parameters. Values that refer to water content in each layer were calculated from texture data.

TOMEJIL, DEEP CLAY SALB= .11 U= 10.5 SWCON= .40 RUNOFF CURVE NO.= 85					
CM	LL	DUL	SAT	WR	PH
0 - 10	.215	.361	.416	1.000	7.9
10 - 25	.216	.361	.415	.819	7.9
25 - 50	.218	.361	.412	.607	7.7
50 - 80	.221	.361	.412	.407	7.7
80 - 110	.225	.360	.409	.247	7.7
110 - 140	.229	.360	.407	.135	7.7
140 - 170	.231	.360	.407	.000	7.7
170 - 200	.231	.360	.405	.000	7.7

Table 11. Description of the soil profile "Las Tiesas". See methods for description of the parameters. Values that refer to water content in each layer were calculated from texture data.

LAS TIESAS, SHALLOW LOAM-CLAY SALB= .13 U= 8.5 SWCON= .20 RUNOFF CURVE NO.= 84					
CM	LL	DUL	SAT	WR	PH
0 - 10	.215	.361	.416	1.000	7.2
10 - 20	.216	.361	.415	.819	7.2
20 - 30	.218	.361	.414	.607	7.2
30 - 40	.221	.361	.412	.407	7.5
40 - 55	.225	.360	.409	.247	7.5

1.6. Genetic coefficients

There are a number of coefficients that can be adjusted in the CERES-Wheat model. The "genetic coefficients" describe the phenology and grain yield components of a particular variety, they are located in the file "genetics.wh9"; the calibration of these coefficients is described below.

The "phillochron interval" is located in the experimental input file with the extension ".wh8". The phillochron interval (in degree days) is used to determine the rate at which leaves appear. It will also affect the time between terminal spikelet and anthesis. It can vary between 75 and 110 degree days. If experimental data are available they should be used. In other cases a typical value of 95 should be used as general value for most varieties and areas. A value of 75 should be used for spring sown wheat in upper latitudes when the mean daily temperature is below 5^{o}C at the time of germination and emergence.

A number of coefficients are fixed internally in the CERES-Wheat model (i.e. P2O optimal photoperiod for development = 20 hours) that are in general standard for all wheat varieties.

There are six coefficients that need to be adjusted to calibrate the model for each wheat variety in a particular climatic area. These coefficients are scalar values that are converted into physiological meaning values within the model.

P1V - Vernalization Coefficient

"Relative amount that development is slowed for each day of unfulfilled vernalization, assuming that 50 days of vernalization is sufficient for all cultivars".

This coefficient reflects the differing vernalization requirements of varieties. The input value is a 0 to 9 scalar which is used internally within the model to compute the required number of vernalizing days. The following table can be used as a guide.

Table 12. Values of PV1 and genetic material

P1V	GENETIC MATERIAL
1	No vernalization requirement. True spring wheats (eg. Mexipak,Anza)
3	Intermediate types
4	Many winter wheats from Western Europe and the great Plains of North America
6	Most winter wheats (eg. Arthur, Maris Huntsman)
7	Some wheats from Northern Europe
8	Very Long duration high vernalization materials

P1D - Photoperiod Coefficient

"Relative amount that development is slowed when plants are grown in a photoperiod 1 hour shorter than the optimum (which is considered 20 hours)." This coefficient is used to describe the sensitivity of varieties to photoperiod. It is input as a scalar value between 1 and 5 which is used internally within the model to scale the rate at which development to terminal spikelet occurs. Use 1 for an insensitive variety and 5 for a highly sensitive variety.

P5 - Grain filling duration coefficient

"Relative amount of degree days above a base of 1^{o}C that are needed from 20 after anthesis to maturity". This is a 1 to 5 scalar which is used internally within the model to alter the duration from anthesis to physiological maturity.

G1 - Kernel number coefficient

A scalar value of 1 to 5 that indicates the relative kernel number per unit weight of stem (less leaf blades and sheaths) plus spike at anthesis (kernel number g^{-1}).

G2 - Kernel weight coefficient

A scalar value from 1 to 5 that indicates the relative kernel filling rate under optimum conditions (mg day^{-1}).

G3 - Spike number coefficient

A scalar value from 1 to 5 that indicates the relative amounts of non-stressed dry weight of a single stem (less leaf blades and sheaths) and spike when elongation ceases (g).

1.7. Calibration in Tomejil, Sevilla (Spain) 1988-89

For the calibration we selected the variety ANZA because it represents the medium cycle wheat varieties grown in the area and it is generally included in all wheat tests performed in Spain, therefore there are many experimental data related to it in other regions.

First we calibrated the coefficients related to phenology and then the coefficients related to the grain filling characteristics.

Phenology: P1V, P1D and P5

We analyzed the sensitivity of the crop biological responses to changes in the coefficients that relate to phenology.

The simulated dates of the phenological stages, and therefore the number of days available for accumulation of grain dry matter, are most sensitive to the photoperiod coefficient (P1D). The sensitivity of the predicted phenology to changes in the vernalization coefficient (P1V), greatly depends on the value of the photoperiod coefficient (P1D). For a particular combination of P1D and P5, the physiological maturity is more sensitive to increases in P1V than the anthesis date. It is important to notice that for certain values of P1D there is an apparent threshold of P1V.

The grain filling duration coefficient (P5) does not have any effect on the flowering date, but for values of P5 above 1.5 there is an increase in the number of days between emergence and physiological maturity. Increases in P5 increase the grain filling period.

The coefficients P1V, P1D and P5 were calibrated so the observed and simulated phenological dates were as close as possible:

P1V = 3.5
P1D = 2.8
P5 = 4.0

The following table compares observed and simulated phenological dates with this combination of coefficients.

Table 13. Dates of emergence, flowering and physiological maturity observed and simulated for ANZA wheat in Tomejil (1988-1989). 1 = 1 January. Sowing date 7 December = Day 341).

1988-89	Observed	Simulated
Emergence date	358	357
End of spike growth date	103	102
Anthesis date	107	107
Phys. Maturity date	147	145
Anthesis to maturity (days)	40	38

Yield components: G1, G2 and G3

Once the phenology coefficients were calibrated, and therefore the simulated number of days available for grain filling, we adjusted the yield component coefficients to represent as accurately as possible the number of spikes m^{-2}, the weight $spike^{-1}$ (from kernel only) and the final grain yield (kg ha^{-1}). The following table shows some of the combinations tested for the adjustment of these coefficients.

Table 14. Sensitivity of the final yield and number of spikes to changes in G1, G2 and G3. Water-limited production. Tomejil 1988-89, sowing 7 December 1988 (day 341), 310 plants m^{-2}, nitrogen non-limiting. Observed data: kg ha^{-1} = 5964; spikes m^{-2}= 550. P1V=3.5; P1D=2.8; P5=4.0.

G1	G2	G3	kg ha^{-1}	spikes m^{-2}
2.9	3.0	1.7	5499	705
3.5	2.7	4.4	5230	333
3.9	2.8	2.3	5595	550
4.5	1.5	2.5	5372	514
4.0	3.0	2.0	5669	616
4.1	3.2	2.3	5700	550
4.2	3.5	2.5	5600	514
4.1	3.5	2.3	5769	550
4.1	3.9	2.3	5992	550
4.1	3.9	2.5	5992	514
4.1	4.1	2.3	5816	550
4.1	4.1	2.5	5816	514
4.1	4.5	2.3	5883	550
4.1	3.0	2.3	5522	550
4.0	3.9	2.3	5787	550
4.2	3.9	2.3	5754	550
4.1	3.9	3.0	5903	445
4.1	3.9	3.5	5903	395
4.1	3.9	4.0	5903	357
3.9	3.9	2.3	5671	550
3.8	3.9	2.3	5555	550
3.9	3.9	2.5	5671	514
3.9	3.9	3.0	5671	445
3.9	4.1	3.0	5847	445
3.9	3.0	4.4	5556	333
3.9	3.5	4.0	5542	357

We selected the following values as representative:

G1 = 4.1
G2 = 3.5
G3 = 2.3

The following table shows grain yield and spike number observed and simulated with these coefficients. The full output of the CERES model for this calibrated variety is included in the Annexes.

Table 15. Observed and simulated yield and spike number.

1988-89	Observed	Simulated
Grain yield (kg ha^{-1})	5946	5992
Spike number (spikes m^{-2})	602	550

The following table shows the field data and simulated data for the calibrated wheat in Sevilla. The full output of the CERES model for this calibrated variety is included in the Annexes.

Table 16. Dates of emergence, flowering and physiological maturity, and spike number and final yield observed and simulated for ANZA wheat in Sevilla (1988-1989). 1 = 1 January. Sowing date 7 December = Day 341).

1988-89	Observed	Simulated
Emergence date	358	357
End of spike growth date	103	102
Anthesis date	107	107
Phys. Maturity date	147	145
Anthesis to maturity (days)	40	38
Grain yield (kg ha^{-1})	5946	5992
Spike number (spikes m^{-2})	602	550

Potential production

Since there are not experiments with full irrigation in this region, the potential production in Tomejil was estimated from the maximum production reported in the area under meteorological conditions that did not imply water stress during any part of the crop cycle (RAEA, 1991): 8500 to 9000 kg ha^{-1}.

Simulated phenological and yield responses as result of changes in the genetic coefficients. The coefficients not shown had their previously adjusted value. Water-limited production is much more sensitive to changes in the genetic coefficients than potential production. Therefore we suggest that water-limited production should be included in model calibration.

It is important to notice that none of the possible combinations of G coefficients in the CERES-model resulted in yields of 9000 kg ha^{-1} with the meteorological conditions of Tomejil and in the grain filling period fixed by the observations. It seems that the model may limit grain filling at high temperatures in a way that does not represent the observations in the area.

The full output of the CERES model for potential production is included in the Annexes.

Representative varieties

The coefficients that define a wheat variety in the CERES model only refer to dates of development and accumulation of dry matter; many other variety characteristics are not defined by these coefficients (such as drought resistance, pest and disease resistance, etc). Therefore a particular set of coefficients may be representative of a group of varieties of similar characteristics in a particular geographical area. In particular, the variety BETRES can be defined with the same coefficients than ANZA in the CERES model.

The following table shows the coefficients that define a representative wheat variety of medium cycle used in southern and central Spain (ANZA-type).

Table 17. Set of genetic coefficients for an ANZA-type variety.

P1V	P1D	P5	G1	G2	G3
3.5	2.8	4.0	4.1	3.5	2.3

Summary of calibration

The phenology coefficients P1V, P1D and P5 were calibrated so the observed and simulated phenological dates were as close as possible. In this model, the simulated dates of the phenological stages, and therefore the number of days available for accumulation of grain dry matter, are most sensitive to the photoperiod coefficient (P1D). The sensitivity of the predicted phenology to changes in the vernalization coefficient (P1V), greatly depends on the value of the photoperiod coefficient (P1D). For a particular combination of P1D and P5, the physiological maturity is more sensitive to increases in P1V than the anthesis date. Once the phenology coefficients were calibrated, and therefore the simulated number of days available for grain filling, we adjusted the yield component coefficients to represent as accurately as possible the yield components.

Table 18. Calibration and validation of the CERES-Wheat model in Tomejil, Sevilla.

	SEVILLA			
	CALIBRATION (2) RAEA89 (1988-89)		VALIDATION RAEA91 (1990-91)	
Variable	OBS	SIM	OBS	SIM
Sowing (DOY)	341	341	333	333
Emergence (DOY)	358	357	348	347
Anthesis (DOY)	107	107	108	110
Phys. Mat. (DOY)	147	145	149	150
Anth. to Phys. Mat. (days)	40	38	41	40
Grain Yield (kg ha^{-1}) Water limited	5946	5992	6013	6769
Grain Yield (kg ha^{-1}) Potential	8150	7181	8350	8258
Spikes m^{-2}	542	550		

(1) Calibrated genetic coefficients for Rothamsted: P1V=6.0; P1D=3.2; P5=7.0; G1=4.7; G2=4.2; G3=3.0.
(2) Calibrated genetic coefficients for Sevilla (ANZA VARIETY): P1V=3.5; P1D=2.8; P5=4.0; G1=4.1; G2=3.5; G3=2.3.
(*) POTENTIAL PRODUCTION (NO LIMITATIONS OF WATER OR NITROGEN).

1.8. Validation in Tomejil, Sevilla

The following table shows observed and simulated data from a wheat experiment in Tomejil in 1990-1991. There is a reasonable adjustment between the observed and the simulated data. The full output of the model is included in the Annexes.

Table 19. Dates of emergence, flowering and physiological maturity observed and simulated in Tomejil (1990-1991) for the ANZA variety. 1= 1 January. Sowing 29 November 1990 (day 333).

1990-91	Observed	Simulated
Emergence date	348	347
Anthesis date	108	110
Phys. Maturity date	149	150
Anthesis to maturity (days)	41	40
Grain yield (kg ha^{-1})	6013	6769

1.9. Validation in Las Tiesas, Albacete

The following table shows observed and simulated data from a wheat experiment in Las Tiesas in 1990-1991; this experiment included potential production. The wheat variety used in the experiment was BETRES. In this site, cooler than Tomejil, potential production seems to be more accurately simulated. The full output of the CERES model is included in the Annexes.

Table 20. Observed and simulated physiological maturity date and final grain yield under water-limited and potential conditions in Las Tiesas (1990-1991) for BETRES wheat variety. 1= 1 January. Sowing 15 December 1990 (day 349).

1990-91	Observed	Simulated
Phys. Maturity date	179	179
Potential production (kg ha^{-1})	7165	7449
Water-limited production (kg ha^{-1})	1848	2507

1.10. Other calibrated varieties

Table 21. Summary of orientative genetic coefficients calibrated by Ana Iglesias in different sites.

Genotype	P1V	P1D	P5	G1	G2	G3
Fidel (France)	4.5	3.0	4.5	4.5	1.5	2.5
Fidel *	0.5	3.5	2.5	4.0	3.0	2.0
Arminda (France)	6.0	4.5	4.5	4.6	1.2	1.7
Arminda *	6.0	2.7	2.0	4.3	4.6	1.9
Spring N. Europe*	0.5	3.5	2.5	4.0	3.0	2.0
Winter N. Plains*	6.0	2.5	2.0	4.0	2.0	1.5
Winter S. Plains*	4.0	3.0	2.5	3.0	3.0	2.0
Winter Europa*	6.0	3.5	4.0	4.0	3.0	2.0
Anza*	0.5	3.4	2.0	3.5	2.7	4.4
Sevilla **	3.5	2.8	4.0	4.1	3.5	2.3
Rothamsted **	6.0	3.2	7.0	4.7	4.2	3.0

2. CERES-Maize model

2.1. Introduction

A crop model with an embedded water-balance model (CERES-Maize, Jones and Kiniry, 1986) was calibrated and validated with experimental field data at two sites that represent contrasting agro-climatic conditions in the Mediterranean Region (Albacete in the Central Plateau and Sevilla in the Guadalquivir Valley (Spain)). The low precipitation during the crop growing season in these regions (less than 100 mm), makes irrigation a necessity (Bignon, 1990; Minguez and Iglesias, 1995). Because evapotranspiration (ET) constitutes an important component of the hydrologic balance and therefore its accurate calculation is essential, the calibration also included the adjustment of the ET calculation of the CERES-Maize model.

2.2. Model Description

The CERES-Maize model (Jones and Kiniry, 1986) is a simulation model for maize that describe daily phenological development and growth in response to environmental factors (soils, weather and management). Modelled processes include phenological development, i.e. duration of growth stages, growth of vegetative and reproductive plant parts, extension growth of leaves and stems, senescence of leaves, biomass production and partitioning among plant parts, and root system dynamics. The model includes subroutines to simulate the soil and crop water balance and the nitrogen balance, which include the capability to simulate the effects of nitrogen deficiency and soil water deficit on photosynthesis and carbohydrate distribution in the crop.

Development

The primary variable influencing phasic development rate is temperature. The thermal time for each phase is modified by coefficients that characterize the response of different genotypes. The timing of crop phenological stages can be calibrated by modifying the coefficients that characterize the duration of the juvenile phase (P1), photoperiod sensitivity (P2), and duration of the reproductive phase (P5).

Dry matter production

Potential dry matter production is a linear function of intercepted photosynthetically active radiation (PAR). The percentage of incoming PAR intercepted by the canopy is an exponential function of leaf area index (LAI). The dry matter allocation is determined by partitioning coefficients which depend on phenological stage and degree of water stress. Final grain yield is the product of plant population, kernels per plant and kernel weight. The number of kernels per plant is a linear function of stem weight (at anthesis) and coefficients that accounts for the variation between genotypes in potential kernel number (G2) and kernel growth rate (G3).

Water balance

Precipitation is a daily input; runoff is a function of soil type, soil moisture and precipitation; infiltration is precipitation minus runoff; drainage occurs when soil moisture is greater than the soil water holding capacity of the bottom layer. Potential evapotranspiration is calculated by the Priestley-Taylor relation. Actual transpiration is modified by LAI, soil evaporation and soil water deficit. Actual evaporation is a function of potential evaporation, LAI and time as described by Ritchie (1972). Daily change in soil moisture is calculated as precipitation minus evaporation minus runoff minus drainage.

Carbon dioxide sensitivity

The CERES-Maize model has been modified to simulate changes in photosynthesis and evapotranspiration caused by higher CO_2 levels. These modifications have been based on published experimental results (see Rosenzweig and Iglesias (1994) for a description of the methodology).

Input data

The model requires daily values for solar radiation, maximum and minimum temperature and precipitation. Soil data needed are values for the functions of drainage, runoff, evaporation and radiation reflection, soil water holding capacities and rooting preference coefficients for each soil layer, and initial soil water contents.

2.3. Site and field experimental data

nput data for the calibration and validation process were obtained from published field experiments conducted at the Agricultural Research Stations of Lora del Rio and Montoro (Sevilla, Spain, +37.42^{o}N, -5.88^{o}W, 31m altitude; Aguilar, 1990; Aguilar and Rendon, 1983), and Las Tiesas and Santa Ana (Albacete, Spain, +38.95^{o}N, -1.85^{o}W, 704m altitude, ITAP, 1985-1993). Maize hybrids selected for the calibration represent highly productive simple hybrids grown in the different agricultural regions. Local daily climate data and soil information for the Sevilla site were provided by the Department of Agronomy of the University of Córdoba (Córdoba, Spain) and for the Albacete site by the Instituto Agronomico Tecnico Provincial de Albacete (ITAP, Albacete, Spain). Daily observed crop evapotranspiration data are from to field experiments in Las Tiesas (Albacete, Spain, Martin de Santa Olalla *et al*., 1990). In all field experiments the crop was irrigated and nitrogen-fertilized to cover total crop requirements.

2.4. Calibration of crop phenology, biomass and yield

The model was calibrated and validated with independent field data sets (that included yield components, phenology, and crop ET) for maize hybrids of different crop growth duration. The coefficients that define a maize hybrid in the CERES model only refer to rate of development and accumulation of dry matter; many other hybrid characteristics are not defined by these coefficients (such as drought resistance, pest and disease resistance, etc). Therefore one set of coefficients may be representative of a group of hybrids of similar characteristics grown in a particular geographical area. A set of coefficients were estimated for the most widely used hybrids in Spain and other Mediterranean regions. The table below shows the coefficients that define representative maize hybrids of different crop-cycle duration used in southern Europe.

The coefficients were first calibrated in relation to phenology based on the thermal integrals of the juvenile period and of the reproductive period. Once the phenology coefficients were calibrated, and therefore the simulated number of days available for grain filling, the yield component coefficients were adjusted to represent as accurately as possible the number of grains ear^{-1}, the final grain yield (t ha^{-1}), and the final biomass (t ha^{-1}). In the experiment crop nitrogen and water requirements were fully covered and pests and diseases were controlled. Nevertheless, these experimental yields are not potential yields, and they include some effect of losses by diseases and suboptimal management. Observed and simulated data are compared (see table). Crop responses to changes in planting date and density under non-limiting conditions were also analyzed. The ability of the CERES-Maize model to simulate grain yields for long cycle hybrids (700 and 800) is proven. The table below shows the agreement between simulated and observed crop data from a second set of field experiments used for validation.

2.5. Calibration of the water balance

As stated above, potential evapotranspiration is calculated in the CERES model with the Priestley-Taylor relation (Priestley and Taylor, 1972). Potential transpiration is directly related to potential evapotranspiration by a coefficient (alpha) which value is fixed to 1.1 in the CERES-Maize v2.1 (Jones and Kiniry, 1986). In many areas of the Mediterranean region, maximum temperatures over 35^{o}C occur in the summer months of July and August. When short cycle maize crop is sown after another crop in late June or July, the crop is subject to high temperatures before reaching full ground cover. These conditions imply that the advective and micro-advective (between rows) processes occur increasing crop ET. Such conditions were not represented in the original ET formulation of the CERES-Maize model, and therefore, simulations of crop ET with the original model underestimated field-observed values. When advective conditions prevail the mentioned coefficient should be higher (Shouse *et al*., 1980; Rosenberg *et al*., 1983; Pereira and Villa-Nova, 1992). The coefficent was set at 1.26 when maximum temperatures were below 35^{o}C and 1.45 above 35^{o}C. The result of these changes is a better estimate of total crop ET in Mediterranean conditions.

Table 22. Values of the calibrated genetic coefficients used as input for the CERES-maize model. P1: Juvenile phase coefficient. P2: Photoperiodism coefficient. P5: Grain filling duration coefficient. G2: Kernel number coefficient. G3: Kernel weight coefficient.

Hybrid(1)	Thermal units(2)	Cycle length (3)	P1	P2	P5	G2	G3
200	2000	90-100	200	0.30	600	825	9.0
400	2000-2300	100-110	200	0.76	750	650	9.0
600	2500	120	200	0.70	800	800	8.0
700	2800	130	220	0.52	910	700	7.0
800	3000	150	260	0.50	980	600	8.5

(1) Hybrids used in the calibration and validation are: FURIO (200), DEMAR (400), LUANA (600), AE703 (700), and PRISMA (800).
(2) Accumulated total thermal units during the growing cycle (sum of degree days above 8^{o}C).
(3) Average duration of the growing cycle (days) in Albacete and Sevilla.

Table 23. Calibration: Comparison of phenology and yield data observed and simulated in Lora del Río (1986, sowing day 75) and in Las Tiesas (1993, sowing day 137). Day 1= January 1.

LORA DEL RIO	HYBRID	Observed	Simulated
Flowering date	600	175	169
	700	175	171
	800	179	177
Physiological maturity date	600	223	216
	700	223	224
	800	230	232
Grain filling period (days)	600	48	47
	700	48	53
	800	51	55
Grain yield (t ha^{-1})	600	13.26	14.90
	700	13.43	14.25
	800	15.05	15.74
LAS TIESAS	HYBRID	Observed	Simulated
Flowering date	200	205	201
	400	207	204
Physiological maturity date	200	245	240
	400	255	255
Grain filling period (days)	200	40	39
	400	48	51
Grain yield (t ha^{-1})	200	12.86	12.64
	400	13.38	13.51

Table 24. Validation: Comparison of phenology and yield data observed and simulated in Lora del Río (1987, sowing day 63), Montoro (1981, sowing day 65), Santa Ana (1991, sowing day 151) and Las Tiesas (1991, sowing day 126). Day 1= January 1.

LORA DEL RIO	HYBRID	Observed	Simulated
Flowering date	600	162	156
	700	166	158
	800	170	164
Physiological maturity date	600	210	203
	700	220	212
	800	224	220
Grain filling period (days)	600	48	47
	700	54	54
	800	54	56
Grain yield (t ha-1)	600	15.05	16.21
	700	14.21	14.51
	800	15.63	16.50
MONTORO	HYBRID	Observed	Simulated
Flowering date	700	168	165
	800	169	168
Grain yield (t ha-1)	700	16.36	16.19
	800	16.27	16.76
SANTA ANA	HYBRID	Observed	Simulated
Grain yield (t ha-1)	400	11.54	11.20
	600	13.97	14.84
	700	15.07	15.06
LAS TIESAS	HYBRID	Observed	Simulated
Flowering date	400	217	212
Grain yield (t ha-1)	400	9.94	9.83

Table 25. Soils and crop management variables.

		Wheat			Maize	
Site	Soil	Variety	Sowing		Hybrid	Sowing
Sevilla	sandy loam	ANZA	1 Dec		700-800	15 Mar
Badajoz	sandy loam	ANZA	1 Dec		700-800	30 Mar
Albacete	silty loam	ANZA	1 Dec		700	15 May
Lérida	silty clay	MARIUS	15 Nov		700	15 May
Zamora	sandy loam	MARIUS	1 Nov		500-600	15 May

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Annex 1. Model output for the calibration in Tomejil 1988-1989

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WEATHER : TOMEJIL 1988-89
SOIL    : TOMEJIL
VARIETY : ANZA1

LATITUDE= 37.4, SOWING DEPTH=   6. CM, PLANT POPULATION=310. PLANTS PER SQ METER

GENETIC SPECIFIC CONSTANTS   P1V =3.5  P1D =2.8  P5 =4.0
                             G1 = 4.1   G2 = 3.5  G3 = 2.3


     SOIL PROFILE DATA [ PEDON:                ]
     SOIL ALBEDO=  .11  U=  10.5  SWCON=   .40   RUNOFF CURVE NO.=  85.0


 DEPTH-CM     LO LIM UP LIM  SAT SW EXT SW  IN SW    WR

   0.-  10.     .215    .361   .416   .146   .361  1.000
  10.-  25.     .216    .361   .415   .145   .361   .819
  25.-  50.     .218    .361   .412   .143   .361   .607
  50.-  80.     .221    .361   .412   .140   .361   .407
  80.- 110.     .225    .360   .409   .135   .360   .247
 110.- 140.     .229    .360   .407   .131   .360   .135
 140.- 170.     .231    .360   .407   .129   .360   .000
 170.- 200.     .231    .360   .405   .129   .360   .000


NITROGEN FERTILIZED (NON-LIMITING)


THE PROGRAM STARTED ON JULIAN DATE  311

OUTPUT 1: WATER-LIMITED PRODUCTION


 DATE  CDTT PHENOLOGICAL STAGE        BIOM    LAI NUPTK   N%   CET  RAIN  PESW
 7 DEC    0. SOWING                  g/m^2        kg/ha        ----mm-----   cm
 8 DEC    7. GERMINATION                                         45.  115.   26.
23 DEC   99. EMERGENCE                                            6.    0.   25.
 7 MAR  882. T SPKLT VE DAYS=50.       471.  5.08 228.6  4.85  131.   97.   22.
28 MAR 1171. END VEG BEGIN EAR GROWTH  817.  5.59 241.7  2.97  188.  116.   19.
12 APR 1358. END EAR GR. EARS= 542.   1087.  5.28 239.9  2.22  227.  156.   19.
27 APR 1568. BEGIN GRAIN FILL         1386.  4.61 237.2  1.72  275.  171.   15.
24 MAY 2071. END GRAIN FILL           1609.   .97  72.3   .73  360.  175.    7.
25 MAY 2087. PHYSIOLOGICAL MATURITY   1609.   .00  72.3   .73  361.  176.    7.

YIELD (KG/HA)= 5992. FINAL GPSM= 18558. KERNEL WT.(mg)= 32.3
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ISTAGE	CSD1	CSD2	CNSD1	CNSD2	S T A G E O F G R O W T H
1	.00	.00	.00	.00	EMERGENCE - TERM SPIKLT
2	.00	.00	.00	.00	END VEG - BEG EAR GROWTH
3	.00	.00	.00	.00	BEGIN EAR - END EAR GROWTH
4	.00	.00	.00	.00	END EAR GRTH - BEG GRN FILL
5	.44	.53	.00	.00	LINEAR GRAIN FILL PHASE

* NOTE: In the above table, 0.0 represents minimum stress and 1.0 represents maximum stress for water (CSD) and nitrogen (CNSD), respectively.

	PREDICTED
ANTHESIS DATE	107
MATURITY DATE	145
GRAIN YIELD (KG/HA)	5992.
KERNEL WEIGHT (MG)	32.289
GRAINS PER SQ METRE	18558.
GRAINS PER EAR	34.22
MAX. LAI	5.59
BIOMASS (KG/HA)	16094.
STRAW (KG/HA)	10102.
GRAIN N%	2.66
TOT N UPTAKE (KG N/HA)	232.5
STRAW N UPTAKE	72.3
GRAIN N UPTAKE	160.1

DAY	SDTT	BIO	TPSM	LAI	ROOT	STEM	GRAIN	LEAF	RTD	PTF	L1	L3	L5
OYR		G/M2			|----- WEIGHT IN G -----|				(CM)		|- RLV --|		
364	78.	4.	310.	.07	.007	.000	.000	.014	29.	.65	.1	.0	.0
5	139.	10.	310.	.15	.013	.000	.000	.032	43.	.65	.2	.0	.0
12	208.	23.	310.	.34	.028	.000	.000	.074	58.	.54	.4	.1	.0
19	273.	39.	327.	.59	.076	.000	.000	.126	73.	.36	.9	.4	.0
26	339.	60.	474.	.90	.149	.000	.000	.194	87.	.34	1.6	.9	.0
33	401.	90.	739.	1.32	.239	.000	.000	.290	100.	.48	2.4	1.4	.1
40	467.	145.	1157.	2.04	.316	.000	.000	.467	115.	.56	3.0	1.8	.3
47	552.	227.	1929.	3.01	.394	.000	.000	.733	133.	.65	3.6	2.2	.5
54	639.	314.	2873.	3.92	.477	.000	.000	1.013	152.	.61	4.2	2.5	.6
61	725.	405.	2934.	4.75	.561	.000	.000	1.305	171.	.65	4.8	2.9	.8
68	29.	504.	916.	5.10	.634	.019	.000	1.608	193.	.80	5.3	3.2	1.0
75	128.	621.	772.	4.81	.672	.116	.000	1.886	200.	.80	5.5	3.3	1.0
82	219.	735.	666.	5.21	.708	.255	.000	2.118	200.	.80	5.7	3.4	1.1
89	28.	854.	557.	5.55	.741	.514	.000	2.241	200.	.85	5.8	3.5	1.2
96	109.	978.	534.	5.41	.761	.942	.000	2.214	200.	.85	5.8	3.5	1.2
103	14.	1106.	542.	5.24	.782	1.385	.000	2.183	200.	.90	5.8	3.5	1.2
110	112.	1243.	542.	4.94	.788	1.857	.000	2.153	200.	.90	5.7	3.4	1.2
117	11.	1386.	542.	4.61	.797	2.348	.210	2.124	200.	.90	5.6	3.4	1.2
124	138.	1548.	542.	4.33	.811	2.113	.787	2.092	200.	.86	5.5	3.4	1.2
131	271.	1609.	542.	3.52	.807	1.744	1.384	2.062	200.	.90	5.1	3.3	1.3
138	413.	1609.	542.	2.28	.782	1.265	1.885	2.039	200.	1.00	4.8	3.1	1.2

* UNITS ARE IN MJ/SQUARE METER.

	---------- AVERAGE					--------- PERIOD		SW CONTENT W/DEPTH				TOTAL	
DAY	EP	ET	EO	SR*	MAX	MIN	PREC	SW1	SW2	SW3	SW4	SW5	PESW
OYR	(MM)	(MM)	(MM)		C	C	(MM)						(CM)
317	.0	2.4	2.5	11.	20.9	11.7	98.00	.36	.36	.36	.40	.39	30.8
324	.0	1.4	2.3	11.	22.0	7.9	4.00	.35	.35	.35	.36	.36	28.4
331	.0	1.2	1.9	10.	15.4	7.4	8.00	.35	.35	.35	.36	.36	26.6
338	.0	1.0	1.7	9.	17.0	3.9	5.00	.34	.34	.35	.36	.36	26.3
345	.0	.6	1.5	8.	16.9	1.9	.00	.33	.34	.35	.35	.36	25.9
352	.0	.4	1.2	7.	16.6	-2.0	.00	.33	.33	.34	.35	.36	25.6
359	.0	.4	1.2	6.	17.0	.6	.00	.32	.33	.34	.35	.35	25.4
366	.1	.4	1.3	6.	19.4	3.3	.00	.32	.33	.34	.35	.35	25.1
7	.2	.8	1.6	9.	15.3	.4	15.00	.35	.35	.35	.35	.35	25.9
14	.4	1.5	1.9	10.	15.7	4.1	9.00	.34	.34	.35	.35	.35	25.8
21	.8	1.4	2.0	11.	16.9	1.6	.00	.31	.32	.34	.35	.35	24.8
28	1.0	1.8	2.0	11.	16.0	1.6	9.00	.32	.32	.33	.34	.35	24.5
35	1.4	2.0	2.1	11.	17.0	1.7	.00	.28	.30	.32	.33	.35	23.1
42	1.2	2.1	2.1	12.	15.1	5.3	40.00	.36	.35	.36	.34	.35	25.6
49	1.6	2.3	2.3	12.	22.4	3.4	.00	.32	.32	.33	.34	.34	23.9
56	1.8	2.2	2.2	12.	16.7	7.1	24.00	.36	.35	.35	.33	.34	24.8
63	2.0	2.4	2.4	13.	20.0	5.4	.00	.32	.32	.33	.33	.34	23.1
70	2.4	2.7	2.7	13.	24.9	4.6	.00	.28	.30	.31	.32	.33	21.3
77	2.1	2.4	2.4	13.	19.4	5.1	16.00	.33	.33	.30	.31	.33	21.2
84	2.6	3.0	3.0	14.	25.4	5.1	.00	.28	.29	.28	.29	.32	19.1
91	2.4	2.6	2.6	14.	20.1	5.7	7.00	.30	.27	.27	.28	.31	18.0
98	2.3	2.6	2.6	14.	16.7	5.7	36.00	.37	.37	.28	.27	.31	19.8
105	2.5	2.8	2.8	15.	20.0	6.4	.00	.31	.31	.28	.27	.30	17.8
112	2.9	3.3	3.3	16.	23.4	6.6	2.00	.27	.27	.27	.27	.29	15.8
119	3.1	3.6	3.6	18.	21.9	7.1	13.00	.26	.26	.26	.26	.28	14.5
126	4.7	5.5	5.5	20.	29.7	9.3	.00	.19	.23	.23	.24	.26	10.6
133	2.9	3.4	5.5	22.	27.6	10.4	.00	.16	.21	.22	.23	.24	8.3
140	1.1	1.1	7.2	24.	31.3	12.3	.00	.16	.21	.22	.22	.23	7.5

	TOPS	NFAC	VEG N	GRAIN	NO3	NO3	NO3	NO3	NO3	NH4	NH4	NH4
DAY	N %		UPTK	UPTK	1	2	3	4	5	1	2	3
OYR			- KG N/HA -		|---------------			UG N/G SOIL		---------------		|
317	4.50	1.00	.0	.0	13.2	10.1	6.4	6.0	5.7	5.7	3.5	1.7
324	4.50	1.00	.0	.0	20.6	12.7	6.9	6.1	5.9	4.6	3.2	1.6
331	4.50	1.00	.0	.0	23.7	14.8	7.4	6.5	6.2	3.5	2.6	1.4
338	4.50	1.00	.0	.0	25.6	15.9	7.7	6.7	6.4	2.9	2.2	1.3
345	4.50	1.00	.0	.0	27.7	16.4	7.9	6.9	6.5	2.5	1.9	1.2
352	4.50	1.00	.0	.0	29.3	16.7	8.1	7.1	6.7	2.1	1.7	1.1
359	4.32	1.00	1.2	.0	30.4	16.9	8.3	7.3	6.8	1.9	1.5	1.0
366	5.70	1.00	3.5	.0	30.4	16.8	8.4	7.4	6.9	1.8	1.4	1.0
7	6.31	1.00	8.0	.0	25.2	18.0	8.9	7.5	7.0	1.6	1.3	1.0
14	6.23	1.00	16.9	.0	83.7	17.6	8.9	7.7	7.1	3.7	1.3	1.0
21	6.38	1.00	29.3	.0	80.0	15.5	8.2	7.6	7.1	2.1	1.2	1.0
28	6.56	1.00	42.7	.0	70.3	15.8	7.6	7.3	7.2	1.6	1.2	.9
35	6.38	1.00	64.8	.0	63.2	12.2	6.2	6.4	7.0	1.5	1.1	.9
42	6.15	1.00	101.0	.0	28.8	17.0	6.5	5.8	6.8	1.4	1.1	.9
49	5.91	1.00	146.3	.0	15.3	9.2	4.4	4.8	6.3	1.1	1.0	.9
56	5.67	1.00	189.1	.0	2.2	2.7	2.7	3.5	5.4	.6	.9	.9
63	5.39	1.00	221.9	.0	.7	.7	1.1	1.2	2.8	.6	.9	.9
70	4.71	.93	233.5	.0	.8	.8	1.0	1.1	1.1	.7	.9	1.0
77	3.93	.89	237.7	.0	.8	1.0	.9	1.0	1.0	.7	.9	.9
84	3.35	.88	240.5	.0	.9	.9	1.1	1.0	1.1	.8	.9	.9
91	2.91	.99	241.7	.0	1.0	1.0	1.0	1.1	1.0	.8	.9	.9
98	2.53	1.00	240.5	.0	.9	1.3	1.2	1.2	1.1	.9	.9	.8

105	2.22	1.00	239.3	.0	1.0	1.4	1.3	1.3	1.2	1.0	1.0	.8
112	1.96	1.00	238.1	.0	1.2	1.5	1.4	1.3	1.2	1.1	1.0	.8
119	1.74	1.00	225.5	11.4	1.4	1.8	1.6	1.4	1.2	1.3	1.0	.7
126	1.52	1.00	179.9	55.8	1.7	1.9	1.6	1.4	1.3	1.3	1.0	.7
133	1.32	1.00	138.9	95.6	1.8	2.0	1.7	1.5	1.3	1.3	.9	.7
140	1.07	1.00	91.7	141.5	1.8	2.0	1.7	1.5	1.3	1.3	.9	.7

OUTPUT 2: POTENTIAL PRODUCTION. 1988-1989.

DATE	CDTT	PHENOLOGICAL STAGE	BIOM	LAI	NUPTK	N%	CET	RAIN	PESW
7 DEC	0.	SOWING	g/m^2		kg/ha		----mm-----		cm
8 DEC	7.	GERMINATION					45.	115.	26.
23 DEC	99.	EMERGENCE					6.	0.	25.
7 MAR	882.	T SPKLT VE DAYS=50.	471.	5.08	228.6	4.85	131.	97.	22.
28 MAR	1171.	END VEG BEGIN EAR GROWTH	817.	5.59	241.7	2.97	188.	116.	19.
12 APR	1358.	END EAR GR. EARS= 542.	1087.	5.28	239.4	2.21	227.	228.	25.
27 APR	1568.	BEGIN GRAIN FILL	1386.	4.61	236.7	1.71	275.	243.	21.
24 MAY	2071.	END GRAIN FILL	1745.	.01	71.6	.70	429.	395.	21.
25 MAY	2087.	PHYSIOLOGICAL MATURITY	1745.	.00	71.6	.70	431.	396.	21.

YIELD (KG/HA)= 7181. FINAL GPSM= 18558. KERNEL WT.(mg)= 38.7

ISTAGE	CSD1	CSD2	CNSD1	CNSD2	S T A G E O F G R O W T H
1	.00	.00	.00	.00	EMERGENCE - TERM SPIKLT
2	.00	.00	.00	.00	END VEG - BEG EAR GROWTH
3	.00	.00	.00	.00	BEGIN EAR - END EAR GROWTH
4	.00	.00	.00	.00	END EAR GRTH - BEG GRN FILL
5	.00	.00	.00	.00	LINEAR GRAIN FILL PHASE

* NOTE: In the above table, 0.0 represents minimum stress and 1.0 represents maximum stress for water (CSD) and nitrogen (CNSD), respectively.

	PREDICTED
ANTHESIS DATE	107
MATURITY DATE	145
GRAIN YIELD (KG/HA)	7181.
KERNEL WEIGHT (MG)	38.696
GRAINS PER SQ METRE	18558.
GRAINS PER EAR	34.22
MAX. LAI	5.59
BIOMASS (KG/HA)	17453.
STRAW (KG/HA)	10272.
GRAIN N%	2.23
TOT N UPTAKE (KG N/HA)	231.7
STRAW N UPTAKE	71.6
GRAIN N UPTAKE	160.1

DAY	SDTT	BIO	TPSM	LAI	ROOT	STEM	GRAIN	LEAF	RTD	PTF	L1	L3	L5
OYR		G/M2			|----- WEIGHT IN G -----|				(CM)		|- RLV --|		
364	78.	4.	310.	.07	.007	.000	.000	.014	16.	.65	4.8	3.1	1.2
5	139.	10.	310.	.15	.013	.000	.000	.032	16.	.65	4.8	3.1	1.2
12	208.	23.	310.	.34	.028	.000	.000	.074	16.	.54	4.8	3.1	1.2
19	273.	39.	327.	.59	.076	.000	.000	.126	16.	.36	4.8	3.1	1.2
26	339.	60.	474.	.90	.149	.000	.000	.194	16.	.34	4.8	3.1	1.2
33	401.	90.	739.	1.32	.239	.000	.000	.290	16.	.48	4.8	3.1	1.2
40	467.	145.	1157.	2.04	.316	.000	.000	.467	16.	.56	4.8	3.1	1.2
47	552.	227.	1929.	3.01	.394	.000	.000	.733	16.	.65	4.8	3.1	1.2
54	639.	314.	2873.	3.92	.477	.000	.000	1.013	16.	.61	4.8	3.1	1.2
61	725.	405.	2934.	4.75	.561	.000	.000	1.305	16.	.65	4.8	3.1	1.2
68	29.	504.	916.	5.10	.634	.019	.000	1.608	16.	.80	4.8	3.1	1.2
75	128.	621.	772.	4.81	.672	.116	.000	1.886	16.	.80	4.8	3.1	1.2
82	219.	735.	666.	5.21	.708	.255	.000	2.118	16.	.80	4.8	3.1	1.2
89	28.	854.	557.	5.55	.741	.514	.000	2.241	16.	.85	4.8	3.1	1.2
96	109.	978.	534.	5.41	.761	.942	.000	2.214	16.	.85	4.8	3.1	1.2
103	14.	1106.	542.	5.24	.782	1.385	.000	2.183	16.	.90	4.8	3.1	1.2
110	112.	1243.	542.	4.94	.788	1.857	.000	2.153	16.	.90	4.8	3.1	1.2
117	11.	1386.	542.	4.61	.797	2.348	.210	2.124	16.	.90	4.8	3.1	1.2
124	138.	1548.	542.	4.33	.811	2.113	.787	2.092	16.	.86	4.8	3.1	1.2
131	271.	1631.	542.	3.40	.812	1.814	1.384	2.062	16.	.90	4.8	3.1	1.2
138	413.	1700.	542.	1.75	.799	1.478	1.964	2.042	16.	.95	4.8	3.1	1.2

* UNITS ARE IN MJ/SQUARE METER.

	---------- AVERAGE ---------						PERIOD	SW CONTENT W/DEPTH				TOTAL	
DAY	EP	ET	EO	SR*	MAX	MIN	PREC	SW1	SW2	SW3	SW4	SW5	PESW
OYR	(MM)	(MM)	(MM)		C	C	(MM)						(CM)
317	.0	2.4	2.5	11.	20.9	11.7	98.00	.36	.36	.36	.40	.39	30.8
324	.0	1.4	2.3	11.	22.0	7.9	4.00	.35	.35	.35	.36	.36	28.4
331	.0	1.2	1.9	10.	15.4	7.4	8.00	.35	.35	.35	.36	.36	26.6
338	.0	1.0	1.7	9.	17.0	3.9	5.00	.34	.34	.35	.36	.36	26.3
345	.0	.6	1.5	8.	16.9	1.9	.00	.33	.34	.35	.35	.36	25.9
352	.0	.4	1.2	7.	16.6	-2.0	.00	.33	.33	.34	.35	.36	25.6
359	.0	.4	1.2	6.	17.0	.6	.00	.32	.33	.34	.35	.35	25.4
366	.1	.4	1.3	6.	19.4	3.3	.00	.32	.33	.34	.35	.35	25.1
7	.2	.8	1.6	9.	15.3	.4	15.00	.35	.35	.35	.35	.35	25.9
14	.4	1.5	1.9	10.	15.7	4.1	9.00	.34	.34	.35	.35	.35	25.8
21	.8	1.4	2.0	11.	16.9	1.6	.00	.31	.32	.34	.35	.35	24.8
28	1.0	1.8	2.0	11.	16.0	1.6	9.00	.31	.32	.33	.34	.35	24.5
35	1.4	2.0	2.1	11.	17.0	1.7	.00	.27	.30	.32	.34	.35	23.1
42	1.2	2.1	2.1	12.	15.1	5.3	40.00	.35	.35	.36	.34	.35	25.6
49	1.6	2.3	2.3	12.	22.4	3.4	.00	.31	.32	.33	.34	.34	24.0
56	1.8	2.2	2.2	12.	16.7	7.1	24.00	.36	.35	.35	.33	.34	24.8
63	2.0	2.4	2.4	13.	20.0	5.4	.00	.32	.32	.33	.33	.34	23.2
70	2.4	2.7	2.7	13.	24.9	4.6	.00	.28	.30	.31	.32	.33	21.3
77	2.1	2.4	2.4	13.	19.4	5.1	16.00	.33	.32	.30	.31	.33	21.2
84	2.6	3.0	3.0	14.	25.4	5.1	.00	.28	.29	.28	.30	.32	19.1
91	2.4	2.6	2.6	14.	20.1	5.7	78.52	.36	.42	.38	.32	.31	24.6
98	2.3	2.6	2.6	14.	16.7	5.7	36.00	.36	.40	.38	.36	.32	25.9
105	2.5	2.8	2.8	15.	20.0	6.4	.00	.34	.34	.35	.35	.34	24.0
112	2.9	3.3	3.3	16.	23.4	6.6	2.00	.31	.32	.32	.33	.33	21.9
119	3.1	3.6	3.6	18.	21.9	7.1	13.00	.31	.31	.31	.31	.32	20.6
126	4.7	5.5	5.5	20.	29.7	9.3	.00	.23	.26	.27	.29	.31	16.8
133	4.4	5.5	5.5	22.	27.6	10.4	74.73	.30	.32	.33	.32	.30	20.2
140	5.5	7.3	7.3	24.	31.3	12.3	73.37	.36	.35	.37	.34	.29	22.3

	TOPS	NFAC	VEG N	GRAIN	NO3	NO3	NO3	NO3	NO3	NH4	NH4	NH4
DAY	N %		UPTK	UPTK	1	2	3	4	5	1	2	3
OYR			- KG N/HA -		|--------------- UG N/G SOIL ---------------|							
317	4.50	1.00	.0	.0	13.2	10.1	6.4	6.0	5.7	5.7	3.5	1.7
324	4.50	1.00	.0	.0	20.6	12.7	6.9	6.1	5.9	4.6	3.2	1.6
331	4.50	1.00	.0	.0	23.7	14.8	7.4	6.5	6.2	3.5	2.6	1.4
338	4.50	1.00	.0	.0	25.6	15.9	7.7	6.7	6.4	2.9	2.2	1.3
345	4.50	1.00	.0	.0	27.7	16.4	7.9	6.9	6.5	2.5	1.9	1.2
352	4.50	1.00	.0	.0	29.3	16.7	8.1	7.1	6.7	2.1	1.7	1.1
359	4.32	1.00	1.2	.0	30.4	16.9	8.3	7.3	6.8	1.9	1.5	1.0
366	5.70	1.00	3.5	.0	30.4	16.8	8.4	7.4	6.9	1.8	1.4	1.0
7	6.31	1.00	8.0	.0	25.2	18.0	8.9	7.5	7.0	1.6	1.3	1.0
14	6.23	1.00	16.9	.0	83.7	17.6	8.9	7.7	7.1	3.7	1.3	1.0
21	6.38	1.00	29.3	.0	80.0	15.5	8.2	7.6	7.1	2.1	1.2	1.0
28	6.56	1.00	42.7	.0	70.3	15.8	7.6	7.3	7.2	1.6	1.2	.9
35	6.38	1.00	64.8	.0	63.2	12.2	6.2	6.4	7.0	1.5	1.1	.9
42	6.15	1.00	101.0	.0	28.8	17.0	6.5	5.8	6.8	1.4	1.1	.9
49	5.91	1.00	146.3	.0	15.3	9.2	4.4	4.8	6.3	1.1	1.0	.9
56	5.67	1.00	189.1	.0	2.2	2.7	2.7	3.5	5.4	.6	.9	.9
63	5.39	1.00	221.9	.0	.7	.7	1.1	1.2	2.8	.6	.9	.9
70	4.71	.93	233.5	.0	.8	.8	1.0	1.1	1.1	.7	.9	1.0
77	3.93	.89	237.7	.0	.8	1.0	.9	1.0	1.0	.7	.9	.9
84	3.35	.88	240.5	.0	.9	.9	1.1	1.0	1.1	.8	.9	.9
91	2.91	.99	241.3	.0	.6	1.0	1.0	1.0	1.0	.8	.9	.9
98	2.52	1.00	240.1	.0	.6	.9	1.1	1.1	1.1	.9	1.0	.9
105	2.21	1.00	238.8	.0	.8	1.1	1.3	1.2	1.2	1.1	1.1	.9
112	1.96	1.00	237.6	.0	1.1	1.3	1.4	1.3	1.3	1.3	1.2	1.0
119	1.74	1.00	224.9	11.4	1.3	1.6	1.6	1.4	1.3	1.5	1.3	1.0
126	1.51	1.00	179.3	55.8	1.8	1.9	1.8	1.5	1.4	1.7	1.3	1.0
133	1.29	1.00	138.2	95.6	1.8	2.0	2.2	1.8	1.4	2.1	1.6	1.1
140	1.00	1.00	91.0	141.5	1.7	2.2	2.7	2.1	1.5	2.1	1.6	1.2

Annex 2. Model output for the validation in Tomejil 1990-1991

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WEATHER : TOMEJIL 1990-91
SOIL    : TOMEJIL
VARIETY : ANZA1

LATITUDE= 37.4, SOWING DEPTH=   6. CM, PLANT POPULATION=310. PLANTS PER SQ METER

GENETIC SPECIFIC CONSTANTS   P1V =3.5  P1D =2.8  P5 =4.0
                             G1 = 4.1   G2 = 3.5  G3 = 2.3


     SOIL PROFILE DATA [ PEDON:                ]
     SOIL ALBEDO=  .11  U=  10.5  SWCON=   .40   RUNOFF CURVE NO.=  85.0


 DEPTH-CM     LO LIM UP LIM  SAT SW EXT SW  IN SW    WR

   0.-  10.     .215    .361   .416   .146   .361  1.000
  10.-  25.     .216    .361   .415   .145   .361   .819
  25.-  50.     .218    .361   .412   .143   .361   .607
  50.-  80.     .221    .361   .412   .140   .361   .407
  80.- 110.     .225    .360   .409   .135   .360   .247
 110.- 140.     .229    .360   .407   .131   .360   .135
 140.- 170.     .231    .360   .407   .129   .360   .000
 170.- 200.     .231    .360   .405   .129   .360   .000


NITROGEN FERTILIZED (NON-LIMITING)


THE PROGRAM STARTED ON JULIAN DATE  311



OUTPUT 1: WATER-LIMITED PRODUCTION


 DATE  CDTT PHENOLOGICAL STAGE        BIOM    LAI NUPTK   N%   CET  RAIN  PESW
29 NOV    0. SOWING                  g/m^2        kg/ha        ----mm-----   cm
30 NOV    5. GERMINATION                                        35.   72.   27.
13 DEC  100. EMERGENCE                                          14.    9.   26.
11 MAR  890. T SPKLT VE DAYS=51.       454.  4.85 212.4  4.68  148.  222.   30.
 1 APR 1179. END VEG BEGIN EAR GROWTH  837.  5.57 232.0  2.77  212.  241.   22.
15 APR 1373. END EAR GR. EARS= 663.   1123.  5.24 232.4  2.07  263.  243.   17.
29 APR 1562. BEGIN GRAIN FILL         1438.  4.65 229.6  1.60  316.  282.   16.
29 MAY 2072. END GRAIN FILL           1718.  3.60  40.3   .39  396.  282.    8.
30 MAY 2093. PHYSIOLOGICAL MATURITY   1718.   .00  40.3   .39  396.  282.    8.

YIELD (KG/HA)= 6769. FINAL GPSM= 19664. KERNEL WT.(mg)= 34.4
```

ISTAGE	CSD1	CSD2	CNSD1	CNSD2	S T A G E O F G R O W T H
1	.00	.00	.00	.00	EMERGENCE - TERM SPIKLT
2	.00	.00	.00	.00	END VEG - BEG EAR GROWTH
3	.00	.00	.00	.00	BEGIN EAR - END EAR GROWTH
4	.00	.00	.00	.00	END EAR GRTH - BEG GRN FILL
5	.44	.50	.00	.00	LINEAR GRAIN FILL PHASE

* NOTE: In the above table, 0.0 represents minimum stress and 1.0 represents maximum stress for water (CSD) and nitrogen (CNSD), respectively.

	PREDICTED
ANTHESIS DATE	110
MATURITY DATE	150
GRAIN YIELD (KG/HA)	6769.
KERNEL WEIGHT (MG)	34.424
GRAINS PER SQ METRE	19664.
GRAINS PER EAR	29.64
MAX. LAI	5.57
BIOMASS (KG/HA)	17179.
STRAW (KG/HA)	10410.
GRAIN N%	2.71
TOT N UPTAKE (KG N/HA)	223.7
STRAW N UPTAKE	40.3
GRAIN N UPTAKE	183.4

DAY	SDTT	BIO	TPSM	LAI	ROOT	STEM	GRAIN	LEAF	RTD	PTF	L1	L3	L5
OYR		G/M2			|----- WEIGHT	IN G	-----|		(CM)		|- RLV	--|	
353	62.	4.	310.	.07	.007	.000	.000	.014	26.	1.79	.1	.0	.0
360	123.	10.	310.	.15	.012	.000	.000	.031	40.	.65	.2	.0	.0
2	198.	21.	310.	.32	.024	.000	.000	.069	56.	.65	.3	.1	.0
9	260.	34.	315.	.52	.051	.000	.000	.110	69.	.54	.7	.3	.0
16	314.	47.	402.	.71	.096	.000	.000	.151	82.	.30	1.2	.5	.0
23	379.	73.	633.	1.10	.158	.000	.000	.237	96.	.37	2.0	.8	.0
30	434.	103.	965.	1.47	.222	.000	.000	.331	109.	.65	2.9	1.1	.2
37	484.	142.	1332.	1.96	.306	.000	.000	.457	120.	.51	3.8	1.4	.3
44	528.	171.	1739.	2.28	.390	.000	.000	.553	129.	.25	4.7	1.7	.5
51	574.	209.	2190.	2.70	.497	.000	.000	.673	139.	.59	5.9	2.1	.7
58	650.	295.	2893.	3.62	.575	.000	.000	.951	155.	.65	6.4	2.5	.8
65	741.	388.	2938.	4.42	.658	.000	.000	1.250	175.	.65	6.5	2.8	1.0
72	24.	489.	923.	4.99	.735	.019	.000	1.559	194.	.78	6.9	3.0	1.3
79	134.	615.	843.	5.09	.783	.122	.000	1.863	200.	.78	7.1	3.1	1.4
86	213.	742.	752.	5.32	.829	.277	.000	2.115	200.	.78	7.5	3.2	1.4
93	23.	877.	667.	5.52	.873	.563	.000	2.265	200.	.84	7.9	3.3	1.4
100	126.	1020.	665.	5.36	.899	1.057	.000	2.233	200.	.85	7.9	3.4	1.3
107	29.	1168.	663.	5.16	.918	1.568	.000	2.200	200.	.90	7.9	3.5	1.3
114	125.	1327.	663.	4.86	.925	2.111	.000	2.171	200.	.90	7.7	3.5	1.3
121	37.	1536.	663.	4.63	.934	2.420	.394	2.141	200.	.85	7.5	3.5	1.3
128	128.	1653.	663.	4.38	.946	2.233	.985	2.115	200.	.87	7.1	3.5	1.3
135	242.	1726.	663.	4.04	.939	1.893	1.585	2.089	200.	.90	6.6	3.5	1.2
142	374.	1728.	663.	3.86	.910	1.377	2.140	2.058	200.	1.00	6.1	3.3	1.2
149	512.	1718.	663.	.00	.879	1.328	2.184	2.030	200.	1.00	6.1	3.3	1.2

* UNITS ARE IN MJ/SQUARE METER.

	---------- AVERAGE				---------	PERIOD		SW CONTENT	W/DEPTH		TOTAL	
DAY	EP	ET	EO	SR*	MAX	MIN	PREC	SW1	SW2	SW3	SW4	SW5	PESW
OYR	(MM)	(MM)	(MM)		C	C	(MM)						(CM)
317	.0	2.0	2.3	10.	22.0	11.9	46.50	.34	.35	.36	.37	.38	28.8
324	.0	.7	2.2	9.	23.0	8.9	.00	.34	.34	.35	.36	.36	27.0
331	.0	1.6	1.6	9.	13.3	2.6	25.00	.36	.36	.37	.37	.36	27.7
338	.0	1.4	1.6	8.	14.0	4.3	5.00	.35	.35	.35	.36	.36	26.9
345	.0	1.1	1.5	8.	14.9	3.1	4.00	.34	.34	.35	.36	.36	26.4
352	.0	.8	1.4	8.	13.9	2.7	3.00	.34	.34	.35	.35	.36	26.1
359	.1	.7	1.4	7.	15.7	2.7	.30	.32	.33	.34	.35	.36	25.6
1	.2	.8	1.4	8.	16.1	4.1	3.00	.32	.33	.34	.35	.36	25.3
8	.4	1.0	1.5	8.	16.0	1.1	2.00	.32	.32	.33	.35	.35	24.8
15	.6	1.2	1.5	8.	14.4	.7	5.30	.31	.32	.33	.34	.35	24.5
22	.9	1.3	1.6	9.	16.4	1.9	.00	.29	.31	.32	.34	.35	23.6
29	1.1	1.5	1.6	9.	15.9	-.3	1.50	.28	.29	.31	.33	.35	22.7
36	.9	1.6	1.6	10.	13.6	-1.7	14.50	.30	.31	.31	.33	.34	23.1
43	1.1	1.7	1.7	11.	12.6	-.6	19.00	.33	.34	.32	.33	.34	23.8
50	1.2	1.8	1.8	11.	10.9	.3	61.00	.36	.38	.38	.36	.34	27.1
57	1.6	2.2	2.2	13.	17.3	3.9	8.00	.36	.36	.36	.36	.35	26.4
64	2.0	2.5	2.5	14.	17.9	8.4	53.00	.36	.42	.39	.38	.36	29.1
71	2.2	2.6	2.6	15.	16.0	8.7	59.50	.36	.41	.36	.40	.38	31.4
78	2.7	3.0	3.0	16.	20.4	10.0	2.00	.34	.34	.35	.35	.36	27.6
85	2.6	3.0	3.0	16.	17.7	5.9	.00	.30	.31	.33	.34	.35	24.0
92	2.9	3.3	3.3	17.	21.0	7.6	.00	.27	.28	.30	.32	.34	21.6
99	3.2	3.6	3.6	18.	21.7	5.0	.00	.24	.26	.28	.30	.33	19.1
106	3.4	3.8	3.8	19.	22.4	5.9	16.50	.34	.27	.26	.28	.31	18.1
113	3.2	3.7	3.7	20.	20.0	7.3	24.00	.31	.31	.27	.27	.30	18.0
120	3.7	4.3	4.3	20.	23.6	7.3	.00	.24	.25	.26	.26	.28	15.0
127	3.6	4.2	4.2	21.	23.3	5.4	.00	.20	.23	.24	.24	.26	12.0
134	3.5	4.0	4.8	22.	25.6	6.9	.00	.16	.22	.22	.23	.25	9.3
141	1.6	1.6	6.0	22.	29.3	10.4	.00	.16	.22	.22	.22	.24	8.2
148	.8	.8	6.5	23.	30.3	9.3	.00	.16	.21	.22	.22	.23	7.6

	TOPS	NFAC	VEG N	GRAIN	NO3	NO3	NO3	NO3	NO3	NH4	NH4	NH4
DAY	N %		UPTK	UPTK	1	2	3	4	5	1	2	3
OYR			- KG N/HA -		|---------------			UG N/G SOIL		--------------- |		
317	4.50	1.00	.0	.0	16.3	10.2	6.1	5.6	5.6	5.7	3.7	1.7
324	4.50	1.00	.0	.0	24.0	12.7	6.6	6.0	5.8	4.6	3.2	1.6
331	4.50	1.00	.0	.0	22.3	16.0	7.8	6.6	6.2	3.3	2.5	1.4
338	4.50	1.00	.0	.0	24.6	16.7	7.9	6.8	6.4	2.7	2.0	1.3
345	4.50	1.00	.0	.0	26.3	17.2	8.2	7.0	6.6	2.5	1.9	1.2
352	4.99	1.00	2.7	.0	26.9	17.5	8.4	7.1	6.7	2.0	1.6	1.1
359	6.36	1.00	5.5	.0	26.9	17.0	8.5	7.3	6.8	1.8	1.5	1.0
1	6.30	1.00	11.9	.0	25.0	16.1	8.4	7.4	6.9	1.7	1.4	1.0
8	6.21	1.00	19.3	.0	23.2	14.6	8.0	7.4	6.9	1.6	1.3	1.0
15	6.40	1.00	29.6	.0	81.8	14.3	7.7	7.4	7.0	3.3	1.3	.9
22	6.48	1.00	44.8	.0	76.9	12.3	6.9	6.9	7.0	2.0	1.2	.9
29	6.32	1.00	64.2	.0	70.9	9.8	5.6	6.0	6.8	1.6	1.1	.9
36	6.18	1.00	82.5	.0	55.8	11.2	5.2	5.6	6.6	1.4	1.0	.8
43	6.04	1.00	100.7	.0	38.3	13.3	5.1	5.3	6.5	1.4	1.0	.8
50	5.94	1.00	116.7	.0	14.3	15.0	7.4	5.4	6.2	1.3	1.0	.7
57	5.78	1.00	160.4	.0	4.4	6.7	4.9	4.2	5.6	1.4	1.1	.8
64	5.56	1.00	203.2	.0	.8	1.5	1.9	2.0	3.3	1.5	1.2	.8
71	4.91	.94	213.4	.0	.8	1.0	1.1	1.4	2.4	1.5	1.1	.9
78	4.07	.82	225.4	.0	.4	.3	.6	1.0	1.1	1.5	1.0	.9

85	3.41	.82	229.2	.0	.8	.5	.8	1.1	.9	1.4	1.0	1.0
92	2.90	.81	232.3	.0	1.0	.6	1.0	.9	1.0	1.2	.9	.9
99	2.49	.92	233.8	.0	1.1	.8	1.0	1.0	1.0	1.0	.9	.9
106	2.16	1.00	232.2	.0	1.2	.9	1.1	1.1	1.1	.9	.8	.9
113	1.87	1.00	230.8	.0	1.1	1.1	1.3	1.2	1.2	.8	.9	.8
120	1.65	1.00	222.5	6.9	1.2	1.3	1.4	1.2	1.2	.8	.9	.8
127	1.48	1.00	186.9	41.2	1.3	1.4	1.5	1.3	1.2	.8	.8	.7
134	1.24	1.00	142.0	84.7	1.3	1.5	1.6	1.3	1.3	.7	.8	.7
141	1.00	1.00	96.9	128.4	1.4	1.5	1.6	1.4	1.3	.7	.8	.7
148	.65	1.00	47.9	175.8	1.4	1.5	1.6	1.4	1.3	.7	.8	.7

OUTPUT 2: POTENTIAL PRODUCTION

DATE	CDTT	PHENOLOGICAL STAGE	BIOM	LAI	NUPTK	N%	CET	RAIN	PESW
29 NOV	0.	SOWING	g/m^2		kg/ha		----mm-----		cm
30 NOV	5.	GERMINATION					35.	72.	27.
13 DEC	100.	EMERGENCE					14.	9.	26.
11 MAR	890.	T SPKLT VE DAYS=51.	454.	4.85	212.4	4.68	148.	222.	30.
1 APR	1179.	END VEG BEGIN EAR GROWTH	837.	5.57	232.0	2.77	212.	241.	22.
15 APR	1373.	END EAR GR. EARS= 663.	1123.	5.24	232.4	2.07	263.	316.	24.
29 APR	1562.	BEGIN GRAIN FILL	1438.	4.65	229.6	1.60	316.	354.	22.
29 MAY	2072.	END GRAIN FILL	1888.	.19	40.5	.38	476.	502.	21.
30 MAY	2093.	PHYSIOLOGICAL MATURITY	1888.	.00	40.5	.38	477.	502.	21.

YIELD (KG/HA)= 8258. FINAL GPSM= 19664. KERNEL WT.(mg)= 42.0

ISTAGE	CSD1	CSD2	CNSD1	CNSD2	S T A G E O F G R O W T H
1	.00	.00	.00	.00	EMERGENCE - TERM SPIKLT
2	.00	.00	.00	.00	END VEG - BEG EAR GROWTH
3	.00	.00	.00	.00	BEGIN EAR - END EAR GROWTH
4	.00	.00	.00	.00	END EAR GRTH - BEG GRN FILL
5	.00	.00	.00	.00	LINEAR GRAIN FILL PHASE

* NOTE: In the above table, 0.0 represents minimum stress and 1.0 represents maximum stress for water (CSD) and nitrogen (CNSD), respectively.

	PREDICTED
ANTHESIS DATE	110
MATURITY DATE	150
GRAIN YIELD (KG/HA)	8258.
KERNEL WEIGHT (MG)	41.999
GRAINS PER SQ METRE	19664.
GRAINS PER EAR	29.64
MAX. LAI	5.57
BIOMASS (KG/HA)	18880.
STRAW (KG/HA)	10622.
GRAIN N%	2.22
TOT N UPTAKE (KG N/HA)	223.9
STRAW N UPTAKE	40.5
GRAIN N UPTAKE	183.4

DAY	SDTT	BIO	TPSM	LAI	ROOT	STEM	GRAIN	LEAF	RTD	PTF	L1	L3	L5
OYR		G/M2			|-----	WEIGHT IN G	-----|		(CM)		|-	RLV	--|
353	62.	4.	310.	.07	.007	.000	.000	.014	26.	1.79	.1	.0	.0

360	123.	10.	310.	.15	.012	.000	.000	.031	40.	.65	.2	.0	.0
2	198.	21.	310.	.32	.024	.000	.000	.069	56.	.65	.3	.1	.0
9	260.	34.	315.	.52	.051	.000	.000	.110	69.	.54	.7	.3	.0
16	314.	47.	402.	.71	.096	.000	.000	.151	82.	.30	1.2	.5	.0
23	379.	73.	633.	1.10	.158	.000	.000	.237	96.	.37	2.0	.8	.0
30	434.	103.	965.	1.47	.222	.000	.000	.331	109.	.65	2.9	1.1	.2
37	484.	142.	1332.	1.96	.306	.000	.000	.457	120.	.51	3.8	1.4	.3
44	528.	171.	1739.	2.28	.390	.000	.000	.553	129.	.25	4.7	1.7	.5
51	574.	209.	2190.	2.70	.497	.000	.000	.673	139.	.59	5.9	2.1	.7
58	650.	295.	2893.	3.62	.575	.000	.000	.951	155.	.65	6.4	2.5	.8
65	741.	388.	2938.	4.42	.658	.000	.000	1.250	175.	.65	6.5	2.8	1.0
72	24.	489.	923.	4.99	.735	.019	.000	1.559	194.	.78	6.9	3.0	1.3
79	134.	615.	843.	5.09	.783	.122	.000	1.863	200.	.78	7.1	3.1	1.4
86	213.	742.	752.	5.32	.829	.277	.000	2.115	200.	.78	7.5	3.2	1.4
93	23.	877.	667.	5.52	.873	.563	.000	2.265	200.	.84	7.9	3.3	1.4
100	126.	1020.	665.	5.36	.899	1.057	.000	2.233	200.	.85	7.9	3.4	1.3
107	29.	1168.	663.	5.16	.918	1.568	.000	2.200	200.	.90	7.8	3.5	1.3
114	125.	1327.	663.	4.86	.925	2.111	.000	2.171	200.	.90	7.4	3.6	1.3
121	37.	1536.	663.	4.63	.934	2.420	.394	2.141	200.	.85	7.2	3.6	1.3
128	128.	1653.	663.	4.38	.946	2.233	.985	2.115	200.	.87	7.0	3.6	1.2
135	242.	1751.	663.	3.70	.945	1.974	1.585	2.090	200.	.89	6.7	3.6	1.2
142	374.	1831.	663.	2.25	.930	1.622	2.217	2.067	200.	.95	6.4	3.5	1.1
149	512.	1888.	663.	.00	.901	1.368	2.664	2.058	200.	1.00	6.0	3.3	1.1

* UNITS ARE IN MJ/SQUARE METER.

	---------- AVERAGE					--------- PERIOD		SW CONTENT W/DEPTH				TOTAL	
DAY	EP	ET	EO	SR*	MAX	MIN	PREC	SW1	SW2	SW3	SW4	SW5	PESW
OYR	(MM)	(MM)	(MM)		C	C	(MM)						(CM)
317	.0	2.0	2.3	10.	22.0	11.9	46.50	.34	.35	.36	.37	.38	28.8
324	.0	.7	2.2	9.	23.0	8.9	.00	.34	.34	.35	.36	.36	27.0
331	.0	1.6	1.6	9.	13.3	2.6	25.00	.36	.36	.37	.37	.36	27.7
338	.0	1.4	1.6	8.	14.0	4.3	5.00	.35	.35	.35	.36	.36	26.9
345	.0	1.1	1.5	8.	14.9	3.1	4.00	.34	.34	.35	.36	.36	26.4
352	.0	.8	1.4	8.	13.9	2.7	3.00	.34	.34	.35	.35	.36	26.1
359	.1	.7	1.4	7.	15.7	2.7	.30	.32	.33	.34	.35	.36	25.6
1	.2	.8	1.4	8.	16.1	4.1	3.00	.32	.33	.34	.35	.36	25.3
8	.4	1.0	1.5	8.	16.0	1.1	2.00	.32	.32	.33	.35	.35	24.8
15	.6	1.2	1.5	8.	14.4	.7	5.30	.31	.32	.33	.34	.35	24.5
22	.9	1.3	1.6	9.	16.4	1.9	.00	.29	.31	.32	.34	.35	23.6
29	1.1	1.5	1.6	9.	15.9	-.3	1.50	.28	.29	.31	.33	.35	22.7
36	.9	1.6	1.6	10.	13.6	-1.7	14.50	.30	.31	.31	.33	.34	23.1
43	1.1	1.7	1.7	11.	12.6	-.6	19.00	.33	.34	.32	.33	.34	23.8
50	1.2	1.8	1.8	11.	10.9	.3	61.00	.36	.38	.38	.36	.34	27.1
57	1.6	2.2	2.2	13.	17.3	3.9	8.00	.36	.36	.36	.36	.35	26.4
64	2.0	2.5	2.5	14.	17.9	8.4	53.00	.36	.42	.39	.38	.36	29.1
71	2.2	2.6	2.6	15.	16.0	8.7	59.50	.36	.41	.36	.40	.38	31.4
78	2.7	3.0	3.0	16.	20.4	10.0	2.00	.34	.34	.35	.35	.36	27.6
85	2.6	3.0	3.0	16.	17.7	5.9	.00	.30	.31	.33	.34	.35	24.0
92	2.9	3.3	3.3	17.	21.0	7.6	.00	.27	.28	.30	.32	.34	21.6
99	3.2	3.6	3.6	18.	21.7	5.0	.00	.24	.26	.28	.30	.33	19.1
106	3.4	3.8	3.8	19.	22.4	5.9	89.02	.36	.41	.37	.33	.32	25.2
113	3.2	3.7	3.7	20.	20.0	7.3	24.00	.35	.35	.35	.35	.34	24.8
120	3.7	4.3	4.3	20.	23.6	7.3	.00	.29	.31	.32	.33	.33	21.8
127	3.6	4.2	4.2	21.	23.3	5.4	.00	.24	.27	.29	.31	.32	18.8
134	4.0	4.8	4.8	22.	25.6	6.9	72.99	.34	.34	.35	.33	.31	22.7
141	4.8	6.0	6.0	22.	29.3	10.4	.00	.25	.29	.30	.31	.30	18.5
148	4.5	6.5	6.7	23.	30.3	9.3	75.04	.32	.34	.35	.33	.29	21.4

DAY OYR	TOPS N %	NFAC	VEG N UPTK	GRAIN UPTK	NO3 1	NO3 2	NO3 3	NO3 4	NO3 5	NH4 1	NH4 2	NH4 3
			- KG N/HA -		|---------------			UG N/G SOIL		---------------		|
317	4.50	1.00	.0	.0	16.3	10.2	6.1	5.6	5.6	5.7	3.7	1.7
324	4.50	1.00	.0	.0	24.0	12.7	6.6	6.0	5.8	4.6	3.2	1.6
331	4.50	1.00	.0	.0	22.3	16.0	7.8	6.6	6.2	3.3	2.5	1.4
338	4.50	1.00	.0	.0	24.6	16.7	7.9	6.8	6.4	2.7	2.0	1.3
345	4.50	1.00	.0	.0	26.3	17.2	8.2	7.0	6.6	2.5	1.9	1.2
352	4.99	1.00	2.7	.0	26.9	17.5	8.4	7.1	6.7	2.0	1.6	1.1
359	6.36	1.00	5.5	.0	26.9	17.0	8.5	7.3	6.8	1.8	1.5	1.0
1	6.30	1.00	11.9	.0	25.0	16.1	8.4	7.4	6.9	1.7	1.4	1.0
8	6.21	1.00	19.3	.0	23.2	14.6	8.0	7.4	6.9	1.6	1.3	1.0
15	6.40	1.00	29.6	.0	81.8	14.3	7.7	7.4	7.0	3.3	1.3	.9
22	6.48	1.00	44.8	.0	76.9	12.3	6.9	6.9	7.0	2.0	1.2	.9
29	6.32	1.00	64.2	.0	70.9	9.8	5.6	6.0	6.8	1.6	1.1	.9
36	6.18	1.00	82.5	.0	55.8	11.2	5.2	5.6	6.6	1.4	1.0	.8
43	6.04	1.00	100.7	.0	38.3	13.3	5.1	5.3	6.5	1.4	1.0	.8
50	5.94	1.00	116.7	.0	14.3	15.0	7.4	5.4	6.2	1.3	1.0	.7
57	5.78	1.00	160.4	.0	4.4	6.7	4.9	4.2	5.6	1.4	1.1	.8
64	5.56	1.00	203.2	.0	.8	1.5	1.9	2.0	3.3	1.5	1.2	.8
71	4.91	.94	213.4	.0	.8	1.0	1.1	1.4	2.4	1.5	1.1	.9
78	4.07	.82	225.4	.0	.4	.3	.6	1.0	1.1	1.5	1.0	.9
85	3.41	.82	229.2	.0	.8	.5	.8	1.1	.9	1.4	1.0	1.0
92	2.90	.81	232.3	.0	1.0	.6	1.0	.9	1.0	1.2	.9	.9
99	2.49	.92	233.8	.0	1.1	.8	1.0	1.0	1.0	1.0	.9	.9
106	2.16	1.00	232.2	.0	.7	.9	1.2	1.2	1.1	.9	.9	.9
113	1.87	1.00	230.8	.0	.7	.9	1.4	1.3	1.2	.9	1.0	1.0
120	1.65	1.00	222.5	6.9	.9	1.1	1.5	1.4	1.3	.9	1.1	1.0
127	1.48	1.00	186.9	41.2	1.1	1.3	1.7	1.5	1.3	.9	1.1	1.0
134	1.24	1.00	142.0	84.7	.8	1.3	2.0	1.7	1.4	1.1	1.2	1.0
141	.95	1.00	96.9	128.4	1.2	1.6	2.2	1.8	1.4	1.4	1.4	1.1
148	.62	1.00	48.0	175.8	1.2	1.7	2.5	2.2	1.5	1.7	1.5	1.2

Annex 3. Model output for the validation in Las Tiesas, Albacete, 1990-1991

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WEATHER: LOS LLANOS 1990
SOIL:    LAS TIESAS
VARIETY: ANZA1

LATITUDE= 39.0, SOWING DEPTH=   6. CM, PLANT POPULATION=200. PLANTS PER SQ METER

GENETIC SPECIFIC CONSTANTS   P1V =3.5  P1D =2.8  P5 =4.0
                             G1 = 4.1   G2 = 3.5  G3 = 2.3

     SOIL PROFILE DATA [ PEDON:              ]
     SOIL ALBEDO=  .13  U=  8.5  SWCON=   .10   RUNOFF CURVE NO.=  84.0


 DEPTH-CM     LO LIM UP LIM  SAT SW EXT SW  IN SW    WR

   0.-  10.     .215    .361   .416   .146   .361  1.000
  10.-  20.     .216    .361   .415   .145   .361   .819
  20.-  30.     .218    .361   .414   .143   .361   .607
  30.-  40.     .221    .361   .412   .140   .361   .407
  40.-  55.     .225    .360   .409   .135   .361   .247


NITROGEN FERTILIZED (NON-LIMITING)

THE PROGRAM STARTED ON JULIAN DATE  311

OUTPUT 1: WATER-LIMITED PRODUCTION. 1990-1991.


 DATE  CDTT PHENOLOGICAL STAGE        BIOM    LAI NUPTK   N%   CET  RAIN  PESW
15 DEC    0. SOWING                  g/m^2        kg/ha        ----mm-----   cm
16 DEC    2. GERMINATION                                        33.   28.    7.
10 JAN   91. EMERGENCE                                          11.    1.    6.
 6 APR  707. T SPKLT VE DAYS=50.       257.  3.16 120.5  4.68  131.   79.    2.
 5 MAY  997. END VEG BEGIN EAR GROWTH  791.  5.71 225.8  2.85  217.  179.    3.
21 MAY 1190. END EAR GR. EARS= 742.   1005.  5.50 225.1  2.24  258.  188.    0.
 2 JUN 1377. BEGIN GRAIN FILL         1022.  5.32 223.2  2.18  271.  202.    0.
27 JUN 1887. END GRAIN FILL           1145.  3.81 113.2  1.27  347.  272.   -1.
28 JUN 1910. PHYSIOLOGICAL MATURITY   1145.   .00 113.2  1.27  347.  272.   -1.

YIELD (KG/HA)= 2507. FINAL GPSM= 11658. KERNEL WT.(mg)= 21.5

ISTAGE      CSD1      CSD2     CNSD1     CNSD2  S T A G E   O F   G R O W T H
     1       .00       .00       .00       .00  EMERGENCE   -    TERM SPIKLT
     2       .00       .00       .00       .05  END VEG  -    BEG EAR GROWTH
     3       .30       .34       .00       .04  BEGIN EAR  -  END EAR GROWTH
     4       .79       .83       .00       .00  END EAR GRTH -  BEG GRN FILL
     5       .62       .65       .00       .00  LINEAR GRAIN FILL PHASE
* NOTE: In the above table, 0.0 represents minimum
  stress and 1.0 represents maximum stress for water
  (CSD) and nitrogen (CNSD), respectively.

                        PREDICTED
ANTHESIS DATE               145
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MATURITY DATE	179
GRAIN YIELD (KG/HA)	2507.
KERNEL WEIGHT (MG)	21.506
GRAINS PER SQ METRE	11658.
GRAINS PER EAR	15.71
MAX. LAI	5.71
BIOMASS (KG/HA)	11452.
STRAW (KG/HA)	8945.
GRAIN N%	4.20
TOT N UPTAKE (KG N/HA)	218.6
STRAW N UPTAKE	113.2
GRAIN N UPTAKE	105.4

DAY	SDTT	BIO	TPSM	LAI	ROOT	STEM	GRAIN	LEAF	RTD	PTF	L1	L3	L5
OYR		G/M2			|----- WEIGHT IN G -----|				(CM)		|- RLV --|		
16	26.	0.	200.	.01	.006	.000	.000	.002	20.	.00	.0	.0	.0
23	62.	2.	200.	.03	.007	.000	.000	.008	28.	.07	.1	.0	.0
30	93.	3.	200.	.05	.009	.000	.000	.015	35.	.15	.1	.0	.0
37	142.	7.	200.	.11	.016	.000	.000	.035	45.	.46	.2	.1	.0
44	173.	10.	200.	.15	.028	.000	.000	.048	52.	.07	.3	.1	.0
51	208.	12.	200.	.19	.048	.000	.000	.061	55.	.28	.5	.2	.0
58	268.	18.	207.	.28	.082	.000	.000	.092	55.	.33	.8	.4	.1
65	334.	32.	290.	.46	.140	.000	.000	.158	55.	.51	1.5	.8	.2
72	399.	52.	480.	.73	.216	.000	.000	.259	55.	.62	2.5	1.3	.4
79	478.	95.	800.	1.28	.363	.000	.000	.476	55.	.58	4.0	2.1	.6
86	536.	149.	1157.	1.91	.510	.000	.000	.746	55.	.56	5.6	2.9	.8
93	599.	221.	1606.	2.75	.680	.000	.000	1.105	55.	.65	7.4	3.9	1.1
100	47.	325.	923.	3.75	.817	.060	.000	1.563	55.	.78	8.1	4.9	1.4
107	118.	463.	907.	4.76	.900	.238	.000	2.079	55.	.80	8.7	5.3	1.5
114	176.	583.	860.	5.38	.963	.446	.000	2.471	55.	.80	8.9	5.5	1.7
121	255.	711.	801.	5.73	1.034	.715	.000	2.842	55.	.80	9.5	5.5	1.9
128	36.	854.	738.	5.65	1.101	1.250	.000	3.019	55.	.84	10.5	5.6	2.0
135	116.	989.	740.	5.53	1.146	1.969	.000	2.977	55.	.83	11.1	5.6	2.0
142	25.	1004.	742.	5.49	1.137	2.102	.000	2.920	55.	.81	10.4	5.5	2.1
149	138.	987.	742.	5.45	1.103	2.076	.000	2.861	55.	.80	9.7	5.1	2.0
156	56.	1096.	742.	5.31	1.087	2.207	.472	2.800	55.	.97	9.8	4.8	1.9
163	197.	1168.	742.	4.82	1.050	2.031	1.079	2.733	55.	1.00	9.7	4.7	1.9
170	346.	1175.	742.	4.17	1.014	1.950	1.253	2.670	55.	1.00	9.7	4.7	1.9
177	497.	1149.	742.	3.87	.979	1.875	1.254	2.616	55.	1.00	9.7	4.7	1.9

* UNITS ARE IN MJ/SQUARE METER.

	---------- AVERAGE --------- PERIOD							SW CONTENT W/DEPTH				TOTAL	
DAY	EP	ET	EO	SR*	MAX	MIN	PREC	SW1	SW2	SW3	SW4	SW5	PESW
OYR	(MM)	(MM)	(MM)		C	C	(MM)						(CM)
317	.0	1.5	1.5	8.	15.7	6.3	15.00	.35	.35	.36	.36	.39	8.1
324	.0	1.3	2.1	10.	19.4	2.6	.00	.33	.32	.36	.34	.37	7.0
331	.0	.6	1.2	7.	11.8	.5	1.80	.33	.35	.32	.36	.35	6.7
338	.0	.5	1.2	7.	9.1	-2.3	.20	.33	.32	.34	.33	.35	6.4
345	.0	.4	1.3	8.	10.4	-1.5	.00	.32	.32	.33	.34	.34	6.1
352	.0	.5	.9	6.	9.9	-2.8	11.00	.33	.35	.31	.36	.36	6.8
359	.0	.6	.7	4.	7.6	-2.7	.60	.33	.32	.35	.33	.36	6.5
1	.0	.4	.8	5.	11.5	2.1	.00	.32	.33	.33	.34	.34	6.2
8	.0	.4	1.2	8.	9.6	-2.0	.00	.31	.32	.33	.33	.34	5.9
15	.0	.3	1.3	8.	11.3	-.9	.00	.31	.32	.32	.33	.34	5.7
22	.0	.3	1.6	10.	10.7	-3.1	.20	.30	.31	.32	.33	.33	5.5
29	.0	.7	1.5	10.	7.9	-.0	7.80	.32	.32	.32	.33	.33	5.8

36	.1	.5	1.6	9.	11.8	.0	.80	.31	.32	.32	.32	.33	5.6
43	.2	.8	1.5	10.	8.4	.7	5.60	.31	.32	.32	.32	.33	5.6
50	.2	.9	1.8	12.	8.4	-2.1	9.70	.32	.32	.32	.33	.34	6.0
57	.5	.8	2.5	14.	15.8	-.6	.00	.30	.31	.32	.33	.33	5.4
64	.6	1.2	2.2	12.	14.6	3.8	2.20	.28	.29	.31	.32	.33	4.8
71	.8	1.6	2.2	12.	14.9	4.7	7.00	.28	.28	.29	.31	.32	4.3
78	1.2	2.7	2.7	15.	15.3	5.7	27.80	.30	.31	.31	.32	.32	5.2
85	1.4	2.8	2.8	16.	13.3	4.2	5.00	.25	.27	.29	.30	.31	3.8
92	1.8	2.9	2.9	17.	15.4	1.5	9.40	.23	.26	.27	.28	.29	2.7
99	2.2	3.0	3.0	17.	17.6	2.8	11.90	.25	.24	.24	.25	.26	1.7
106	2.5	3.1	3.1	18.	18.3	2.2	66.80	.35	.42	.35	.32	.26	6.3
113	2.4	2.7	2.7	17.	15.2	1.3	12.40	.32	.32	.31	.33	.33	5.6
120	2.7	3.0	3.0	18.	16.6	3.5	3.40	.28	.28	.28	.29	.30	3.8
127	3.1	3.4	3.4	20.	17.5	2.4	8.00	.25	.25	.25	.26	.27	2.2
134	2.6	2.9	2.9	17.	18.0	2.8	9.10	.23	.23	.23	.24	.25	1.1
141	1.2	1.7	4.4	22.	23.9	5.1	.00	.19	.22	.22	.22	.23	-.1
148	.2	.7	5.5	24.	26.6	4.5	.20	.16	.21	.22	.22	.23	-.6
155	2.0	2.4	4.8	23.	23.6	10.0	23.90	.23	.22	.22	.22	.22	.1
162	4.4	5.2	6.8	26.	28.2	12.8	44.40	.25	.25	.25	.22	.22	.9
169	2.0	2.9	6.8	22.	31.4	14.4	11.30	.22	.21	.22	.22	.22	.0
176	.0	1.1	6.7	22.	31.1	12.7	4.20	.19	.21	.22	.22	.22	-.3

	TOPS	NFAC	VEG N	GRAIN	NO3	NO3	NO3	NO3	NO3	NH4	NH4	NH4
DAY	N %		UPTK	UPTK	1	2	3	4	5	1	2	3
OYR			- KG N/HA -		|---------------			UG N/G SOIL		---------------		-|
317	4.50	1.00	.0	.0	15.3	10.8	5.9	5.4	5.6	5.2	3.8	1.8
324	4.50	1.00	.0	.0	22.7	12.8	6.6	5.8	5.8	4.7	3.7	1.7
331	4.50	1.00	.0	.0	26.5	15.1	7.0	6.4	6.0	3.4	2.8	1.5
338	4.50	1.00	.0	.0	28.3	15.3	8.0	6.4	6.3	2.6	2.1	1.2
345	4.50	1.00	.0	.0	57.7	28.5	8.2	6.7	6.4	4.2	3.6	1.1
352	4.50	1.00	.0	.0	54.0	32.7	10.5	7.4	6.7	2.8	2.4	1.0
359	4.50	1.00	.0	.0	55.2	30.4	12.3	7.4	6.8	2.7	2.2	.9
1	4.50	1.00	.0	.0	56.7	30.3	12.2	7.8	6.8	2.4	1.9	.9
8	4.50	1.00	.0	.0	58.2	30.2	12.3	7.8	6.8	2.1	1.7	.8
15	5.10	1.00	1.6	.0	115.9	29.9	12.2	7.8	6.9	12.5	1.6	.8
22	6.31	1.00	1.9	.0	124.8	29.7	12.2	7.8	6.9	4.4	1.5	.8
29	6.25	1.00	2.4	.0	123.1	32.4	12.5	7.9	7.0	3.1	1.3	.7
36	6.19	1.00	4.3	.0	123.7	31.9	12.4	8.0	7.0	2.3	1.3	.7
43	6.50	1.00	6.9	.0	121.4	33.0	12.4	8.0	7.1	2.0	1.3	.7
50	6.85	1.00	7.7	.0	110.8	40.0	14.6	8.4	7.2	1.8	1.2	.7
57	6.81	1.00	11.2	.0	110.5	38.5	14.1	8.3	7.2	1.8	1.3	.7
64	6.52	1.00	18.6	.0	108.7	35.8	13.1	7.9	7.0	1.7	1.3	.7
71	6.30	1.00	30.9	.0	104.2	32.4	11.5	7.2	6.6	1.7	1.3	.7
78	6.10	1.00	51.7	.0	74.6	40.4	14.6	7.5	6.5	1.7	1.4	.7
85	5.85	1.00	80.1	.0	68.1	29.7	10.2	5.9	5.7	1.6	1.3	.7
92	5.61	1.00	112.5	.0	52.5	22.7	7.5	4.7	4.7	1.5	1.2	.7
99	4.70	.91	134.2	.0	42.9	18.4	5.9	3.8	3.9	1.4	1.1	.6
106	4.50	.92	200.1	.0	1.2	8.6	4.9	3.9	3.7	1.5	1.2	.7
113	4.12	1.00	220.7	.0	1.1	.8	.7	1.4	2.4	1.5	1.3	.7
120	3.48	.97	224.8	.0	.6	1.0	.8	1.1	1.1	1.4	1.2	.7
127	2.94	.95	225.8	.0	.9	.7	.9	1.0	1.0	1.3	1.1	.7
134	2.46	.94	225.9	.0	1.1	.9	.9	1.1	1.1	1.2	1.0	.7
141	2.25	1.00	225.1	.0	1.3	.9	1.0	1.1	1.1	1.2	.9	.7
148	2.25	1.00	224.0	.0	1.5	.9	1.0	1.1	1.1	1.1	.9	.7
155	2.18	1.00	214.5	8.4	1.6	1.0	1.0	1.1	1.1	1.1	.9	.7
162	2.05	1.00	186.5	35.1	1.5	1.4	1.1	1.1	1.1	1.5	1.2	.7
169	1.78	1.00	155.7	64.6	1.9	1.6	1.2	1.1	1.1	1.5	1.2	.7

176	1.51	1.00	123.5	95.5	2.2	1.6	1.2	1.1	1.1	1.4	1.2	.7

OUTPUT 2: POTENTIAL PRODUCTION

DATE	CDTT	PHENOLOGICAL STAGE	BIOM	LAI	NUPTK	N%	CET	RAIN	PESW
15 DEC	0.	SOWING	g/m^2		kg/ha		----mm-----		cm
16 DEC	2.	GERMINATION					33.	28.	7.
10 JAN	91.	EMERGENCE					11.	1.	6.
6 APR	707.	T SPKLT VE DAYS=50.	257.	3.16	138.2	5.37	131.	150.	8.
5 MAY	997.	END VEG BEGIN EAR GROWTH	791.	5.71	222.0	2.81	217.	250.	5.
21 MAY	1190.	END EAR GR. EARS= 762.	1136.	5.38	221.4	1.95	277.	332.	6.
2 JUN	1377.	BEGIN GRAIN FILL	1419.	4.78	219.4	1.55	337.	423.	8.
27 JUN	1887.	END GRAIN FILL	1799.	.06	33.2	.31	503.	567.	4.
28 JUN	1910.	PHYSIOLOGICAL MATURITY	1799.	.00	33.2	.31	504.	567.	4.

YIELD (KG/HA)= 7449. FINAL GPSM= 21710. KERNEL WT.(mg)= 34.3

ISTAGE	CSD1	CSD2	CNSD1	CNSD2	S T A G E O F G R O W T H
1	.00	.00	.00	.00	EMERGENCE - TERM SPIKLT
2	.00	.00	.00	.00	END VEG - BEG EAR GROWTH
3	.00	.00	.00	.00	BEGIN EAR - END EAR GROWTH
4	.00	.00	.00	.00	END EAR GRTH - BEG GRN FILL
5	.00	.00	.00	.00	LINEAR GRAIN FILL PHASE

* NOTE: In the above table, 0.0 represents minimum stress and 1.0 represents maximum stress for water (CSD) and nitrogen (CNSD), respectively.

	PREDICTED
ANTHESIS DATE	145
MATURITY DATE	179
GRAIN YIELD (KG/HA)	7449.
KERNEL WEIGHT (MG)	34.311
GRAINS PER SQ METRE	21710.
GRAINS PER EAR	28.48
MAX. LAI	5.71
BIOMASS (KG/HA)	17990.
STRAW (KG/HA)	10541.
GRAIN N%	2.55
TOT N UPTAKE (KG N/HA)	223.1
STRAW N UPTAKE	33.2
GRAIN N UPTAKE	189.9

DAY	SDTT	BIO	TPSM	LAI	ROOT	STEM	GRAIN	LEAF	RTD	PTF	L1	L3	L5
OYR		G/M2			|-----	WEIGHT IN G	-----|		(CM)		|-	RLV	--|
16	26.	0.	200.	.01	.006	.000	.000	.002	20.	.00	.0	.0	.0
23	62.	2.	200.	.03	.007	.000	.000	.008	28.	.07	.1	.0	.0
30	93.	3.	200.	.05	.009	.000	.000	.015	35.	.15	.1	.0	.0
37	142.	7.	200.	.11	.016	.000	.000	.035	45.	.46	.2	.1	.0
44	173.	10.	200.	.15	.028	.000	.000	.048	52.	.07	.3	.1	.0
51	208.	12.	200.	.19	.048	.000	.000	.061	55.	.28	.5	.2	.0
58	268.	18.	207.	.28	.082	.000	.000	.092	55.	.33	.8	.4	.1
65	334.	32.	290.	.46	.140	.000	.000	.158	55.	.51	1.5	.8	.2
72	399.	52.	480.	.73	.216	.000	.000	.259	55.	.62	2.5	1.3	.4
79	478.	95.	800.	1.28	.363	.000	.000	.476	55.	.58	4.0	2.1	.6
86	536.	149.	1157.	1.91	.510	.000	.000	.746	55.	.56	5.6	2.9	.8
93	599.	221.	1606.	2.75	.680	.000	.000	1.105	55.	.65	7.5	4.0	1.1

100	47.	326.	920.	3.76	.812	.061	.000	1.570	55.	.80	8.9	4.8	1.4
107	118.	466.	887.	4.79	.892	.241	.000	2.090	55.	.80	8.8	5.5	1.7
114	176.	585.	843.	5.40	.958	.447	.000	2.479	55.	.79	8.9	5.6	2.2
121	255.	712.	795.	5.74	1.034	.714	.000	2.846	55.	.79	9.7	5.5	2.6
128	36.	854.	740.	5.66	1.102	1.246	.000	3.021	55.	.84	10.6	5.7	2.7
135	116.	993.	749.	5.53	1.150	1.985	.000	2.979	55.	.85	10.9	5.7	2.7
142	25.	1165.	762.	5.34	1.206	2.900	.000	2.923	55.	.90	11.5	5.9	2.7
149	138.	1329.	762.	4.99	1.228	3.776	.000	2.868	55.	.90	11.5	5.9	2.6
156	56.	1554.	762.	4.74	1.253	4.078	.879	2.813	55.	.88	11.5	5.9	2.5
163	197.	1661.	762.	4.14	1.258	3.510	2.041	2.753	55.	.92	11.3	5.8	2.4
170	346.	1730.	762.	2.69	1.228	2.705	3.238	2.705	55.	.99	10.8	5.6	2.3
177	497.	1798.	762.	.47	1.186	2.601	3.702	2.685	55.	1.00	10.7	5.5	2.3

* UNITS ARE IN MJ/SQUARE METER.

	---------- AVERAGE ---------						PERIOD	SW CONTENT W/DEPTH				TOTAL	
DAY	EP	ET	EO	SR*	MAX	MIN	PREC	SW1	SW2	SW3	SW4	SW5	PESW
OYR	(MM)	(MM)	(MM)		C	C	(MM)						(CM)
317	.0	1.5	1.5	8.	15.7	6.3	15.00	.35	.35	.36	.36	.39	8.1
324	.0	1.3	2.1	10.	19.4	2.6	.00	.33	.32	.36	.34	.37	7.0
331	.0	.6	1.2	7.	11.8	.5	1.80	.33	.35	.32	.36	.35	6.7
338	.0	.5	1.2	7.	9.1	-2.3	.20	.33	.32	.34	.33	.35	6.4
345	.0	.4	1.3	8.	10.4	-1.5	.00	.32	.32	.33	.34	.34	6.1
352	.0	.5	.9	6.	9.9	-2.8	11.00	.33	.35	.31	.36	.36	6.8
359	.0	.6	.7	4.	7.6	-2.7	.60	.33	.32	.35	.33	.36	6.5
1	.0	.4	.8	5.	11.5	2.1	.00	.32	.33	.33	.34	.34	6.2
8	.0	.4	1.2	8.	9.6	-2.0	.00	.31	.32	.33	.33	.34	5.9
15	.0	.3	1.3	8.	11.3	-.9	.00	.31	.32	.32	.33	.34	5.7
22	.0	.3	1.6	10.	10.7	-3.1	.20	.30	.31	.32	.33	.33	5.5
29	.0	.7	1.5	10.	7.9	-.0	7.80	.32	.32	.32	.33	.33	5.8
36	.1	.5	1.6	9.	11.8	.0	.80	.31	.32	.32	.32	.33	5.6
43	.2	.8	1.5	10.	8.4	.7	5.60	.31	.32	.32	.32	.33	5.6
50	.2	.9	1.8	12.	8.4	-2.1	9.70	.32	.32	.32	.33	.34	6.0
57	.5	.8	2.5	14.	15.8	-.6	.00	.30	.31	.32	.33	.33	5.4
64	.6	1.2	2.2	12.	14.6	3.8	2.20	.28	.29	.31	.32	.33	4.8
71	.8	1.6	2.2	12.	14.9	4.7	7.00	.28	.28	.29	.31	.32	4.3
78	1.2	2.7	2.7	15.	15.3	5.7	27.80	.30	.31	.31	.32	.32	5.2
85	1.4	2.8	2.8	16.	13.3	4.2	5.00	.25	.27	.29	.30	.31	3.8
92	1.8	2.9	2.9	17.	15.4	1.5	80.50	.36	.36	.39	.40	.40	9.1
99	2.2	3.0	3.0	17.	17.6	2.8	11.90	.36	.32	.37	.36	.38	7.7
106	2.5	3.1	3.1	18.	18.3	2.2	66.80	.35	.44	.40	.40	.40	10.0
113	2.4	2.7	2.7	17.	15.2	1.3	12.40	.34	.35	.36	.36	.40	8.0
120	2.7	3.0	3.0	18.	16.6	3.5	3.40	.31	.32	.32	.34	.34	6.1
127	3.1	3.4	3.4	20.	17.5	2.4	8.00	.28	.29	.30	.31	.32	4.5
134	2.6	2.9	2.9	17.	18.0	2.8	82.38	.36	.45	.40	.39	.40	9.8
141	4.0	4.4	4.4	22.	23.9	5.1	.00	.30	.31	.33	.34	.35	6.1
148	4.9	5.5	5.5	24.	26.6	4.5	76.76	.36	.38	.42	.40	.40	9.4
155	4.2	4.8	4.8	23.	23.6	10.0	23.90	.35	.33	.35	.39	.39	8.0
162	5.8	6.7	6.7	26.	28.2	12.8	44.40	.31	.35	.34	.35	.38	7.1
169	5.4	6.8	6.8	22.	31.4	14.4	11.30	.28	.26	.27	.28	.30	3.4
176	4.6	6.9	6.9	22.	31.1	12.7	78.82	.28	.30	.32	.33	.35	5.6

	TOPS	NFAC	VEG N	GRAIN	NO3	NO3	NO3	NO3	NO3	NH4	NH4	NH4
DAY	N %		UPTK	UPTK	1	2	3	4	5	1	2	3
OYR			- KG N/HA -		|--------------- UG N/G SOIL ---------------|							
317	4.50	1.00	.0	.0	15.3	10.8	5.9	5.4	5.6	5.2	3.8	1.8

324	4.50	1.00	.0	.0	22.7	12.8	6.6	5.8	5.8	4.7	3.7	1.7
331	4.50	1.00	.0	.0	26.5	15.1	7.0	6.4	6.0	3.4	2.8	1.5
338	4.50	1.00	.0	.0	28.3	15.3	8.0	6.4	6.3	2.6	2.1	1.2
345	4.50	1.00	.0	.0	57.7	28.5	8.2	6.7	6.4	4.2	3.6	1.1
352	4.50	1.00	.0	.0	54.0	32.7	10.5	7.4	6.7	2.8	2.4	1.0
359	4.50	1.00	.0	.0	55.2	30.4	12.3	7.4	6.8	2.7	2.2	.9
1	4.50	1.00	.0	.0	56.7	30.3	12.2	7.8	6.8	2.4	1.9	.9
8	4.50	1.00	.0	.0	58.2	30.2	12.3	7.8	6.8	2.1	1.7	.8
15	5.10	1.00	1.6	.0	115.9	29.9	12.2	7.8	6.9	12.5	1.6	.8
22	6.31	1.00	1.9	.0	124.8	29.7	12.2	7.8	6.9	4.4	1.5	.8
29	6.25	1.00	2.4	.0	123.1	32.4	12.5	7.9	7.0	3.1	1.3	.7
36	6.19	1.00	4.3	.0	123.7	31.9	12.4	8.0	7.0	2.3	1.3	.7
43	6.50	1.00	6.9	.0	121.4	33.0	12.4	8.0	7.1	2.0	1.3	.7
50	6.85	1.00	7.7	.0	110.8	40.0	14.6	8.4	7.2	1.8	1.2	.7
57	6.81	1.00	11.2	.0	110.5	38.5	14.1	8.3	7.2	1.8	1.3	.7
64	6.52	1.00	18.6	.0	108.7	35.8	13.1	7.9	7.0	1.7	1.3	.7
71	6.30	1.00	30.9	.0	104.2	32.4	11.5	7.2	6.6	1.7	1.3	.7
78	6.10	1.00	51.7	.0	74.6	40.4	14.6	7.5	6.5	1.7	1.4	.7
85	5.85	1.00	80.1	.0	68.1	29.7	10.2	5.9	5.7	1.6	1.3	.7
92	5.61	1.00	112.5	.0	22.9	27.1	20.4	12.1	7.5	1.6	1.3	.7
99	5.36	1.00	160.4	.0	8.6	14.0	11.6	9.0	7.2	1.7	1.4	.8
106	4.67	1.00	190.3	.0	.4	.7	7.1	8.6	7.9	1.7	1.5	.8
113	3.83	.95	204.9	.0	.8	1.0	.4	2.2	7.8	1.6	1.4	.9
120	3.34	.89	222.0	.0	.3	.4	.6	.5	1.0	1.4	1.3	.9
127	2.89	.92	222.0	.0	.7	.7	.7	.6	1.0	1.4	1.3	.9
134	2.42	.90	222.0	.0	.6	.9	.9	.8	1.2	1.3	1.2	.9
141	2.09	1.00	221.4	.0	1.0	1.1	1.0	.9	1.0	1.5	1.3	1.0
148	1.78	1.00	220.2	.0	.9	1.2	1.4	1.3	1.2	1.6	1.3	1.1
155	1.57	1.00	203.5	15.6	1.2	1.5	1.5	1.4	1.4	1.8	1.6	1.2
162	1.32	1.00	152.5	65.4	1.5	1.9	1.9	1.7	1.5	2.0	1.7	1.3
169	.99	1.00	96.4	120.2	2.3	2.3	2.3	1.9	1.6	2.0	1.3	1.4
176	.59	1.00	37.1	176.3	1.9	1.9	2.4	2.3	2.0	1.5	1.2	1.5