Flowering Calculator: Parameters for predicting flowering dates of new wheat varieties in Western Australia

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Abstract

Wheat varieties need to be matched to sowing date so that flowering occurs at an optimum period when the risks of occurrence of damaging low temperature (frost), and high temperature and water stress are minimised. The Flowering Calculator, a computer program previously developed by the Department of Agriculture and Food Western Australia has been available for predictions but is not calibrated for current and new cultivars. Field experiments were conducted with about 50 current varieties over four years (2006-2009) at Geraldton (28.79 ?S), Northam (31.64?S), and Katanning (33.40?S) in Western Australia and parameters for different models in this program are presented. Comparison with observed flowering dates revealed that predictions for early sowing dates in southern latitudes were invariably earlier than actual flowering dates with all models – the inability of the model to perform at southern latitudes is the major limitation of this package. However, flowering time in the warmer, northern locations of the wheatbelt could be reasonably predicted and as such, we expect these parameters will be applicable within this region. We have tabulated in this paper the parameters of important varieties that can be used in the Flowering Calculator in the public domain. With these coefficients of parameters and the inbuilt daily average temperatures and photoperiods of the locations predictions of flowering dates can be produced for all these varieties.

Key Words

Phenology, vernalisation, photoperiod, maturity group, frost, screenings, time of sowing

Introduction

Since early part of the 20th century, it was known that sexual reproduction in many plant species is highly influenced by length of the day and prevailing temperature (Garner and Allard 1920). Crop phenology has since then been investigated and exploited to improve productivity in a range of crops.

Flowering date in spring wheat is critical to protect crops from damaging effects of frost (Gott 1961; Anderson 1988) and dry warm finishing conditions (Sharma et al. 2008). Wheat crops are known to yield the most under sowing periods which result in the crop flowering after the danger of frost damage had passed but before the period available for grain growth was significantly shortened (Single 1961; Fischer and Kohn 1966; Syme 1968).

A range of flowering models differing in complexity has been developed over time in Australia (Angus et al. 1981. Perry et al. 1987. Loss and Elliot 1988). Based on these statistical models, Tennant and Tennant (2000) wrote a menu-based program called 'Flowering Calculator' which is usable throughout Australia by selecting relevant location and the state. It allows the use of four models which range from simple heatsum accumulation to linear regression of daily development rate (DDR) on day length, mean temperature and their interaction. This software is available on a CD that can be purchased from the Department of Agriculture and Food, Western Australia (Contact: Dr Meredith Fairbanks mfairbanks@agric.wa.gov.au). A particular advantage of this application is that the reporting window graphs historical minimum and maximum temperatures and reports on the frost likelihood with changing sowing date.

However, like any other software program, the Flowering Calculator is usable only for the varieties that have their parameters included in it. Unfortunately, the package has flowering parameters for only 10 varieties (Aroona, Bodallin, Eradu, Gamenya, Miling, Gutha, Sunset, Bencubbin, Spear, WW33), most of which are obsolete. This has rendered this potentially usable tool useless for the want of parameters for current varieties. We present in this paper the parameters that we have developed for current and new wheat cultivars in Western Australia. Users can now update their copy of the program by adding these parameters to the existing 'Crops-Varieties.dat' file.

Methods

Unreplicated field experiments were conducted over four seasons (2006-2009) at three locations varying for latitude (Geraldton 28.79 ?S, Northam 31.64?S, and Katanning 33.40?S) in the wheatbelt of Western Australia. Each year, seeds were sown in one metre long rows and plant density thinned to 40 plants per linear metre where needed. Sowings in each year were done on 25 April, 16 May, 02 June, 21 June to cover the spread of the sowing period in the WA wheatbelt. Date to anthesis of 50% heads was recorded and parameters of models 1 to 4 were calculated.

Results

Table 1. Parameters for four models in the Flowering Calculator software.

Model 1: Thermal time to flowering C?d = Σ(Tm-Tb); Tm, mean daily temperature; Tb, base temperature

Model 2: DDR = a + b (Tm - Tb); DDR, daily development rate = 1/days to flower; a, temperature intercept coefficient; b, temperature slope coefficient; Tm, mean seasonal temperature

Model 3: DDR = a + b (Tm - Tb) + c DLm; c, photoperiod coefficient; DLm, mean day length

Model 4: DDR = a + b (Tm - Tb) + c DLm + d (Tm * DLm); d, temperature and photoperiod interaction coefficient

Cultivar	Thermal time for model 1	Parameters of models 2, 3 and 4					
?	[C?.d (standard error)]	Model	a	B	c	d	Adjusted R^2
Annuello	1348	2	-0.0002	0.0008			87.0
	(18.9)	3	-0.0142	0.0008	0.0013		88.5
		4	-0.0447	0.0032	0.0042	-0.0002	88.4
Arrino	1273	2	0.0002	0.0008			84.1

	(18.1)	**3**	-0.0146	0.0008	0.0014		85.4
		4	-0.0796	0.0064	0.0075	-0.0005	86.3
Binnu	1326	**2**	0.0005	0.0007			72.8
	(23.3)	**3**	-0.0148	0.0008	0.0014		74.0
		4	-0.0674	0.0053	0.0063	-0.0004	74.2
Braewood	1511	**2**	0.0015	0.0006			76.4
	(30.8)	**3**	-0.0258	0.0006	0.0025		84.8
		4	-0.0554	0.0029	0.0053	-0.0002	84.5
Bumper	1335	**2**	0.0021	0.0006			74.2
	(29.2)	**3**	-0.0342	0.0007	0.0033		90.2
		4	-0.0444	0.0016	0.0042	-0.0001	89.7
Calingiri	1370	**2**	0.0014	0.0006			81.3
	(18.0)	**3**	-0.0191	0.0007	0.0019		86.0
		4	-0.0402	0.0024	0.0038	-0.0002	85.9
Carinya	1330	**2**	-0.0004	0.0008			88.7
	(19.3)	**3**	-0.0203	0.0008	0.0018		91.7
		4	-0.0874	0.0066	0.0081	-0.0005	92.9
Carnamah	1312	**2**	0.0013	0.0007			82.9
	(17.4)	**3**	-0.0106	0.0007	0.0011		84.4

		4	-0.0638	0.0053	0.0061	-0.0004	85.1
EGA 2248	1277	**2**	0.0006	0.0007			76.3
	(20.4)	**3**	-0.0140	0.0008	0.0013		77.7
		4	-0.1287	0.0105	0.0121	-0.0009	81.5
EGA Bonnie Rock	1253	**2**	0.0000	0.0008			82.6
	(19.6)	**3**	-0.0161	0.0008	0.0015		84.1
		4	0.0093	-0.0013	-0.0009	0.0002	83.8
EGA Eagle Rock	1337	**2**	-0.0004	0.0008			82.2
	(23.3)	**3**	-0.0073	0.0008	0.0006		82.1
		4	-0.1124	0.0095	0.0105	-0.0008	85.2
EGA Jitarning	1487	**2**	0.0035	0.0004			58.2
	(27.1)	**3**	-0.0181	0.0004	0.0020		69.3
		4	-0.0771	0.0052	0.0075	-0.0004	72.2
EGA Wentworth	1333	**2**	0.0004	0.0007			80.3
	(20.4)	**3**	-0.0083	0.0007	0.0008		80.6
		4	-0.1058	0.0088	0.0100	-0.0008	83.9
Endure	1560	**2**	0.0031	0.0004			56.6
	(32.6)	**3**	-0.0254	0.0005	0.0025		73.5
		4	-0.0106	-0.0007	0.0012	0.0001	72.8

Fang	1430	**2**	0.0028	0.0005			57.9
	(37.7)	**3**	-0.0339	0.0006	0.0033		75.5
		4	-0.0006	-0.0022	0.0002	0.0003	74.8
Fortune	1374	**2**	0.0013	0.0006			70.1
	(32.1)	**3**	-0.0220	0.0007	0.0021		87.0
		4	-0.0619	0.0041	0.0058	-0.0003	86.3
GBA Sapphire	1318	**2**	0.0007	0.0007			85.4
	(17.5)	**3**	-0.0065	0.0007	0.0007		85.6
		4	-0.0883	0.0073	0.0084	-0.0006	87.6
LongReach Lincoln	1287	**2**	0.0000	0.0008			85.3
	(21.4)	**3**	-0.0186	0.0008	0.0017		87.5
		4	-0.0517	0.0037	0.0048	-0.0003	87.4
Mace	1306	**2**	0.0013	0.0007			78.3
	(28.1)	**3**	-0.0341	0.0008	0.0032		90.0
		4	-0.0323	0.0006	0.0030	0.0000	89.4
Magenta	1381	**2**	0.0011	0.0006			84.4
	(18.8)	**3**	-0.0155	0.0007	0.0015		87.6
		4	-0.0689	0.0051	0.0065	-0.0004	88.8
Spear	1468	**2**	0.0031	0.0004			69.0

	(24.7)	**3**	-0.0104	0.0005	0.0012		73.4
		4	-0.0085	0.0003	0.0011	0.0000	72.8
Stiletto	1411	**2**	0.0045	0.0004			67.4
	(35.9)	**3**	-0.0084	0.0004	0.0012		70.5
		4	-0.0115	0.0006	0.0015	0.0000	68.8
Tammarin Rock	1214	**2**	0.0015	0.0007			87.3
	(14.8)	**3**	-0.0070	0.0007	0.0008		87.7
		4	-0.0752	0.0063	0.0073	-0.0005	88.8
Wedgetail	1691	**2**	0.0051	0.0002			26.5
	(44.4)	**3**	-0.0178	0.0002	0.0021		50.4
		4	-0.0670	0.0039	0.0066	-0.0003	53.4
Westonia	1221	**2**	-0.0002	0.0008			87.4
	(17.3)	**3**	-0.0084	0.0009	0.0008		87.4
		4	-0.0978	0.0084	0.0092	-0.0007	88.9
Wyalkatchem	1288	**2**	0.0002	0.0008			84.5
	(18.0)	**3**	-0.0122	0.0008	0.0011		85.4
		4	-0.0541	0.0043	0.0051	-0.0003	85.6
Wylah	1715	**2**	0.0065	0.0001			0.4
	(66.3)	**3**	-0.0232	0.0000	0.0028		43.0

		4	-0.0131	-0.0008	0.0019	0.0001	39.3
Yandanooka	1307	**2**	0.0016	0.0006			83.0
	(16.7)	**3**	-0.0162	0.0007	0.0016		86.6
		4	-0.0380	0.0025	0.0037	-0.0002	86.6
Yitpi	1454	**2**	0.0030	0.0004			63.4
	(25.7)	**3**	-0.0123	0.0005	0.0014		67.9
		4	-0.0509	0.0037	0.0050	-0.0003	68.3
Young	1210	**2**	-0.0002	0.0008			79.6
	(25.6)	**3**	0.0066	0.0008	-0.0006		79.0
		4	-0.1680	0.0147	0.0159	-0.0013	84.6
Zippy	1178	**2**	-0.0006	0.0009			85.3
	(28.5)	**3**	-0.0247	0.0010	0.0022		87.3
		4	-0.0796	0.0059	0.0074	-0.0005	87.2

Parameters for different models in respect of current and new wheat cultivars are given in Table 1.

In order to check the reliability of the models, predictions of flowering time were made for the Geraldton site in the north and Katanning in the south using the temperature datasets of year 2007 and comparisons made with the actual flowering dates. These comparisons revealed that the model predicted flowering date with a RMSE error of 7 days for all sowing dates in the north (Geraldton) and June sowing in the south (Katanning) but deviations from expected date were high for early sowing dates (RMSE = 16 days) at southern latitudes. All the models tended to under-predict flowering date at the southern location (Katanning). We anticipate that vernalisation requirement of the varieties and the hourly temperature profile to be the likely causes.

Conclusion

Parameters to predict flowering times using the Flowering Calculator are now available for new and current wheat cultivars grown in Western Australia. The predictions at southern latitudes (33?S) showed large deviation from observed dates. However, flowering dates in northern, warmer locations at latitudes around 29?S could be reasonably predicted and thus might have application in other Australian states with similar location attributes. Given the location related observed limitations of the current model, we have now initiated the development of an improved model.

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