Comparison and Validation of Three Soybean Phenology Models

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Temperature and photoperiod regulate the duration of soybean development stages. Photothermal sensitivity varies between the genotypes, being higher in long-cycle cultivars compared with short-cycle ones. Temperature and photoperiod also vary according to geographic location (latitude) and time of the year (sowing season), generating a complex genotype-environment interaction. This interaction makes it difficult to predict crop phenological stages. A simulation model to predict the date of occurrence of these phenological stages is very useful for decision-making in crop management [1]. In this work, we compared and validated three empirical models for simulating soybean phenology stages. The three models presented in this paper are in commercial phase under the brand SIFESOJA.

We built the first model (model A) from a database generated by trials with multiple cultivars (maturation groups III to VIII) and different sowing dates (September to February each year). These trials were conducted for 10 years (2003-2013) on 23 locations in Argentina (24º to 38º Latitude South). The other two models were similar to the first one, but in this case we replaced cultivar by maturity group, splitting each group in 10 sub-groups (model B) and then in 3 sub-groups: short, medium and large (model C). The 143 cultivars included in the model A were grouped according to maturity group and sub-group and finally we calculated the parameters needed to build the models B and C. For model validation, we used data of full flower (R2), seed formation (R5), maturity (R7), and full maturity (R8) following [2], obtained on trials from the National Nerwork of Soybean Cultivar Trials [3]; the total data observed was 420. We compared these data with simulated results obtained from the three models.

The deviations between observed and simulated data were lesser than or equal to 4: i) in the 75.5 % of cases when predictions where obtained from the first model (model A); ii) 61.4 % cases when the model was B; and iii) 64.8 % when we utilized the model C (Table 1). In turn, the average deviation of the 420 cases used for validation was 3.0 days for model A, 4.1 days for model B and 3.7 for model C.

Table 1. Absolut frequency, relative frequency and cumulative frequency of the deviation between observed data and simulated data, with the three models.

Desviation	SIFESOJA A			SIFESOJA B			SIFESOJA C		
(dias)	Absolut	Relative (%)	Acumulative	Absolut	Relative (%)	Acumulative	Absolute	Relative (%)	Acumulative
0	54	12.9	12.9	35	8.3	8.3	32	7.6	7.6
1	83	19.8	32.6	61	14.5	22.9	70	16.7	24.3
2	73	17.4	50.0	75	17.9	40.7	73	17.4	41.7
3	55	13.1	63.1	43	10.2	51.0	44	10.5	52.1
4	52	12.4	75.5	44	10.5	61.4	53	12.6	64.8
5	35	8.3	83.8	41	9.8	71.2	53	12.6	77.4
6	31	7.4	91.2	34	8.1	79.3	28	6.7	84.0
7	16	3.8	95.0	31	7.4	86.7	21	5.0	89.0
8	8	1.9	96.9	17	4.0	90.7	20	4.8	93.8
9	6	1.4	98.3	13	3.1	93.8	18	4.3	98.1
10	3	0.7	99.0	10	2.4	96.2	2	0.5	98.6
11	3	0.7	99.8	5	1.2	97.4	4	1.0	99.5
12	1	0.2	100.0	0	0.0	97.4	0	0.0	99.5
13				6	1.4	98.8	0	0.0	99.5
14				2	0.5	99.3	1	0.2	99.8
15				2	0.5	99.8	1	0.2	100.0
16				0	0.0	99.8			
17				1	0.2	100.0			
Total	420			420			420		

A few cultivars had a very different behavior compared to their partner types on the maturation group. These variations explained deviations higher than 12 days on some cases in the models B and C (Table 1).

The replacement of cultivar for the maturity group and sub-group (in model B and C) increased the prediction error. However, model adjustment was reach with a mean deviation of around 4 days. We suggest the use of models B and C, given its low prediction error and independence of cultivar types (something important considering frequent actualizations and continuous emergence of new cultivars), and considering that this model is broadly adopted in all the Argentine soybean cultivation area.

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