MODELING DRY BEAN AND SOYBEAN YIELDS IN CENTRAL OREGON

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Abstract

Farmers experimented with both soybean and dry bean as new crops for central Oregon in the 1998 season. While both performed well in 1998, the summer was warmer than most and there is some doubt as to how they would perform in a more typical year. In order to estimate how these crops would produce over time, yields were predicted from 1979 to 1998 by running weather data from Prineville and Madras areas through the CROPGRO simulation model. The CROPGRO model predicted that soybean yields would be variable due to cool temperatures. The maturity group 00 soybeans were predicted to have the best performance over time with a predicted average yield of 43 bushels per acre across the 20 year period. The model predicted that dry beans would give more consistent yields than soybeans, but that frost at the end of the season will be a hazard that will need to be considered (depending on location and variety grown).

Introduction

There is increasing interest in growing soybean *(Glycine max)* and dry bean *(Phaseolus vulgaris)* as alternative crops in central Oregon. Soybean is known to have poor tolerance for cool temperatures (less than 55°F) during pod set (Hume and Jackson, 1981). Dry bean is susceptible to frost damage throughout its life-cycle. Crop modeling provides one way to obtain an initial estimate of how well these crops may do with the relatively cool temperatures of central Oregon. The CROPGRO model predicts daily growth, days to flower and maturity, and seed yield for soybean and dry bean (Boote et al., 1997). Rate of development of the crop is estimated each day based on temperature and photoperiod. The model requires inputs of genetic coefficients for each variety, daily weather data, and soil type. Genetic coefficients for each variety have to be developed or calibrated for the model. Weather data was obtained from the Oregon Climate Service for Madras and Prineville locations, where available, from 1979 through 1998 and used to simulate dry bean and soybean yields at the two locations.

Materials and Methods

The model used for the simulation analysis was the CROPGRO series of models found in DSSAT version 3.5 (IESNAT, University of Hawaii, Honolulu, HI). Weather data for 1979 through 1998 at Prineville and Madras were obtained from the Oregon Climate Service web site (www.ocs.orst.edu). Years where there were substantial gaps in the weather data were dropped from the simulation analysis. Missing values were estimated by using the average of the adjacent data points. Soil type used was a standard one given in the model for a "shallow sandy loam" with a depth of 60 cm. For soybean simulation, standard genetic coefficients given for generic maturity group 000, 00, 0, 1, 2, and 3 varieties already in the model were used. For dry bean, three contrasting genotypes already in the model were used with modification to make their

predicted time to maturity for 1998 match that observed in the variety trial at Madras (also in this report). The three genotypes were: 'Canadian Wonder', `UI 114 Pinto', and 'Seafarer'. Each line was calibrated to have a predicted flowering date of 42 to 43 days after planting (DAP) in 1998. Physiological maturity for each line was then calibrated to both 93 and 87 DAP (so there was a set of 6 hypothetical dry bean varieties) by modifying time from seed set to physiological maturity. The 93 DAP maturity date came directly from the variety trial data gathered in 1998. The 87 DAP value was added because it appeared that cutting off irrigation earlier might have brought about more rapid maturity - so to give a broader base to the analysis, the 87 DAP maturity date was also calibrated for. Other than these two phenological traits, no other genetic coefficients were changed in the model. All model runs were made with a 1 June planting date. All results for dry bean are presented as the mean of the 6 hypothetical varieties. Soybean data are presented by maturity group. All yield data is set at 12 percent moisture. The model was set to irrigate 40 mm (1.6") of water every 4 days from the end of June through the first week of September at Madras. For this same period at Prineville the model was set to irrigate 20 mm of water (0.8") every four days, except in 1981 when it was set to 40 mm (the model didn't predict drought stress for the other years at Prineville, so the irrigation amount was left at 20 mm).

Results and Discussion

Soybean. Model results should only be taken as estimates to get a general idea of how soybeans may perform in central Oregon. The mean and range of predicted soybean yields and time to maturity for each maturity group are given in Table 1. The model predicted that varieties with maturity group 00 (adapted to northern Minnesota and North Dakota in the Midwest) would give the greatest average yield over the 20-year period with yield being near 50 bushels per acre in good years and less than 20 bushels per acre in poor years. Looking at variation across the period (Fig. 1), the model predicts that 1993 would have been a particularly poor year with yields less than 20 bushels per acre. The last season, 1998, was better than most. In terms of season duration, frost was predicted 1 year out of 5 at the end of the season; however, the frosts came late enough that they probably wouldn't be a limitation for soybeans.

These model predictions suggest that central Oregon may be too cool to get consistent yields from soybeans. Cold tolerance will be an important trait for any variety to do well here. Also, if higher-value soybeans, such as varieties used for tofu or tempe could be grown here, it would increase the margins in better years and might justify the risk of periodically having a poor year. Future research with soybean in central Oregon should probably focus on identifying cold-tolerant, food (or some other high-value) soybean varieties.

Table 1. Range and mean of soybean yields and time to maturity predicted by the CROPGRO model for 6 maturity groups of soybean grown at Madras over a 20 year period (1979-1998). The model predicted that maturity group 2 would not reach maturity in most years, and that group 3 would not in any year, therefore their times to maturity are indicated on the table as "n/a".

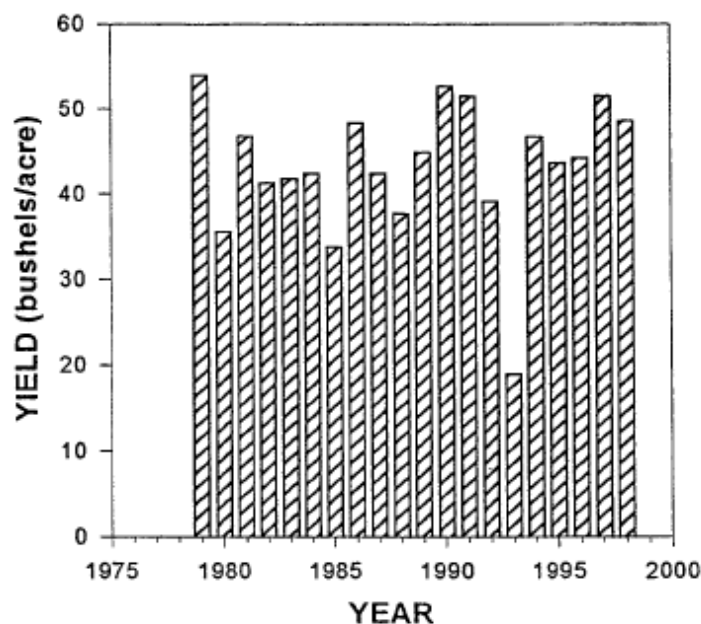| Maturity Group	Seed yield			Time to maturity		
	Least	Average	Greatest	Least	Average	Greatest
		(bu/acre)			(DAP)	
000	22.2	41.6	51.6	97	104	111
00	18.9	43.3	54.0	101	108	115
0	10.3	40.6	57.0	108	116	125
1	6.9	34.5	55.7	116	124	131
2	0.8	19.1	52.5	127	n/a	n/a
3	0.0	5.4	26.0	n/a	n/a	n/a

Figure 1. Predicted yield of a standard maturity group 00 variety simulated over a 20 year period with the CROPGRO computer model. The model predicted low yields for 1993 because of cool night temperatures during pod set that season. The average predicted yield across the 20 year period was about 43 bushels per acre. Note that 1998 was a better year than most.

Dry Beans. The dry bean model is not as well tested as the soybean one, so results should only be taken as general estimates of dry bean performance in central Oregon. Comparing predicted yield to actual for the dry bean variety trial at the Madras experiment station, the model was within 10 percent of actual values (4500 lbs per acre predicted, versus 4230 lbs per acre actual average yield for the 10 best lines in the trial). However, yields on commercial fields in the area were typically closer to 2600 lbs per acre, so the dry bean model over-predicted yield relative to what might be expected in a production environment. The model doesn't predict yield losses due to disease or shattering at harvest. Because of the uncertainty of the model predictions, 1998 will be used as a benchmark for evaluating results.

The model predicted that 1998 was a typical season for yield at Madras (about 90 percent of the 20-year predicted average; Fig. 2), and a better year than most at Prineville (Fig. 3). In terms of season length, 1998 was the shortest predicted season in the 20-year period at both sites, about 5 days shorter than predicted average at Madras, and about 7 days shorter than predicted average at Prineville. This was because July and August had higher temperatures than normal in 1998. The model predicted occurrence of frost at the end of the season one year out of five at Madras. Given that this occurred at the end of the season, it is not clear what effect this would have on the value of the crop. The frosts occurred late enough that seed yield would probably not be greatly affected, but whether it would affect the pigmentation of the seed or not is uncertain. The model predicted frost 8 years out of 15 at Prineville with 6 of these frosts occurring at the end of the season and 2 occurring early in the season. The two frosts which occurred early in the season (second and third week of June) resulted in zero predicted yield in 1991 and 1996. Again it is unclear what effect, if any, the frosts at the end of the season might have on the value of the crop. The weather data for Prineville was collected at the KRCO station, which is reported to be a relatively cooler part of the Prineville area. Areas with a warmer microclimate than the KRCO radio station would stand less risk than the model indicates.

In conclusion, results of the dry bean simulation indicated that farmers may expect fairly similar yields to what they obtained in 1998 in the future, as long as the crop is not subject to frost. According to the model, the average growing season for dry bean in central Oregon will be 5 to 7 days longer than that observed in 1998. Obviously, short duration will be an important trait for varieties to do well in this area.

Literature Cited

Boote, K. **J., J. W.** Jones, and G. Hoogenboom. 1997. Simulation of crop growth: CROPGRO model. **p. 18.1** to 18-42. *In* Peart and Curry (ed.) Agricultural Systems modeling and simulation. Marcel Dekker, New York, NY.

Hume, D. J., and K. H. Jackson. 1981. Pod formation in soybeans at low temperatures. Crop Sci. 21: 933-937.
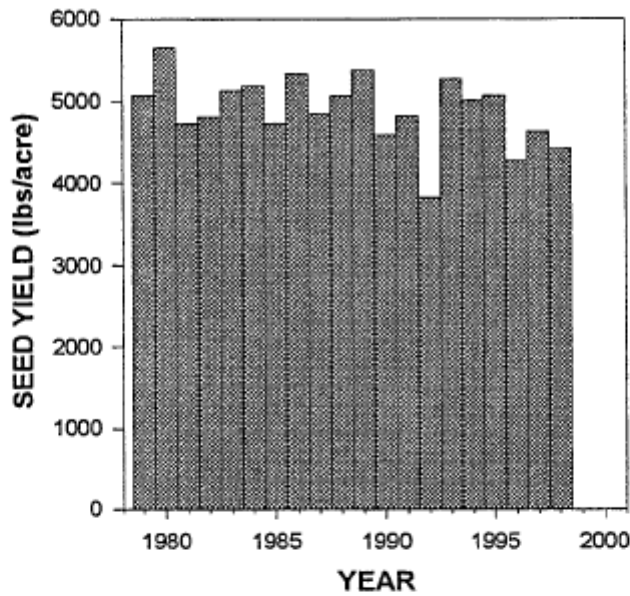
Figure 2. Predicted dry bean yields at Madras, 1979-1998, as simulated by the CROPGRO model.
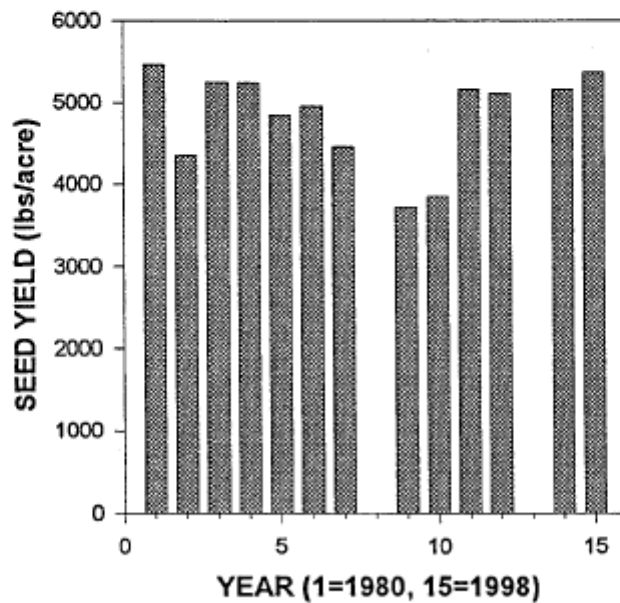

Figure 3. Predicted dry bean yields at Prineville, 1980-1998 (with skips) as simulated by the CROPGRO model. In two years (1991 and 1996), the model predicted no yield due to frost damage early in the season. The years 1983, 1984, 1987, and 1988 were not simulated due to lack of weather data.