Using a Computer Application to Predict Irrigated Alfalfa Yield

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Introduction

Alfalfa (*Medicago sativa* L.) is the leading cash crop (>$185 million) in the state of New Mexico and is grown on more than 250,000 acres (NM Agricultural Statistics, 2006). It is likely that alfalfa interest and plantings will increase across the state as rapid dairy industry expansion continues to dictate which crops will be grown in a particular area. Due to its excellent nutritive value, alfalfa is highly sought after by dairies for mixing into feed rations. There exists a constant need for current and reliable management information relating to alfalfa production and how the crop can be grown most efficiently with as little resource use as possible. Yield prediction is difficult not only from one year to the next, but between cuttings in a given year. Being able to estimate yields by using simple, physical methods is one step in improving overall understanding of field potential and input efficiency. The purpose of this publication is to describe the *Alfalfa Yield Predictor*, a computer model that predicts alfalfa yields, based on user-input parameters such as fall dormancy rating, cutting (or general time of year), plant height at time of cutting, growing degree days, and rainfall, even under irrigation. All of these parameters may be valuable tools for assessing potential alfalfa yields in New Mexico. It is our hope that this publication will assist New Mexico Cooperative Extension Service personnel, producers, consultants, and government personnel by providing a fast, user-friendly application for estimating alfalfa yields.

Materials and Methods

The *Alfalfa Yield Predictor* was developed from a four-year (1998-2001) dataset generated from a study conducted at the New Mexico State University Agricultural Science Center at Tucumcari, New Mexico, USA (35.20º N, 103.68º W; elev. 4086 ft). Alfalfa was sown at 20 lb/ac 30 April 1997 into a Canez fine sandy loam soil. All seed was uniformly inoculated before planting with a product including *Sinorhizobium meliloti* and *Rhizobium leguminosarum* biovar *trifolii*. Fall dormancy (FD) categories of alfalfa ranged from 2 to 9 and varieties used were: Viking I representing FD 2; DK127, Garst 645, and Rainier representing FD 3; Jade II and Landmark for FD 4; Archer and Baralfa54 within FD 5; Tahoe and Wilson representing FD 6; Dona Ana and Helena 7000 for FD 7; 13R Supreme and WL525HQ within FD 8; and Salado and WL612 for FD 9] (Alfalfa Council, 1999).

Irrigation was furrow applied. Irrigation water was delivered through gated pipe into furrows spaced 3 ft apart for sufficient duration to completely wet the area between furrows. Irrigation and fertility were adequate throughout the duration of the collection period.

Harvests were scheduled when the first flower was observed and were executed often within 5 days, before any plot reached 10% bloom but after all plots had reached bud stage. Dry matter yields leaving a 3-in stubble were measured five times May through September, based on first flower, and near the end of October, allowing a 6-week fall rest prior to anticipated first fall temperature of 24°F (Bootsma and Suzuki, 1985; Sholar et al., 1983; 1988). Natural height of alfalfa was measured just prior to each harvest as described by Field et al. (1986) and Rhodes and Collins (1993).

Weather data were collected from a National Weather Service station located within 1 mi of the study area. Growing-degree-days (GDD, base temperature 41°F; Sanderson et al., 1994; Sharratt et al., 1989) were calculated for each harvest, beginning after the last spring temperature of 41°F or less and between the final harvest and the first fall temperature of 41°F or less (Sholar et al., 1983; 1988). The beginning and ending temperature of 41°F was used because alfalfa can initiate growth at lower temperatures (Sharratt et al., 1989) and continues to remain green throughout the winter at this latitude (Sholar et al., 1983).

Alfalfa Yield Predictor Application

The *Alfalfa Yield Predictor* (fig. 1) is a query application that retrieves actual measured records according to user-input requests. The application retrieves all of the records that satisfy requested criteria. The application presents a histogram, an exceedance curve and all relevant statistics for a selection.

The field trial dataset has 3,072 records from which the application filters the data according to user selections of FD, cutting, height, GDD, and rainfall. For FD and harvest, users can make selections from drop boxes. Users can select FD = 2 to 9 and 1 to 6 cuttings corresponding to May through October harvest dates. It is possible to select ‘All’ for these two parameters, meaning that all records on that parameter will be used to calculate the predicted yield. In the cases of height, GDD, and rain, the user needs to select a range between a minimum and a maximum value for each one of these parameters. For the minimum and the maximum values in the subset selected, as a reference, these are presented above the drop box menus. The box menus have pre-defined values that the user can select. It is also possible for the user to enter values directly into the drop boxes.

After entering information for these five parameters, the user can click a button to *predict* the yields. The application will then select the appropriate records and display the results in the same screen where the selections were made. The application for default, at first opening, displays the results from a broad selection including all FD, all cuttings, and all minimum and maximum values found for height, GDD, and rainfall. Also at first opening, the application shows the statistics and distribution of the 3,072 records measured in the field trial. The user can custom-tailor these estimates to his /her specific situation. For each prediction, the statistics will show how many field records were used for the calculations.

We insisted on presenting probabilistic results in order to provide the user with a more complete picture of all the information, to better suit the decision-making process. Probabilistic results help users to make better decisions according to their risk aversion characteristics. For example, for a selection of FD = 6 and a harvest = 4, there will be 64 records with an average of 1.59 tons/ac. However, the minimum value could be as low as 1.24 tons/ac and the maximum as high as 2.00 tons/ac. Additional information presented through the exceedance curve allows the user to make these extra decisions. If the user's goal is to produce at least 1.25 tons/ac, the curve indicates that it is a reachable goal; there is a probability that the yield falls short in only 3% of the cases. Similarly, if the user wants to know the probability of producing 1.75 tons/ac or more, the application will respond to that question immediately, indicating that a 1.75 tons/ac yield or more will occur in one of every seven harvests (14% of the time =100-86%).

We attest the fact we are not using mathematical equations to predict alfalfa yields. We are presenting all the measured yield variability obtained under field conditions defined by the parameters selected in the application. When smaller ranges are selected for the parameters, fewer observations are returned. If the selection is too specific, there is a possibility of obtaining invalid results. If the selection is too narrow to obtain any record, the application will present a message letting the user know that.

Results and Discussion

This section shows some outcomes obtained using the *Alfalfa Yield Predictor*. The purpose of showing these results is twofold. First, it summarizes the yield of alfalfa during four years of experiments according to fall dormancy, harvest timing, height, growing degree days, and rainfall. Second, it provides a reference for the application user.

Overall alfalfa yield for all fall dormancies (FD) was 1.39 ton/ac (fig. 2-All). The SD for all data was 0.51 ton/ac, the minimum registered yield was 0.03 ton/ac and the maximum was 3.27 ton/ac. The mean value is higher than the median and the distribution was slightly skewed to the right. Five percent of the yields were 2.25 ton/ac or higher and 10% of the yields were 0.75 ton/ac or lower. Yield increased together with fall dormancy until FD 6 and 7 (fig. 2), from where it decreases again. The average yield for FD 6 and 7 was exactly the same (1.46 ton/ac); however the SD was slightly higher for FD 6 and the maximum value was also lower for FD 6 (2.90 versus 3.00 ton/ac).

Higher alfalfa yields are expected during third harvest (1.61 ton/ac) (fig. 3), although harvests 2 to 4 are very comparable (≥1.55 ton/ac). However, harvest 2 has higher probabilities of obtaining yields above 2.00 ton/ac than harvest 3 and 4, indicated by their less steeped probability of exceedance curve. Harvests 5 and 6 are substantially lower than the others (1.21 and 0.83 ton/ac, respectively). Notice how the curves vary greatly among harvests. With the exception of harvest 4, all other distributions had negative kurtosis, indicating a flattened distribution around the mean, that is, a low probably of having many extreme values at most harvests. Even though harvest 4 has positive kurtosis, this doesn't necessarily mean that the 4th cutting will have a greater chance of extremes, as indicated by a large number of observations (>200) around the mean. Harvests 4 to 6 have negative skewness suggesting that the distribution has a large proportion of scores grouped on the low end (left tail); this could mean that with later harvests in the season, there is a greater chance of obtaining lower yields.

Regarding height of plants before harvesting, as expected, taller heights had higher yields, from a mean of 0.30 ton/ac for heights 10 in or lower to a mean yield of 1.91 ton/ac for heights above 30 in (fig. 4). Yields for heights 10 in or lower had only a 16% probability of being higher than 0.50 ton/ac, whereas yields for heights above 30 had a 91% probability of being above 2.25 ton/ac. In similar fashion, yields were directly impacted by growing degree days (GDD); higher yields are expected for greater GDD accumulated (fig. 5). Whereas with 980 ºF GDD or less there is a 94% of chance of having yields lower than 1.75 ton/ac, with 1,500 ºF GDD or greater, there is only a 9% of chance of having yields lower than 1.50 ton/ac.

Conclusions

The *Alfalfa Yield Predictor* can be openly and freely downloaded at http://dairy.nmsu.edu: Tools. It is a spreadsheet containing macros that need to be enabled at first use. A document over the specifics of downloading and using the application (user-guide) is also available at the same website.

The *Alfalfa Yield Predictor* is a database query application that retrieves information on-demand with respect to user selections. The purpose of the application is to provide alfalfa producers, crop advisers, Extension agents, and other interested stakeholders a user-friendly computer application for the anticipation of yields according to determined parameters of fall dormancy, harvest, standing crop height, growing degree days, and rain. In contrast to other applications, the Alfalfa Yield Predictor provides not one average yield as a result of a query, but a whole distribution of yields for better decision-making.

The *Alfalfa Yield Predictor* can also play a role as an application model to be replied under different environmental conditions or by other crops or livestock farm activities.

Acknowledgements

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References:

Alfalfa Council. 1999. Fall dormancy and pest resistance ratings for alfalfa varieties, 1999/00 edition. The Alfalfa Seed Council, Davis, CA.

Bootsma, A. M. Suzuki. 1985. Critical autumn harvest period for alfalfa in the Atlantic region based on growing degree-days. Can. J. Plant Sci. 65:573-580.

Field, L., B. Melton, and C. Currier. 1986. Fall growth of alfalfa and cultivar adaptation. Res. Rep. 595. New Mexico State Univ. Agric. Exp. Stn., Las Cruces, NM.

New Mexico Agricultural Statistics Service. 2006. New Mexico Agricultural Statistics – 2006. USDA-NM Dept. of Agric., Las Cruces, NM

Rhodes, I., and R.P. Collins, 1993. Canopy Structure. *In* A. Davies, R.D. Baker, D.A. Grant, and A.S. Laidlaw (ed.). Sward Measurement Handbook, 2nd Ed. The British Grassland Society, Reading England.

Sanderson, M.A., T.P. Karnezos, and A.G. Matches. 1994. Morphological development of alfalfa as a function of growing degree days. J. Prod. Agric. 7:239-242.

Sharratt, B.S., C.C. Sheaffer, and D.G. Baker. 1989. Base temperature for the application of the growing-degree-day model to field-grown alfalfa. Field Crops Res. 21:95-102.

Sholar, J.R., J.L. Caddel, J.F. Stritzke, and R.C. Berberet. 1983. Fall harvest management of alfalfa in the Southern Plains. Agron. J. 75:619-622.

Sholar, J.R., J.F. Stritzke, J.L. Caddell, and R.C. Berberet. 1988. Response of four alfalfa cultivars to hall harvesting in the Southern Plains. J. Prod. Agric. 1:266-270.

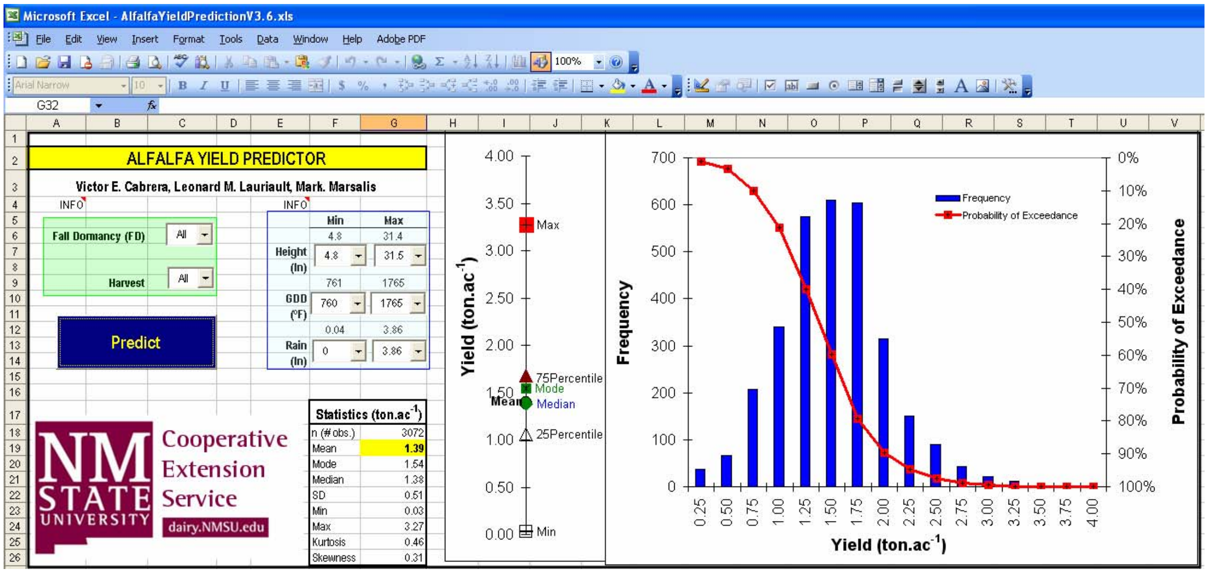

Figure 1. The *Alfalfa Yield Predictor*.

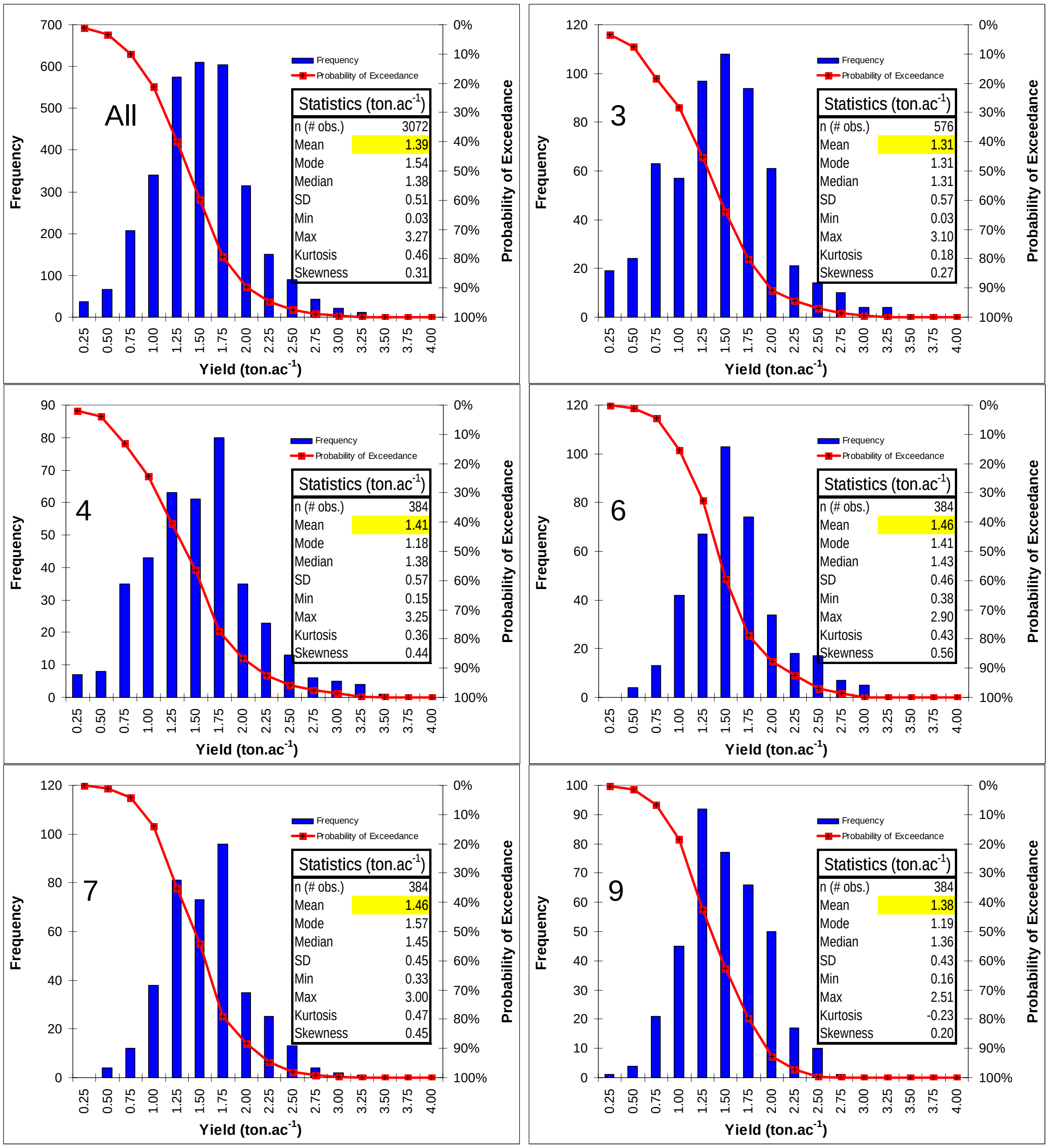

Figure 2. Alfalfa yield distributions for all and fall dormancies (FD) 3, 4, 6, 7, and 9.

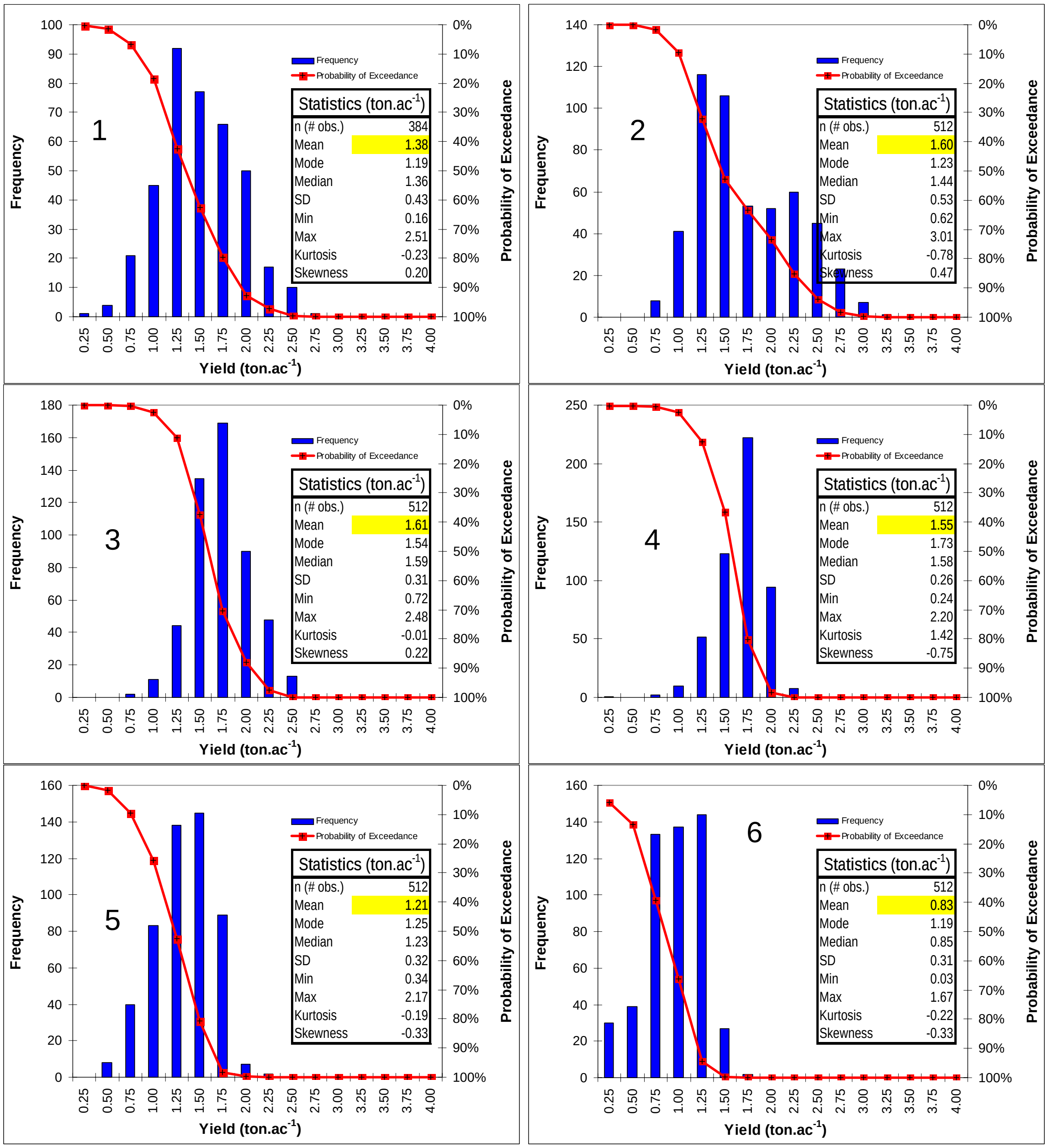

Figure 3. Alfalfa yield distributions for harvest 1 to harvest 6.

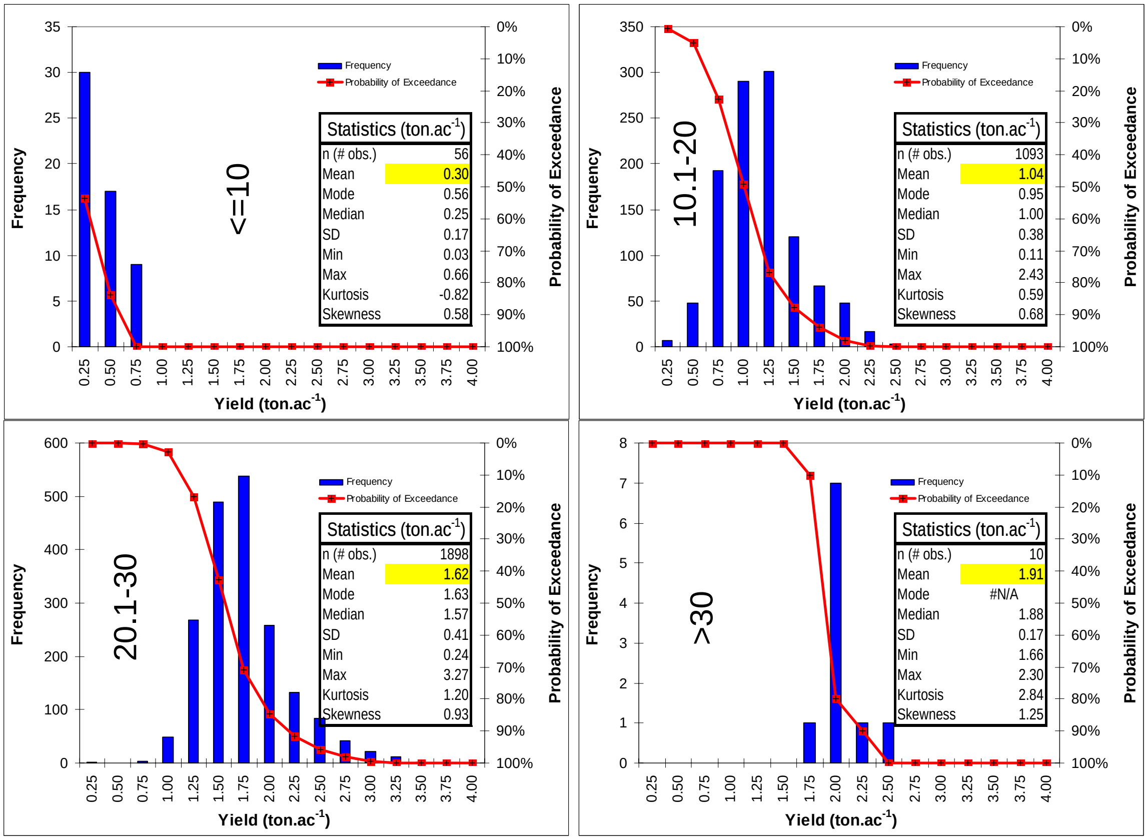

Figure 4. Alfalfa yield distributions for different height ranges: ≤10, 10.1-20, 20.1-30, and >30 in.

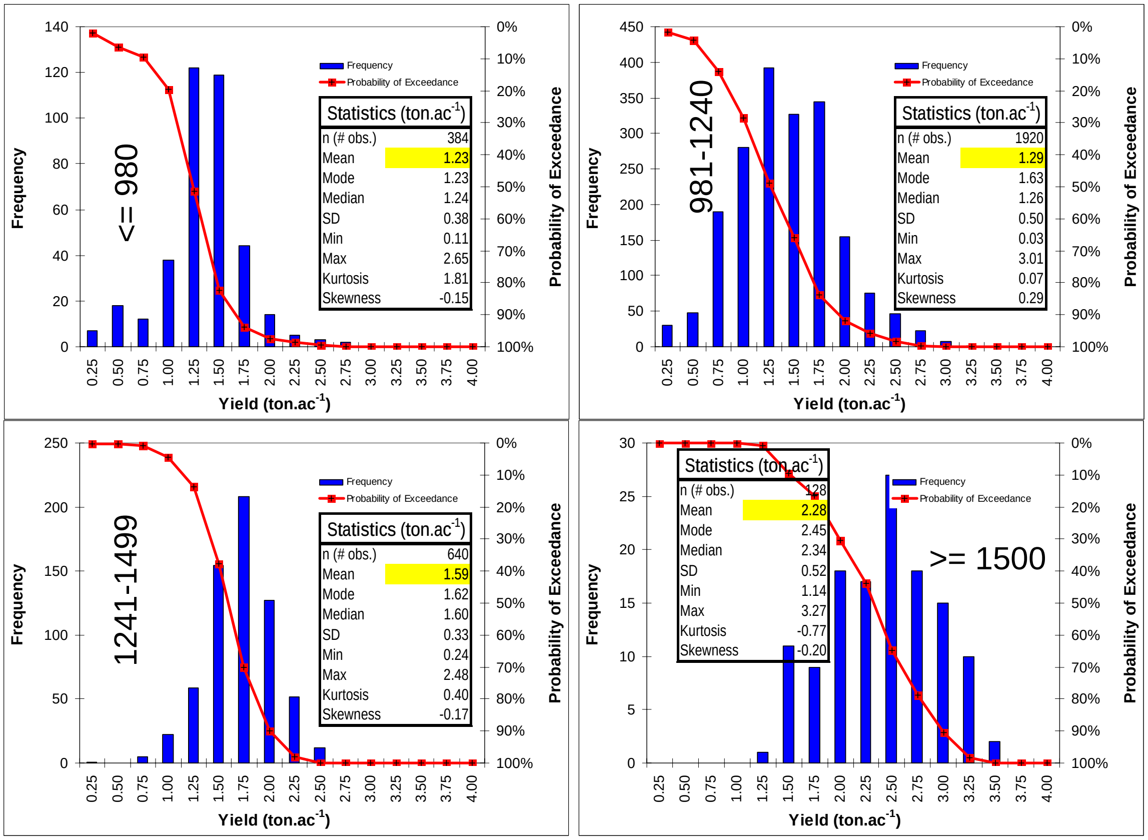

Figure 5. Alfalfa yield distributions for different growing degree days: ≤ 980, 981-1240, 1241-1499, and ≥ 1500 ºF.