ESTIMATING THE ECONOMIC VALUE OF ALFALFA VARIETY SELECTION

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ABSTRACT

Economic analysis of yield differences due to variety selection provides a rational approach to selection of seed for planting. Partial economic returns due only to variety choice can be over $500 per acre per year for any given site, and can accumulate to thousands of dollars per acre over the life of the stand. Examination of the economic returns from a single variety trial provides some indication of the potential reward due to variety selection. This reward nearly always exceeds the higher cost sometimes charged for superior varieties. Long-term estimated economic returns due only to variety selection were determined for every multiple-year trail conducted in California over the past 30 years in Intermountain (3-4 harvests per year), Mediterranean (6-8 harvests), coastal (4-5 harvests) and Desert (6-11 harvests) environments. The maximum potential yield differences due to variety are worth an estimated $319 million in California each year; not including other traits such as disease and insect resistance, persistence, quality, or biotech traits such as Roundup-Ready. Agronomic factors (poor pest management, irrigation mistakes, soil fertility limitations, and cutting schedules) can sometimes mask genetic differences due to variety choice; nevertheless variety selection is a critical economic factor, providing opportunities for improved profitability for farmers. It is clear that variety performance (yield, pest resistance, quality, persistence) is economically much more important than seed cost. See http://alfalfa.ucdavis.edu for current variety information.

Key Words: alfalfa variety testing, genetics, economics, cultivar choice, yield

VARIETY SELECTION SETS THE UPPER LIMIT OF YIELD & PERFORMANCE

There are many influences on crop productivity, quality, and overall profitability. Stand establishment practices, cutting schedule, soil fertility, irrigation, harvest schedule, and pest management are frequently more important factors in determining yield and quality than cultivar selection. However, alfalfa cultivar selection sets the upper genetic potential for crop yield and other performance traits. The seed planted by a farmer represents decades of careful selection by private seed breeders or University scientists. Competition between seed companies assures a wide range of varieties available to farmers – there are over 250 currently listed by the National Alfalfa and Forage Alliance (see www.nafa.org for up-to-date listings). Variety testing programs provide an independent and scientific approach to cultivar selection, but growers still frequently favor inexpensive seed. An economic analysis enables a more rational approach to the value of

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variety data when used to guide cultivar selection. The objectives of this paper are to estimate the economic value of variety selection for individual variety choices, and to evaluate the more global economic value of varieties to California alfalfa production.

ALFALFA CULTIVAR TESTING

The University of California Alfalfa Cultivar Testing Program is one of the most comprehensive in the United States (Figure 1). Varieties are evaluated via yield tests at 7-8 locations/year. Varieties range in Fall Dormancies (FD) from 3 to 11, and the number of cuttings ranges from 3 to 11 per year. Locations match the key major alfalfa production areas in the state: Intermountain, Sacramento Valley, San Joaquin Valley, High Desert and Low Desert environments. Protocols used are those recommended by The North American Alfalfa Improvement Conference, with approximately 3 x 20 ft plots at all locations, minimum of 4 replications, with Randomized Complete Block Designs. A nationwide listing for variety tests from all states can be seen at: http://www.naaic.org/Resources/yields.html

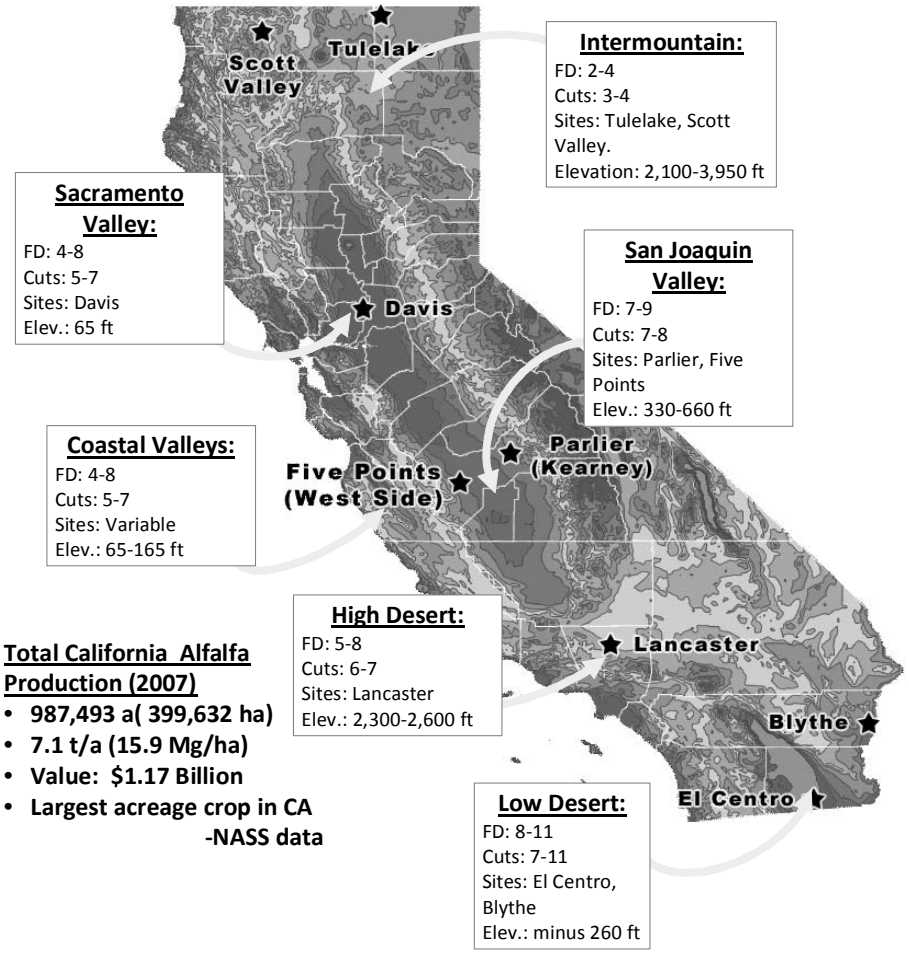

Figure 1. Locations used for the UC alfalfa cultivar testing program

ECONOMIC ANALYSIS OF SINGLE TRIALS FOR VARIETY SELECTION

If one examines a yield trial dataset (see http://alfalfa.ucdavis.edu for a complete listing of variety trial data from UC), the difference between the highest- and lowest-yielding variety may range from about 0.5 tons/acre on the low end, up to 2 or 3 tons/acre for a single year. Ascribing a zero value to the lowest-yielding variety enables a measurement of the potential economic value of these genetic differences as measured by yields in that trial. Figure 2 shows the economic difference for a single year (Davis, 2009). Differences due only to variety were as over $500/acre in this example In a multi-year (3 year) dataset from Fresno County, California, these differences were over $2,000/acre over three years (Figure 3). These numbers indicate the maximum potential advantage due to variety selection as observed in the trials. Seed costs generally differ by a maximum of about $3/lb in US markets (or approximately $60/acre at 20 Lbs/A seeding rates). Thus, relative costs of improved seed are easily covered by the yield advantages of superior varieties, even in a single year.

Keep in mind that these economic estimates do not include advantages that may be due to disease and insect resistance, stress tolerance, improved quality, biotech traits or other traits – only yields. Also, the potential yield advantages of improved varieties may not be fully realized in farmers' fields for a variety of reasons, including the masking of variety differences with sub-optimum cutting schedules, irrigation, or pest management.

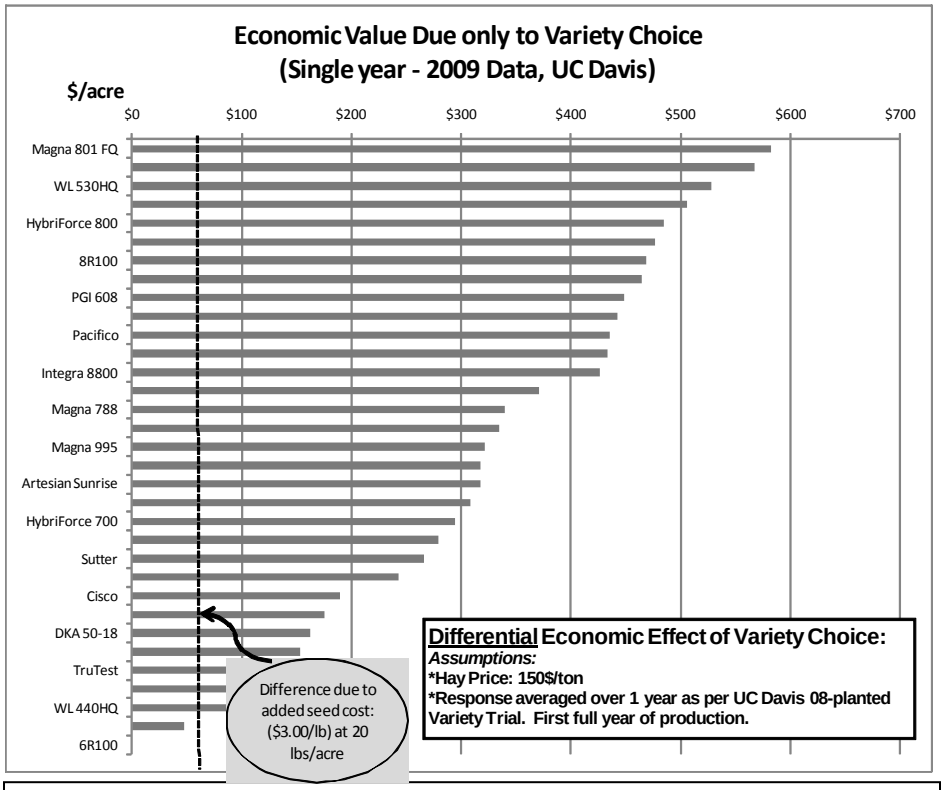

Figure 2. Partial economic returns of each variety calculated compared to the lowest yielding variety from a first year trial conducted in Davis, CA, 2009. These are differences based only

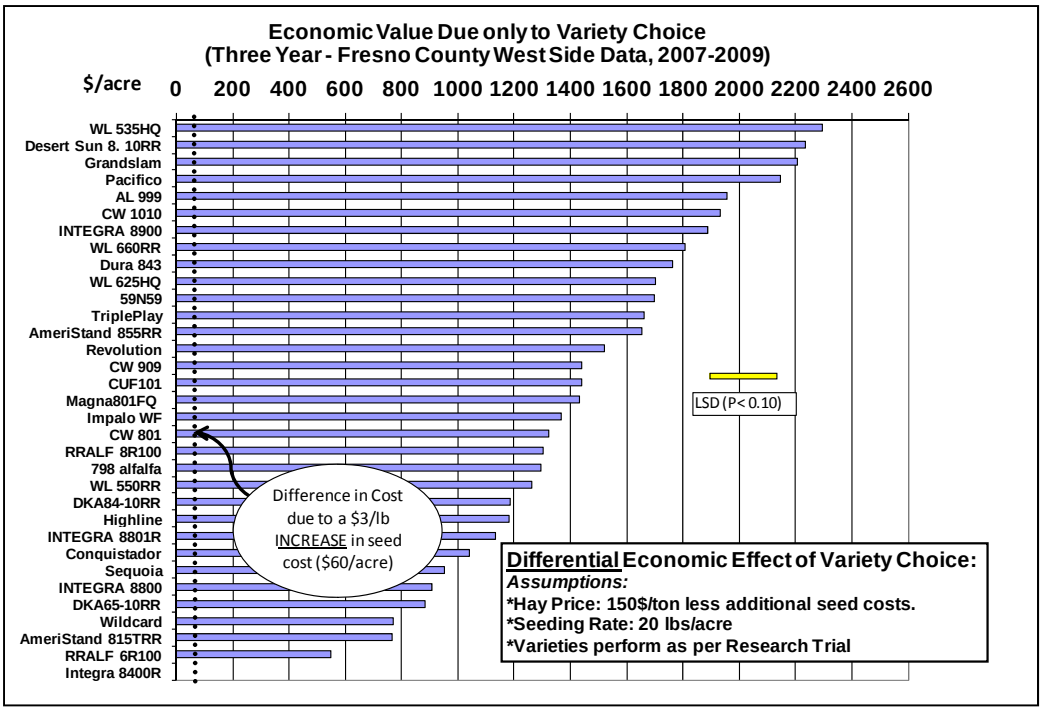

Figure 3. Partial economic returns due to variety, calculated based on yield differences in a three year trial conducted in Fresno County, CA. Difference in cost due to $3 increase in seed price is illustrated.

THE VALUE OF IMPROVED VARIETIES ALMOST ALWAYS EXCEEDS DIFFERENCES IN SEEED COSTS.

Growers clearly don't like higher seed prices, and therefore gravitate towards lower-cost seed. Yet, they often ignore the far more important economic factor of yield potential during planting decisions. Figures 2 and 3 show the differences in crop yield compared with the increased cost of seed that may be associated with seed of a higher-yielding variety. Table 1 illustrates different scenarios where gross returns are significantly impacted by choice of variety compared with the cost of seed. Although growers tend to look for a "good deal" while choosing alfalfa seed, the current economic situation (relatively inexpensive seed and reasonable hay prices) clearly favors higher yielding (and more expensive) seed to cheaper seed that does not perform as well. Even a four fold increase in seeding rates does not have a significant impact of gross returns compared with differences in yield (Table 1). By choosing a higher yielding variety, Seed A, instead of Seed B (at a seeding rate of 30Lb/A) a farmer would have an extra return of 179% ($510/A). This table considers hay prices at $150/ton, using actual yield performance data from the UC Variety trial in Five Points, CA, Fresno County.

Table 1. Economic consequenses of choosing varieties which differ in yield as well as seed cost. It is clear that yield and other performance traits are economically more important than seed cost. Variety yield data (varieties A, B, and C) are real data taken from the UC Variety trial, Five Points, CA (2007-

	Choice of Variety		
	High Yielding Variety (Seed A)	Medium Yielding Variety (Seed B)	Low Yielding Variety (Seed C)
Seed price ($/Lb)	3.50	2.50	1.50
Potential yield (ton/A/yr)	12.8	11.6	10.9
Seed cost ($/A)	87.50	62.50	37.50
* Gross Returns 3yrs ($/A)	5,760	5,220	4,905
Net - Seed cost ($/A)	5,673	5,158	4,868

Seeding Rate (Lb/A)	Difference in Return ($/A) vs. lower yielding variety**		
10	835	305	-
20	815	295	-
30	795	285	-
40	775	275	-

* Gross Returns = Potential yield (from variety trials) * $150

** Assuming differences among A, B and C are only due to variety choice

Hay price = $150

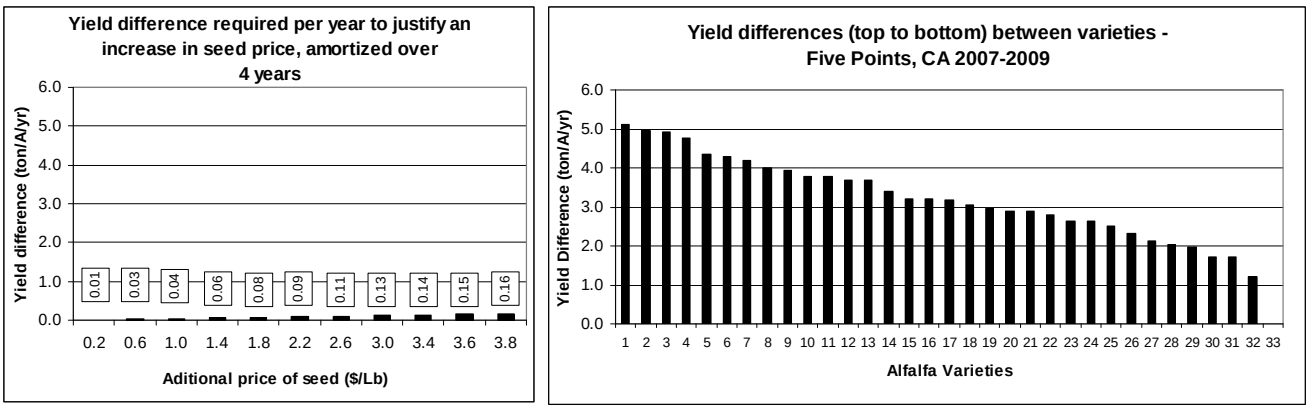

Figure 4. Yield difference (ton per acre per year) required to justify increases in seed price of improved varieties (left) compared with average annual differences between highest and lowest yielding varieties at a 3-year trial in Five Points, CA (2007-2009).

WHAT CAN YOU AFFORD TO PAY FOR A BETTER VARIETY?

Most will answer that question 'as little as possible'. However, let's examine this a little more closely. Although the yield of improved varieties can have a significant impact on economic returns (see above), seed costs represent only approximately 12% establishment costs, and 2% of alfalfa production costs over a 4-year stand life (Figure 5). Yield differences required to justify a $1, 2, $3 or even $4 per pound increase in seed price is shown in Figure 4, left. A large seed-price difference of about $4 a pound requires only 0.16 tons/year of alfalfa hay to justify that

increase. This is a very small difference compared with the magnitude of the differences commonly observed in our yield trials (see Figure 4, right). What other inputs provide a 5 to 10 fold return on investment? The reality is that seed prices don't vary this much. It is clear that you are better off evaluating the performance potential rather than concentrating too much on the seed cost.

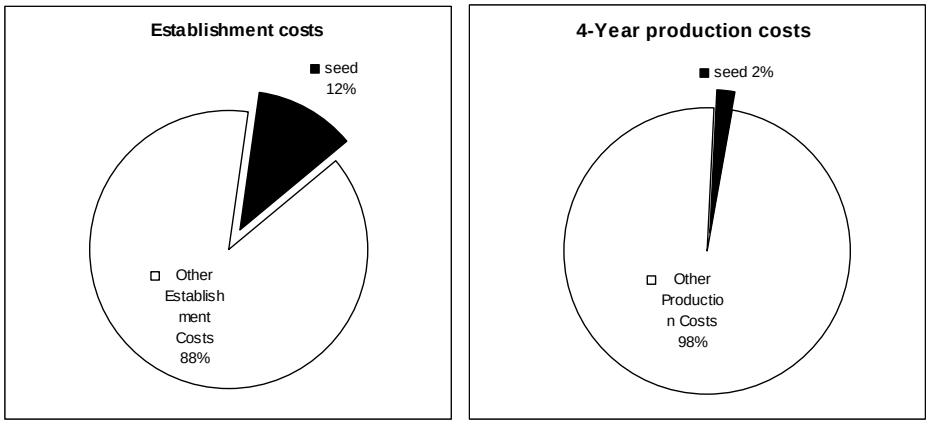

Figure 5. Seed cost as a percentage of production costs during stand establishment (left) and production costs over 4 years of production (right).

WHAT IS THE OVERALL VALUE OF VARIETIES TO THE CALIFORNIA ALFALFA INDUSTRY?

We have been testing alfalfa varieties for many decades here in California, as have many other states. The question may be asked: *What is the value of all of that data to the California alfalfa industry?*

This is difficult to answer directly. Although seed companies utilize these yield tests (and their own yield tests) to choose the varieties to promote, and farmers and seed salesmen use these data to select seeds for specific fields, we do not know the degree to which this occurs. It would depend upon the extent of adaptation, and the extent to which these data transfer to field conditions.

Table 2. Summary of Alfalfa Cultivar Trials conducted from 1974 through 2009 in the different production regions of California. Each N is the summation of a multi-year trial (for example, a 3-year trial, 35 varieties, 7 cuts/year at Davis). The average yield difference is the top-to-bottom difference averaged across all the trials in a region. Most trials are conducted for 3 years. Statewide averages are weighted based upon percent acreage of regions.

Region	Number of Trials	Harvests Per year	Duration of Testing	Total Number of Harvests	Average Trial Yield	Average Yield Difference Due to Variety	Regional Contribution to CA Production	Potential Yield Difference Due to Variety
	(N)	Cuts	Years	(N)	t/a	t/a	%	%
Intermountain	32	3 to 4	128	379	6.2	1.5	10%	23.9%
Sacramento Valley	27	5 to 7	87	498	9.3	2.6	14%	28.4%
San Joaquin Valley	25	7 to 8	86	556	10.1	3.5	54%	34.3%
Coastal	4	4 to 5	9	38	4.0	1.1	1%	27.4%
High Desert	4	6 to 7	12	78	9.2	1.8	2%	19.1%
Low Desert	21	8 to 11	56	356	7.8	1.6	20%	21.0%
Statewide	**113**	**6 to 7**	**378**	**1905**	**8.9**	**2.7**	**100%**	30.0%

Potential Variety Impact on Yield and Dollar Return. One way to calculate the value of varieties is to determine the potential differences that might be due to variety that we have observed in yield trials. We summed up more than 30 years of yield testing in California (Table 2). The key production areas where we have done the greatest number of yield tests include the Intermountain area, the Sacramento and San Joaquin Valleys, and the Low Desert (Imperial Valley and Blythe), but we have also conducted tests in the High Deserts and Coastal regions. The yield difference between the top to the bottom yielding varieties in each trial was calculated, and then we averaged this yield difference across all of the trials within a region. The average yield of California variety trials over 378 location/years was 8.9 tons/acre (averaged over locations, and weighted for the relative acreage of the different production zones). As a percent of the mean of each trial, and weighted by the state-wide production, the average yield difference was about 2.7 tons per acre, or 30% of the average production. Using a $150/ton standard price, this amount is equivalent to about $400/acre statewide.

Potential economic value differs by Region. The potential effect of variety on economic return using a single price ($150/ton) differs by region, with greater differences in the San Joaquin and Sacramento Valleys, and fewer differences in desert, coastal, and intermountain regions (Figure 6). A wider range of Fall Dormancy groups are grown in the Sacramento and San Joaquin Valleys compared with the Northern Mountain, Coastal and Low Desert Regions, which may account in part for the greater yield differences.

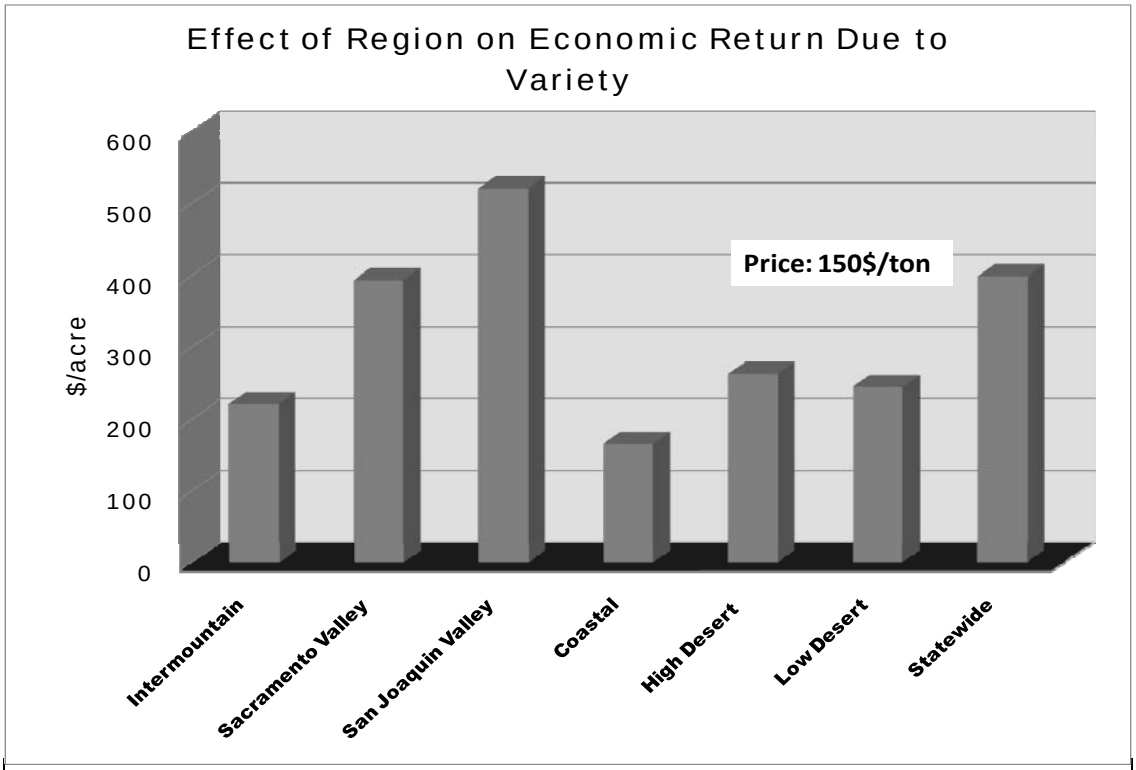

Figure 6. Regional differences due to variety. These are the average top-to-bottom yield differences due to variety, averaged across all UC trials, over the past 30 years, multiplied by $150/ton. This represents 378 location/years of testing statewide.

What is the Potential Global Economic Value to California?

The potential economic returns due to variety selection are estimated to be $319,081/year, or approximately 30% of the economic value of alfalfa hay in California (Figure 7). This figure is essentially a maximum, since it is calculated as the maximum difference in variety trials, expressed as a percentage of the mean yields. This is a significant portion of the industry, considering all the other agronomic practices like fertilization, irrigation and pest management. These economic values were calculated based on the average performance in variety trials.

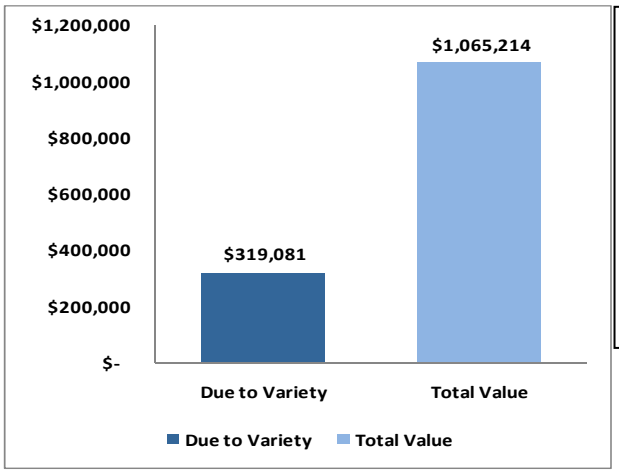

Figure 7. Total annual yearly farm gate value of California's hay crop, averaged over 30 years, and the value potentially due to variety, data normalized to 2009 dollars.

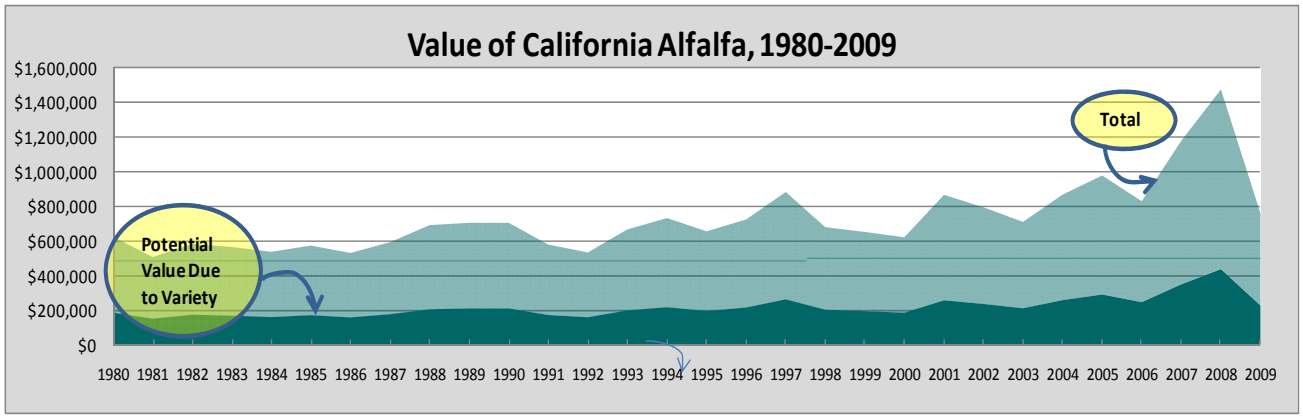

Figure 8. Total Annual Gross Economic Value and the value potentially due to variety over 30 years of California alfalfa production.

Assumptions for these Calculations: that the potential yield differences due to variety in grower's fields are similar to those measured in 378 trial/years of UC variety tests, as a percent of average value**.** That the economic value of varieties is due to yield alone, not to other genetic traits. These calculations do not consider yield effects on supply-demand curves, or the effects of forage quality on price and the yield-quality tradeoff. This is essentially a description of the maximum effects on economic returns due to variety.

DOES THE POTENTIAL ECONOMIC VALUE OF VARIETIES MATCH THE ACTUAL ON-FARM VALUE?

This is difficult to measure directly, since growers adapt varieties slowly, and other factors are also important in limiting yield potential. Estimation of the actual economic value of improved varieties is limited by several factors:

- **Transferability of Data.** Degree to which yield performance in trials match farmer's fields due to differences in soil type and management.
- **Adaptation Rate.** Extent to which farmers and seed companies choose varieties based upon this information.
- **Value of Yield vs. Other Traits.** The relationship of yield to other valuable attributes (e.g. resistance to disease and insects, forage quality, persistence, salt tolerance, herbicide tolerance). Improved varieties may have other agronomic traits besides simply yield.
- **Masking of Genetic Potential.** The yield potential of a variety may be limited by other practices, such as suboptimum cutting schedules, pest management, fertility practices which limit the genetic advantages of better varieties.

CONCLUSIONS

- ❖ Potential yield increases due to variety choice are economically significant for farmers.
- ❖ This value typically easily exceeds differences in seed costs, especially over years.
- ❖ Yield and value differences due to variety were greater in some regions than others, with greater differences California's Central Valley.
- ❖ Average yield differences due to variety, as measured in 378 location/years in California field trials was 2.7 tons/acre/year, or approximately 30% of the mean values from variety tests. This is equivalent to about $400/acre at $150 hay prices.
- ❖ The potential maximum economic benefit of varieties is $319 million/year (expressed in 2009 dollars), averaged over 30 years of California production value.
- ❖ Growers may or may not realize these economic returns depending upon soil limitations, production practices, and the degree to which research trials translate into grower's field conditions. However, this illustrates the potential value of variety selection to growers and the industry as a whole.

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Figure 9. Photo of a variety test conducted in El Centro, CA, 2005.