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Combine "Sweet Spot": Integrating Harvested Yield, Grain Damage and Losses.

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ABSTRACT

Grain losses from the processor with properly-adjusted modern combines can be extremely low, for example well below 1 % for separator and shoe in corn and soybeans. However there are other harvest losses that can be much larger. They are not well accounted for because these other losses are difficult to measure in the field. Traditional grain loss measuring methods do not pick them out, but they are capable of assessment. By carefully monitoring field and harvested yield, the difference between what is in the field and what ends up in the combine grain bin is determined. The discrepancy is made up of

- **pre-harvest losses**
- **gathering head, processor and body losses, and**
- **grain damage, leading to fines and powdered material being blown out the back.**

Estimates of field yield were made by hand harvesting multiple quadrats at a number of test sites. Bin yield of seven different combines was recorded contemporaneously using electronic-recording weigh carts for yield from measured areas. The grain damage in corn and soybeans associated with those tests was measured to see if there was any correlation between damage and yield loss.
Each combine was found to have a certain "sweet spot " where the harvested or bin yield is optimal under the given crop conditions. Grain damage was shown to play a role in the location of the optimum harvested yield, since grain damage increases at low throughputs.
An hyperbolic relationship was established between grain damage and harvested yield.
Using harvested yield measurement as the dependent variable provides an integrator. Harvested yield indirectly accounts for all machine-related losses. The significance of the "sweet spot"measurement is that it delineates harvest efficiency and it relates directly to farmer profitability.

Introduction:

The usual way to assess and display combine performance is to measure processor loss as the dependent variable over a range of throughputs. Frequently, MOG throughput is the independent variable; see for example ANSI/ASAE S 396.2 "Combine Capacity and Performance Test Procedure". According to ANSI/ASAE S343.3 "Terminology for Combines and Grain Harvesting", the 'bar' for combine performance is set at the 1% processing loss level to establish the combine's maximum sustained MOG feed rate in corn (0.4-0.8 MOG/G ratio), and it is 1% in soybeans also (0.5-1.5 MOG/G), Figure 1 (Example from PAMI 1991, where PAMI uses the 3% loss level as well.) Nowadays, grain losses from the processor with a properly-adjusted, modern, run-in combine and an experienced operator, are extremely low. They can be well below 1 % for separator and shoe in good quality corn and soybean crops with a rotary-type combine. Such low losses hardly show on electronic loss monitors and represent only a small financial penalty to corn and soybean producers.
There are losses however that are not accounted for by traditional grain loss measuring methods.
This paper addresses the losses issue and combine assessment technique from some different perspectives.

Grain Damage – a source of loss

Grain damage is a source of loss. Grain damage however has several meanings, depending on the end use of a commodity and is typically defined as *'grain that lacks the characteristics of quality grain'* (Federal Grain Inspection Service, FGIS). For this exercise, machine-induced damage is of concern. Grain damage is measured at delivery using screening and visual methods. There is considerable latitude in the allowable levels of grain damage in regular corn and soybeans when loads are delivered to commercial elevators. USDA grain grading standards apply and, for grade 2 commodities, the following are among the allowances (USDA, 1959) :

No2 Yellow Corn: 5% damage (TDK)*, 3% broken corn & foreign material (BCFM)

No 2 Soybeans: 3% damage*, 2% foreign material, and 20% splits.

** Note that the Total Damaged Kernels criterion that USDA uses does not relate directly to mechanically-induced damage as it deals primarily with field and other factors, such as insect damage, sprouted grain, stack burn, mold, etc.*

In the peak of the season and under good conditions these grading standards are easily met.

However if the combine has new processor components with sharp edges (for example on augers and thresher bars), or the machine is mal-adjusted, or in adverse crop conditions, such as harvesting at higher moisture, then grain damage levels rise and grading penalties can apply. Mechanical damage caused by the harvester can be an order of magnitude higher than USDA TDK and BCFM, and needs to be measured kernel by kernel. Machine damage is caused by machine component actions and settings, and is dependent on moisture content among other things. Effects of harvesting at higher moisture are shown in Figure 2, where damage is seen to diminish as the corn dries down in the field.

There is a 'hidden' loss and cost related to damage. Damaged grain means some material will be blown over the back of the combine and is irretrievable. This will reduce harvested yield. That yield reduction will now be considered in more detail.

METHODOLOGY AND PROCEDURES

Eleven different combines – both rotary and walker types – have been assessed to provide some of the data in this paper. The combines were equipped with 4, 6, 8 or 12 row cornheads for corn and with 30 ft flexible cutterbar heads in soybeans. Pre-harvest losses were monitored. From five to ten quadrat frames, each 1/1000 acre in corn or 10 ft2 each in soybeans, were hand-collected from many test sites to provide estimates on field yield prior to combining. Combines were set to book settings for thresher speed in particular and matched to crop and conditions thereafter.

With the exception of a specially-instrumented Deere 4420, all of the combines were recent models, and each machine had over 25 separator hours of use before testing (following ASAE test standard protocol).

Crop conditions: Each of the formal experimental areas was subdivided to permit three replications at four or five forward speeds in a randomized block design. An alleyway of about 60 feet between reps allowed space for machines to maneuver between plots.

Machine setup tests were conducted outside the formal plot areas to adjust the combines and check for losses etc. A combine "run" consisted of one pass, always in the same direction, down the previously staked-out plot over the respective number of rows for a full head width over a measured distance, from 300 to 730 feet long, depending on field shape and available weigh bin capacity. Time of each run was recorded by stopwatch to check against the displayed forward speed on the combine speedometer in each run. The weight of grain collected was measured in the grain cart after emptying the combine grain bin from each run, except for the instrumented 4420 which has an in-bin electronic batch weigher. Representative loads were 700 to 1800 pounds of grain from a run. Harvested yields from each run were measured mainly with a Brent Model 620 weigh wagon, 620 bushel capacity (serial number 86-620269; with J-Star Model 5 #OMP-5 electronic weigh scale, 60,000 pound full scale, 5 pound LSD). Two-pound grain samples were collected by catch tin at the combine bubble-up or fountain auger discharge point from the runs and stored in cloth bags for subsequent lab analysis. Kernel moisture and bushel weight was measured with a calibrated Dickey-John GAC 2000 laboratory instrument. Grain quality was measured first using the USDA standard 10/64 X ¾" slotted screen for soybean splits, or 12/64" round hole sieve for corn. The bags from each run were sieved for splits or Broken-Corn-Foreign-Material (BCFM) respectively then sub-sampled for visual damage by two people. Total grain damage was assessed by adding together the weights of the splits or BCFM plus the visual damage. 'Visual damage' refers to the total weight of any defective kernels plus broken pieces that stayed above the sieves, each kernel being individually examined in the 100 gram subsamples from each run.

Example; Machine Damage, % = 100 X (BCFM + Visual Damage Measure)

Total weight of that subsample

Nominal or indicated speeds established for each of the runs were 0.8, 1.5, 3.0, 4.5, 6.0, 7.5 mph. Where crop/machine constraints applied, runs that could not achieve the upper speeds were duly noted. True speed was found by stopwatch and run distance check. Subsequent and other test runs were conducted with different rotor/cylinder speeds, different feeder speeds, fan, and concave settings, primarily to consider the effects of these variables on grain damage. Choppers or spreaders were either disengaged or removed

Grain losses were measured by checking ahead of the combines for pre-harvest loss and for header loss. Catch pans were thrown down under or driven over by the moving combines to measure combine processor loss. Head losses were deducted from the total to calculate processor loss. However for certain test runs, a 30 ft tarp was rolled out behind each combine to catch MOG and losses for more precise assessment of separator loss. A small self-propelled rethresher was used to assay the MOG catches. Where measured individually, the rotor and shoe losses were captured separately then summed to determine the processor or *machine loss*. *Machine Loss* was calculated as a percent of total yield. Head loss was accounted separately. *"Machine Harvested Grain Throughput"* (in tons/hour) or forward speed (rather than MOG throughput) were used for the X axis. Grain throughput was calculated for each run from bin yield divided by stopwatch time times the appropriate conversion factor. Measured yield was determined by adding machine loss on the ground (in Bu/A) to the bin yield for a particular run. Kernels collected in the pans or from the drop sheet/rethresher were weighed and a multiplier used to both account for average kernel weight, collector pan area and pan number, combine body width concentrating factor (Head width divided by body- or separator-width) etc. Data was entered onto Excel spreadsheets for analysis. The graphs plotted from the data were fitted with trendlines, primarily second-order polynomial regressions where the fit was best, otherwise exponential relationships were established. In certain cases for the *"Machine Harvested Yield (MHY, in Bu/A)* versus *Grain Throughput, Tons/hour*" graphs, the data was pooled to provide general comparisons Note that where field capacities were calculated, these grain throughputs are "spot rates" and are not *sustained* work-day rates.

RESULTS (*refer to graphs at the end of paper)*

1. Thresher-induced damage. Figure 3 shows the trend for damage to increase exponentially with thresher peripheral speed, in this case for a rotary-type combine in 18% MC corn.
2. Grain Test Weight (TW). As damage increases, test weight declines, gradually for the low damage levels, but substantially at high damage levels. Three varieties of corn shown in Figure 4.
3. Quantifying damage. In Figure 5, the trend for damage to rise when the combine is lightly loaded is seen. However this figure displays several ways to measure damage. Commercial elevators measure BCFM and do a cursory check for visual damage. Careful checks, kernel by kernel, provide the data for the 'visible damage' line here. In this paper and the previous two figures, the sum of BCFM plus Visual damage is used as the prime damage criterion. Another way to measure damage is to use light boards, chemicals or dyes to emphasize or expose more pericarp damage. Time involved to measure samples for damage using chemicals is considerable however.
4. Quantifying combine performance: the standard way to present combine performance throughput (usually MOG throughput) at which the 1% loss level (for corn and soybeans) is exceeded becomes the rated capacity under a given set of conditions. Measuring MOG throughput is a complicated and tedious task, best accomplished by using an elaborate material catch system and a power rethresher. Doing this type of measurement, while worthy, is beyond the range or interests of most farmers. That 1% criterion is used in this work where *Machine Harvested Yield (MHY)* is a dependent variable.

MHY on the other hand, is immediately measurable by yield monitor or, more reliably, by measuring harvested quantities over a known area. Available weigh carts facilitated the task of making yield measurements on plot areas up to five acres. Trendline graphs of Machine Harvested Yield vs forward speed, or, replotting the same data against Grain Throughput, show characteristic parabolic-arch shapes; Figures 6 and 7 are derived from tests on five different combines in corn.

5. The regression lines in Figures 6 through 10, may have low correlation coefficients, but they generate similar outcomes. The variability is largely due to field yield variations across a field, see Figure11. Despite the variability, there are enough results to be able to conclude
    (a) There is a certain optimal grain throughput or "Sweet Spot" that characterizes each combine under given field conditions.
    (b) Harvested yield falls away either side of the sweet spot.

(c) Machine harvested yield is lower than the average preharvest quadrat yield or potential field yield.

(d) Field variability demands that care be taken in both recording accuracy, and doing sufficient replications to provide some confidence in the data.

6. The 'gap' or discrepancy between Potential Yield and MHY, refer Figure 6, can be caused by :

- Preharvest losses
- Gathering losses
- Machine losses out the back (separator, shoe, body losses).
- Damaged grain and powdered grain (invisible loss) that does not make it into the combine grain bin . This is very difficult to measure directly in the field.
- Grain damage effects on *reducing test weight* of collected grain.

7. No unusual trends were found for *gathering losses*. Corn head loss, although low in good crop conditions, was inclined to increase slightly with forward speed (just as it does in soybeans), but at low forward speeds random ear drops occurred. Butt shelling was negligible with the correct stripper or snapper plate spacing. Variable speed head drive, where provided, was effective in reducing ear drop losses, but more particularly at improving feeding at the head. Stripping plate clearance however was a critical factor on head loss in corn. Figure 12 emphasizes the influence of the gathering head. In this case the experiment was to see what effect stripping or deck plate *clearance* has on MHY. The wider deck plate opening cost the farmer some 10 bushels of corn per acre. Clearance in setting these plates is therefore critical.

8. Similarly for processor losses. Each machine behaved predictably for shoe and separator loss, these being largely dictated by crop (MOG) throughput. The gathering and processor loss results were below 1% with standard machine settings. These machine losses only partly explain "the gap"; they are insufficient in and of themselves, since the "gap "was of the order of 5% or more loss. It is the *machine-induced damage* that became the 'prime suspect' to explain the gap in this test series.

9. Prime factors affecting machine-induced grain damage are:

(a) Grain Moisture Content

(b) Machine settings

In Figure 2 the effects of harvest moisture on grain damage are shown for a conventional cylinder-and-walker-type (CWT) combine over two seasons harvesting yellow corn in the same field at various times through the season. Similar trends were found with a rotary combine. Corn is far more susceptible to damage at high grain moisture contents, but the degree of damage levels off at lower moisture contents, below say 22% in corn.

Of the machine settings, thresher speed was found to be the most critical on grain damage.

Figure 3 shows effects of rotor speed on damage in corn, while Figure 4 shows the effects of rotor speed on test weight measured here in pounds per bushel; the high damage data was generated by deliberately overspeeding the rotor and closing concave on the combines on test.

10. Forward speed affects damage. Referring to Figures 8 and 9, the general trend is for grain damage to be higher with lighter loading, due to greater exposure of ears or pods and grain-heads-to-metal contact with less crop cushioning at low throughputs. The point is that the combine needs to be kept loaded for best grain quality. The effects of low forward speed on damage are more pronounced if the machine is mal-adjusted. Compounding that, with lower throughputs, there is less load on the shoe, with greater crop exposure to the cleaning fan blast to blow material rearwards. As damage increases, there is more likelihood of fines and grain particles to be blown out of the machine irretrievably, thus reducing MHY.

Concave and shoe settings - especially as they affect returns - were found to be somewhat influential on damage but to a far smaller extent than thresher type, forward and peripheral speeds.

In summary then, when the low throughput damage effect and the high throughput processor loss effect are taken into account, then the aggregated loss curve assumes a basin shape in effect a mirror image of the loss and the MHY curves. A number of field tests on eleven combines in several crops and in different seasons practically all exhibited the characteristic "sweet spot". The parabolic curves are not sharply pronounced however, as when the ordinate is extended to zero; and the variability is high. The instrumented Deere 4420 CWT had the sweet spot at approximately the same forward speed in each crop - oats, corn and soybeans. Evidently the machine has coordinated capacity, "tuned" to perform best at

around that forward speed, despite the fact that the grain throughput levels are quite different between oats, corn and soybeans. Figure 10 shows the MHY for the 4420 in oats.
11. Relationship between Damage and Yield. A knowledge of the relationship between grain damage and bin yield provides an incentive to keep damage levels down.
In Figures 13 and 14, Machine Harvested Yield (MHY) is regressed against grain damage in replicated tests on two types of combines. The near-zero damage figures were obtained by hand-shelling the corn or soybeans collected from quadrats in the respective fields. The data for the rotary combine in Figure 14 was collected by operating the machine in corn over a range of rotor speeds from too-slow 190 rpm to deliberately-abusive 700 rpm (book setting for that machine was around 300 rpm). For the 4420 CWT, Figure 13, in corn at 16% MC and operating at 3 mph, *there was a yield penalty of approximately 6 bushels an acre for each 1 % increase in (visible) grain damage.* BCFM levels on the other hand were practically negligible. The key is to be adept at matching thresher speeds to crop conditions and keep the machines loaded for best grain quality. The incentive is there to keep damage levels down since there is a strong correlation between grain damage and bin yield.

CONCLUSIONS

1. Grain damage emerged as the 'prime suspect' affecting Machine Harvested Yield (MHY) at low throughputs. However, anything that exacerbates grain damage will reduce harvested yield, even at higher speeds. Grain damage may seem incidental to a farmer when delivering corn to commercial elevators – the USDA grain grading standards allow considerable margin for damage - and in any event Number 2 corn is the acceptance grade at Midwest elevators. *But grain damage and harvested yield are related. In corn, for each percentage point in visible grain damage there can be as much as six bushels lower yield and that is lost profit for the farmer.* A combine that is gentler on the grain will result in more bushels in the bin. The strong correlation between grain damage and harvested yield means that even if a farmer delivers damaged grain and is not penalized at the elevator, every effort should be made to keep down grain damage as it directly affects harvest profitability because of reduced yield. Aside from sharp edges on thresher components (as when new), the most important factor affecting damage is rotor speed, following that is concave setting, grain returns, etc.
2. Grain damage affects test weight. Lower test weight means less tons of grain in the bin.
3. The primary variables under the control of the operator that affect damage are thresher speed and forward speed. At low forward speeds, grain damage goes up, especially if the machine is mal-adjusted. Concave setting, sieves/returns, fan and other machine settings play a secondary role.
4. Even if a farmer delivers damaged grain and is not penalized at the elevator, every effort should be made to keep down grain damage as it directly affects harvest profitability because of reduced yield.
5. The *Machine Harvested Yield* trendlines displayed a characteristic parabolic-arch shape; the degree of fit (as measured by coefficient of variation) was often low but enough machines have been tested with similar outcomes to conclude that there is a certain optimal grain throughput or "Sweet Spot" that characterizes each combine under given field conditions. The harvested yield falls away either side of the sweet spot.
6. The harvested yield is lower than the average preharvest quadrat yield. Although there is large variability in yield, there is a discernible 'gap' which is explained by :
   - Preharvest losses
   - Gathering losses
   - Machine losses out the back (separator, shoe, body losses).
   - Damaged grain and powdered grain (invisible loss) that does not make it into the combine grain bin . This is very difficult to detect in the field.
7. Grain damage reduces test weight.
8. Deck plate setting on the cornhead was found to be critical. The level of yield loss climbed substantially if the stripping plates were too wide.
9. Presenting combine performance data *in the form of Machine Yield (MHY) vs Grain Throughput* is a useful method, especially for marketing and for farmer-readable material. Not only that, but it is a simpler and cheaper test procedure, and gives far more information than processor loss measurements alone. A drawback with the use of MHY is that if the MOG/G ratio changes dramatically in the field, then the processor losses change and affect harvested yield, but that is a

secondary issue, since this work has shown that processor losses can be lower than the other field losses, such as cornhead loss and more particularly grain damage effects.

10. Harvest yield as the dependent variable is more valuable than some other ways of presenting data, simply because it can be readily converted into dollar returns. Harvested yield effectively accounts for all losses from the harvest, not just rear end loss - even gathering head plus processor losses, and invisible loss or powdered grain that is not collected in the combine grain bin.

Discussion

The use of test procedures that provide results *showing Machine Harvested Yield versus Speed or Grain Throughput is a meaningful and productive way to show combine performance*. Not only is it an 'integrating' methodology, but the advantages of this method of presentation are that it is immediately comprehensible to farmers. Dollar returns can be rapidly interposed on the data. The ASAE standard method for performance, based only on processor loss versus MOG or Total Crop Throughput, is complex and expensive, and deals with only a part of the overall loss picture.

Harvest yield as the dependent variable shows the "sweet spot" or optima, readily converted into dollar returns. The main *drawback* of this approach is that harvested yield data is influenced by many factors that may not be well quantified. Cutting height, and MOG/G ratio in particular change in the field and affect yield results – the extent to which needs to be further quantified.

Grain damage is strongly influential on performance. Grain damage levels with modern combines that are operated astutely are low and suggest that the USDA standards may need to be revised.
In corn, the use of wider heads eg 12 row vs 8 row at lower forward speeds is probably advantageous as long as crop throughput is kept up. Corn head loss needs to be monitored. The data so far is inconclusive, but hints that more grain is recovered at high MOG throughputs by deploying a wider corn head and operating at slower forward speeds. In any event, a *variable speed* head drive is a distinct advantage, especially in adverse crop conditions.

When preharvest quadrats are measured, a broader perspective is gained on the overall situation in a given field and crop, after all the producer has invested time and resources into every grain that is out there. Whatever is not collected may be useful for wildlife, but is wasted for the producer. Ways to close the 'gap' are worth considering.

IN SUMMARY :

- Harvested Yield Measurements are a valuable and better way of presenting combine performance to farmers.
- Harvested Yield versus throughput shows an optimum or "sweet" spot.
- Damaged grain may not result in penalty at the elevator, but any harvest grain damage results in yield reductions.
- The location of the "sweet spot" on the performance map is affected by the degree of grain damage, all else being equal.
- There is an inverse correlation between grain damage and yield. This work relates so far to corn and soybeans, but there is reason to believe that a similar trend will be found in other grains.
- Reduced yield equals reduced profit.

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PAMI 1991. Prairie Agricultural Machinery Institute Evaluation Report 649. Ford New Holland TR 96 Combine. ISSN 0385-3445. April 1991.

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Acknowledgements: Field tests were conducted at University field sites and on farmer fields. Nevada farmer Bill Couser was extremely helpful at providing sites and equipment, he provided a weigh wagon, his 9550 combine and STS 9650 when needed. The efforts of Agricultural Engineering Technical staff Marc Lott, Richard Vandepol , Jeff Erb and Dan Crosman are acknowledged.

A number of undergraduate ISU students participated in the laborious visible grain damage measurements - they were appropriately remunerated. Graduate students Brian Hollatz, Nathan Isaac, Michael Brand and Seth Williams assisted in the testing at various times and their contributions are appreciated. The gift of a John Deere STS 9750 ex-test combine with heads by Deere Harvester Works, through the office of Kevin Ehrecke and David Kmoch in Moline has proved to be an invaluable asset for Departmental purposes. Other brands of combines evaluated were loaned or placed at Iowa State for certain other purposes on a short-term basis.

SET OF FIGURES:

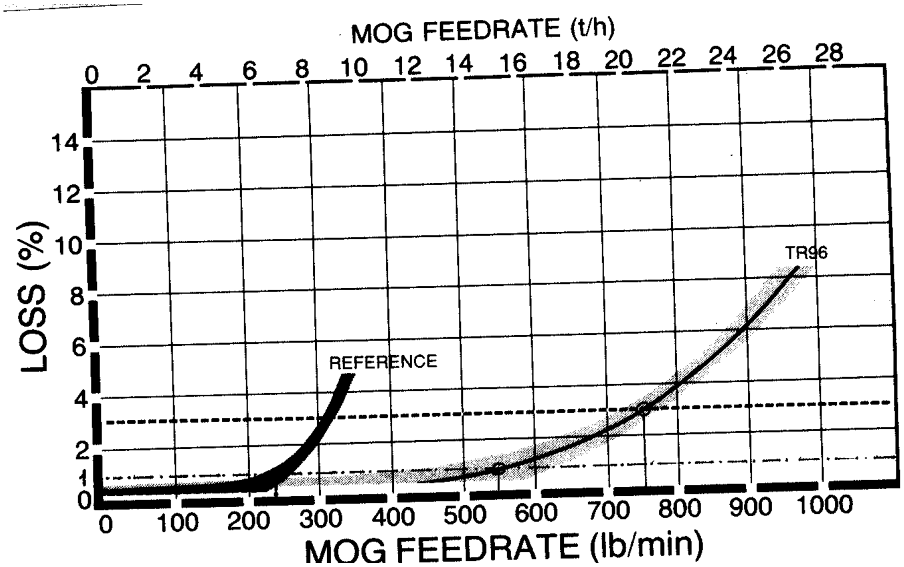

Figure 1. Quantifying combine performance: the throughput (usually MOG throughput) at which the 1% loss level is exceeded becomes the rated capacity under a given set of conditions. Measuring MOG throughput is a complicated and tedious task, best accomplished by using an elaborate material catch system and a power rethresher. Doing this type of measurement is beyond the range or interests of most farmers. The graph here are from PAMI Canada, testing a Ford New Holland TR 96 in barley. For barley, the acceptable loss level is 3% processor loss, in accordance with the ASAE Standard. A 1% line is drawn in as well.

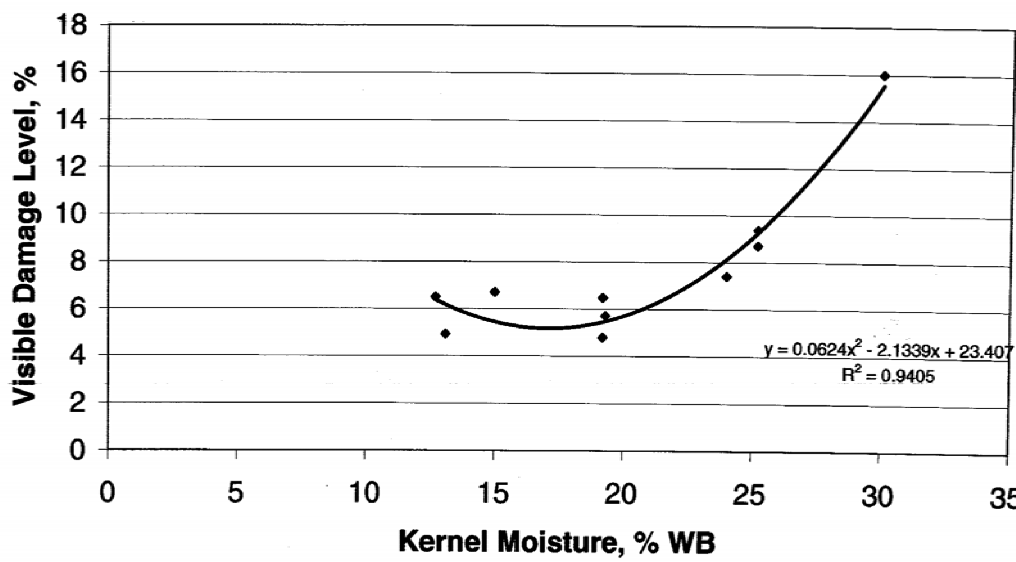

Figure 2. Effects of harvest moisture on grain damage. These results were for an instrumented Deere 4420 conventional cylinder-and-walker-type (CWT) combine over two seasons harvesting yellow corn in the same field; the tests were conducted at various times through the season. Similar results were found with a rotary combine - grain damage increased with grain moisture content. Damage tends to level off at low moisture contents, say around 22%. This field was planted with Garst yellow corn, variety #8342.

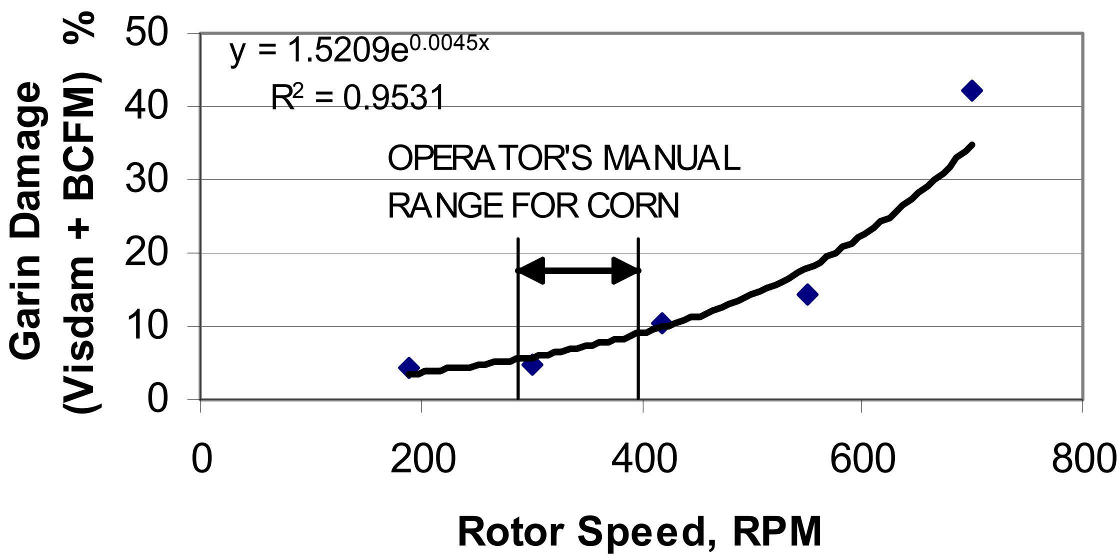

Figure 3. Effects of rotor speed on grain damage. Data from tests of a Deere STS 9750 in Fontanelle corn of approximately 18% MC and at a forward speed of 4.5 mph.

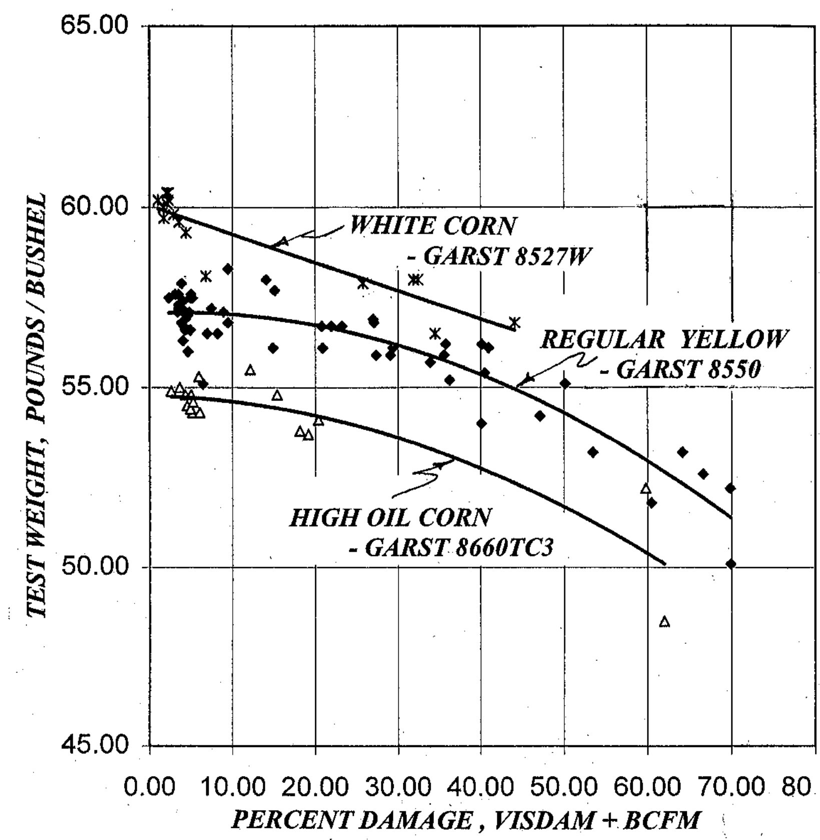

Figure 4 . Effects of grain damage on test weight in pounds per bushel for three different corn varieties harvested with a certain class seven rotary combine. In order to obtain the high damage/low bushel weight data, the machine was deliberately set up to excessive rotor speeds for those points.

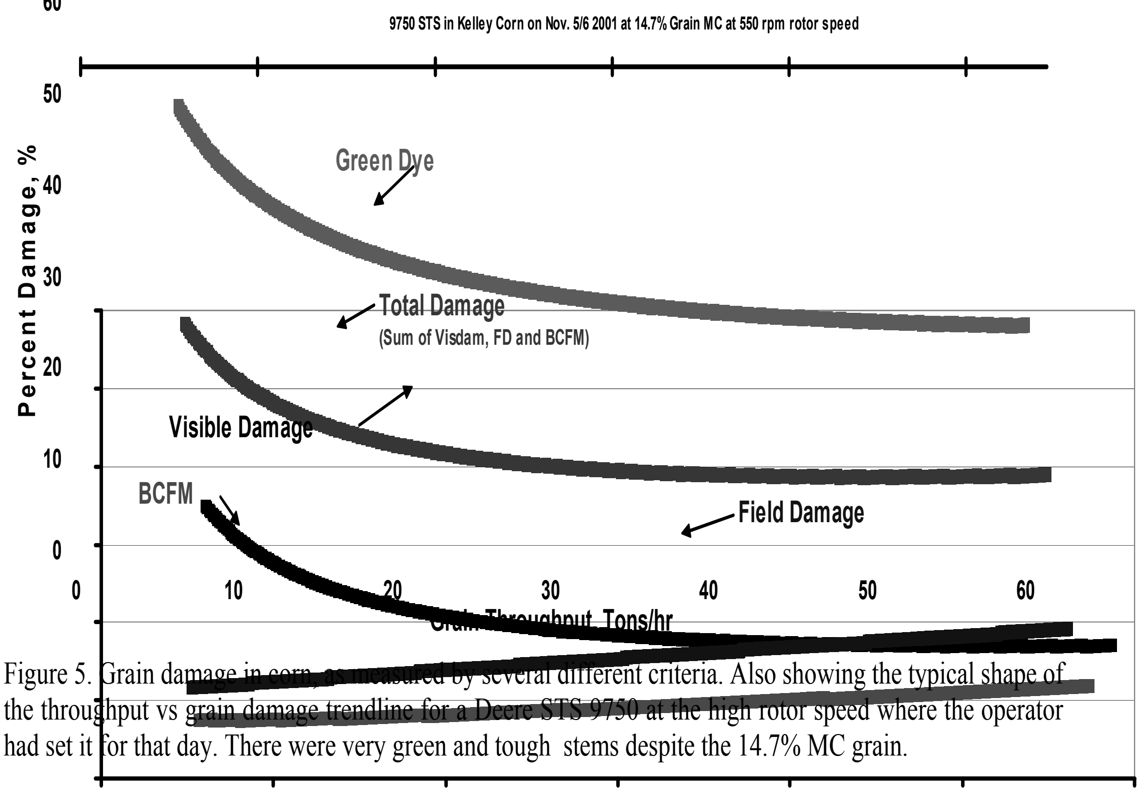

Figure 5. Grain damage in corn, as measured by several different criteria. Also showing the typical shape of the throughput vs grain damage trendline for a Deere STS 9750 at the high rotor speed where the operator had set it for that day. There were very green and tough stems despite the 14.7% MC grain.

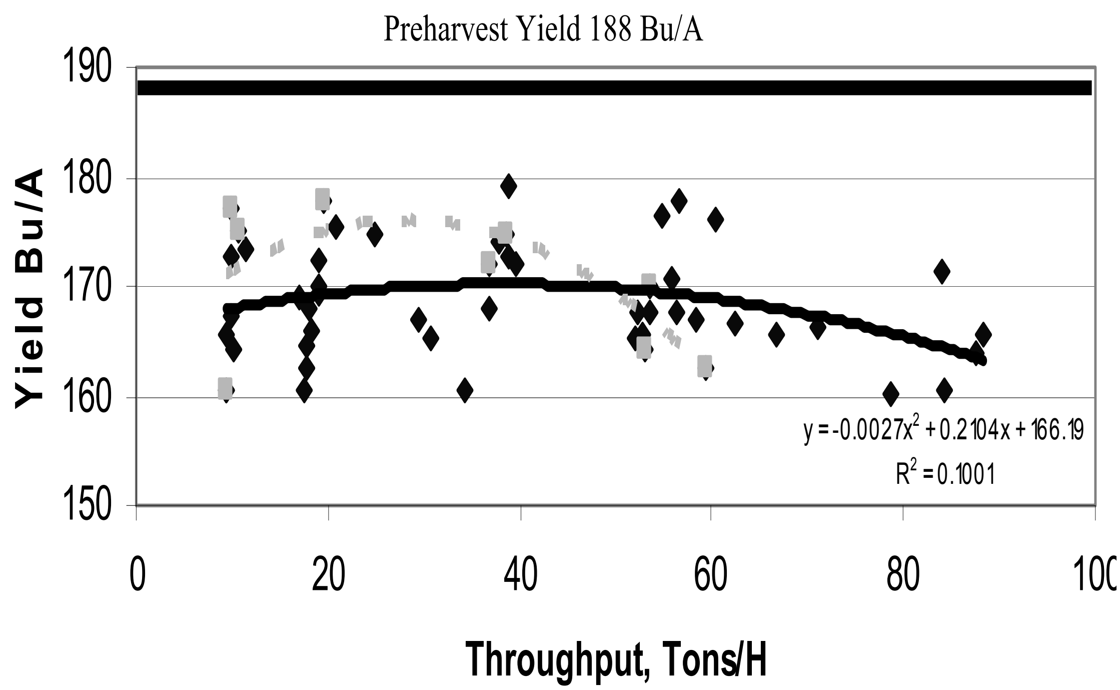

Figure 6. Machine Harvested Yield (MHY) regressed on forward speed for five modern class six combines (combine names suppressed for proprietary reasons). Pre-harvest quadrats yielded an average of 188 bu/A in that field (upper line). On average - and at best - these five combines harvested ten percent less than what was estimated to be in that field.

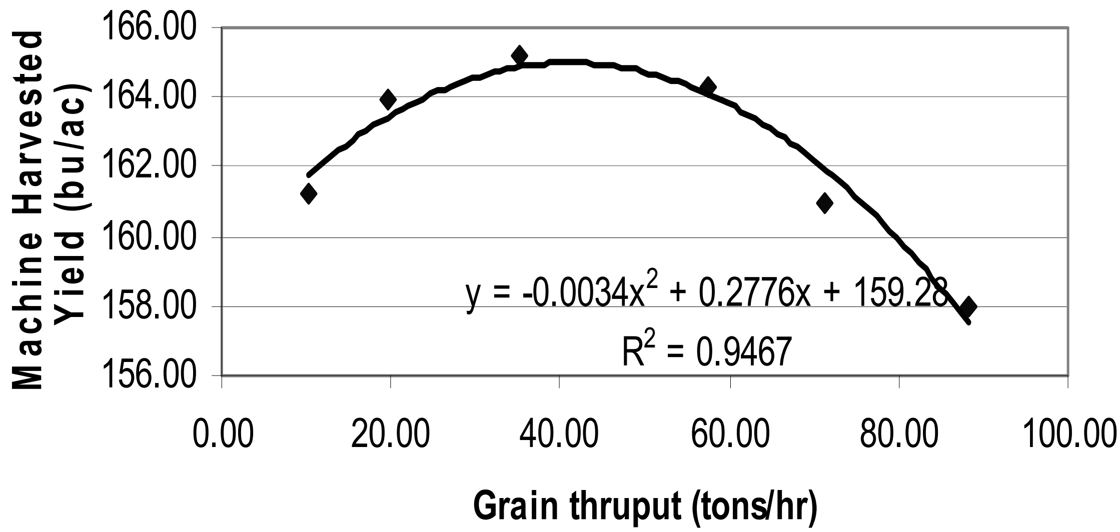

Figure 7. Combine "Sweet Spot". Aggregated data from a range of tests on a class six walker–type combine in corn, using a weigh bin to calculate yield over measured field areas.

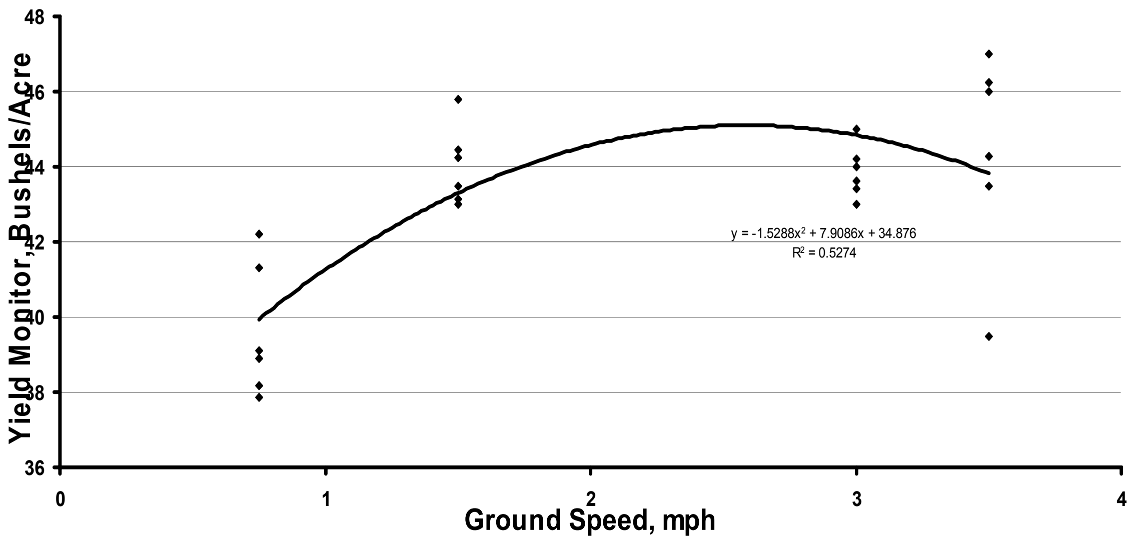

Figure 8. MHY versus forward speed for a Deere 9550 class five CWT combine in soybeans – using the yield monitor readout checked at regular intervals to generate the data, but the method does not produce reliable yield results unless well into the field.

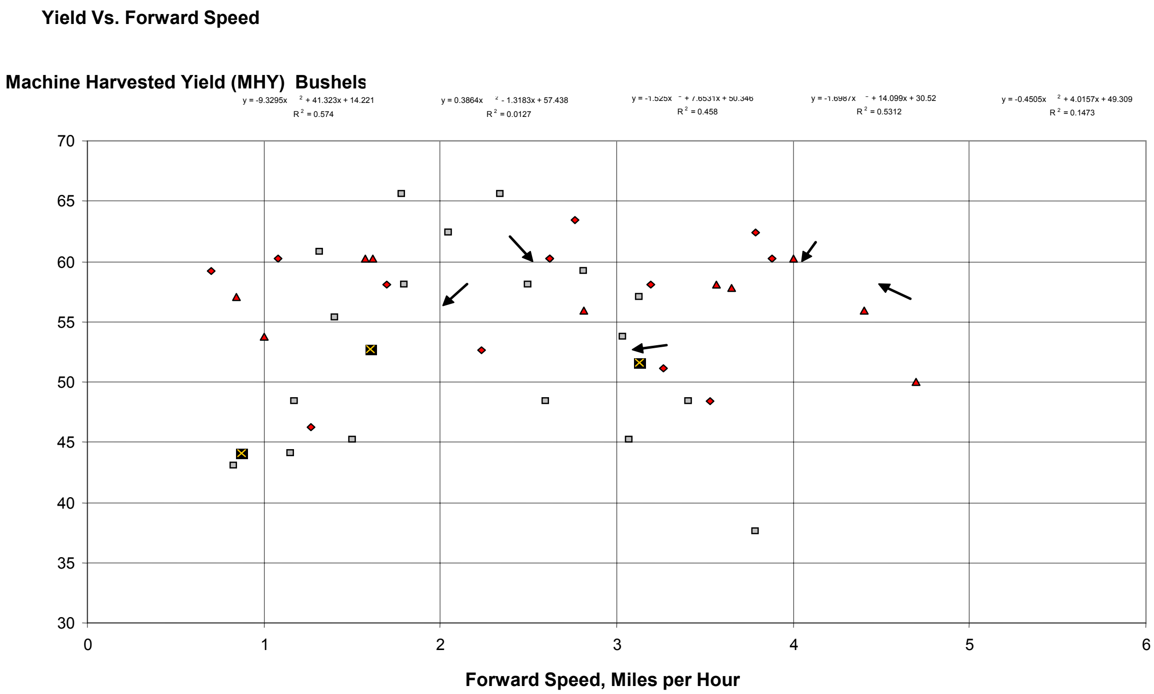

Figure 9. MHY versus forward speed for five different combine in the same soybean field – yield was recorded for each run/data point by electronic weigh cart from measured areas.

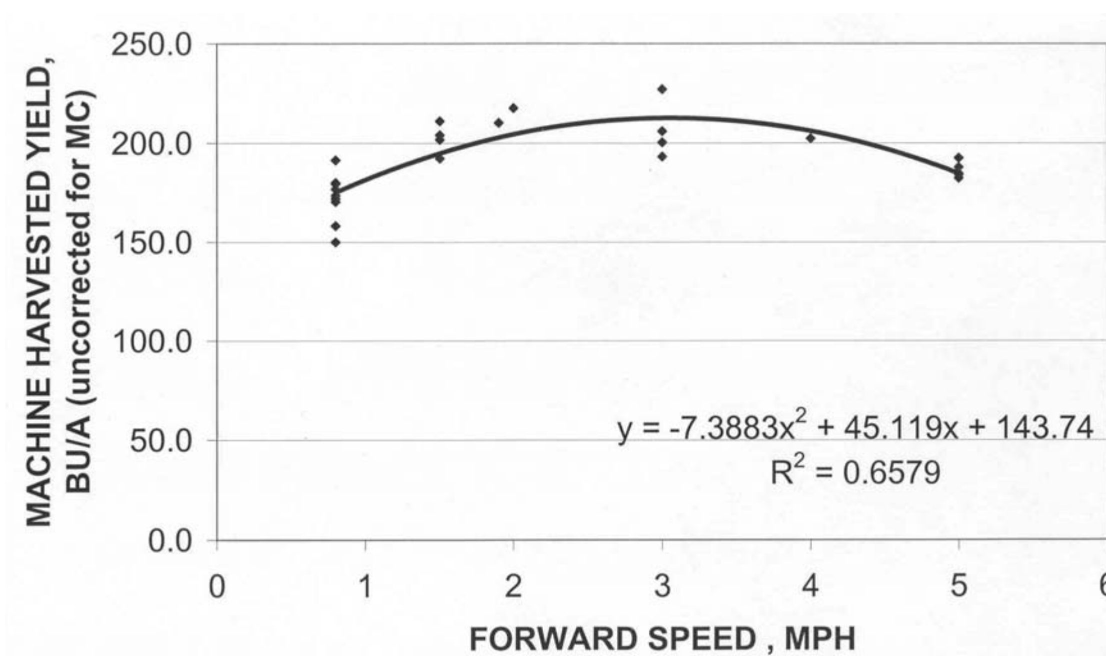

Figure 10. MHY versus forward speed for the Deere 4420 conventional combine in oats. Correlation coefficient for the MHY regressed on Grain Throughput is low, but enough tests have been conducted on eleven different combines in different crops to give confidence to assert that each machine has a sweet spot in a given crop. Field variability explains much of the scatter - see Figure 8.

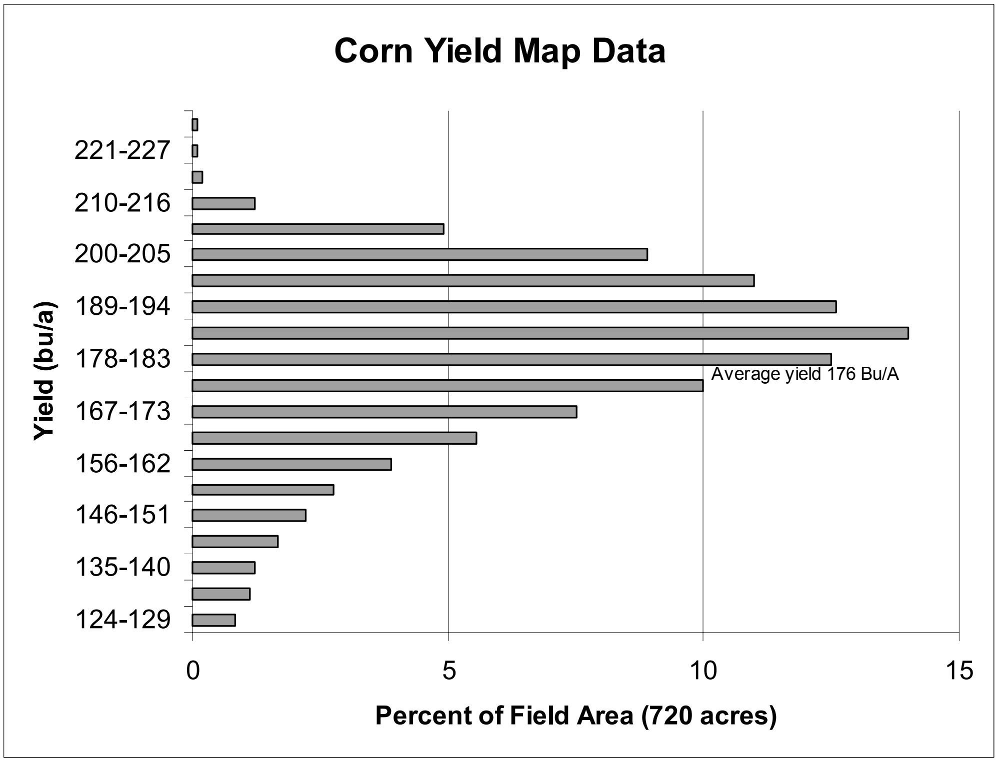

Figure 11. Data from combine yield mapping 720 acres of corn in Riceville, Iowa, in 2002 shows the range of yield across that field. Original data courtesy Daryl Thiess from Pioneer Field Information System.

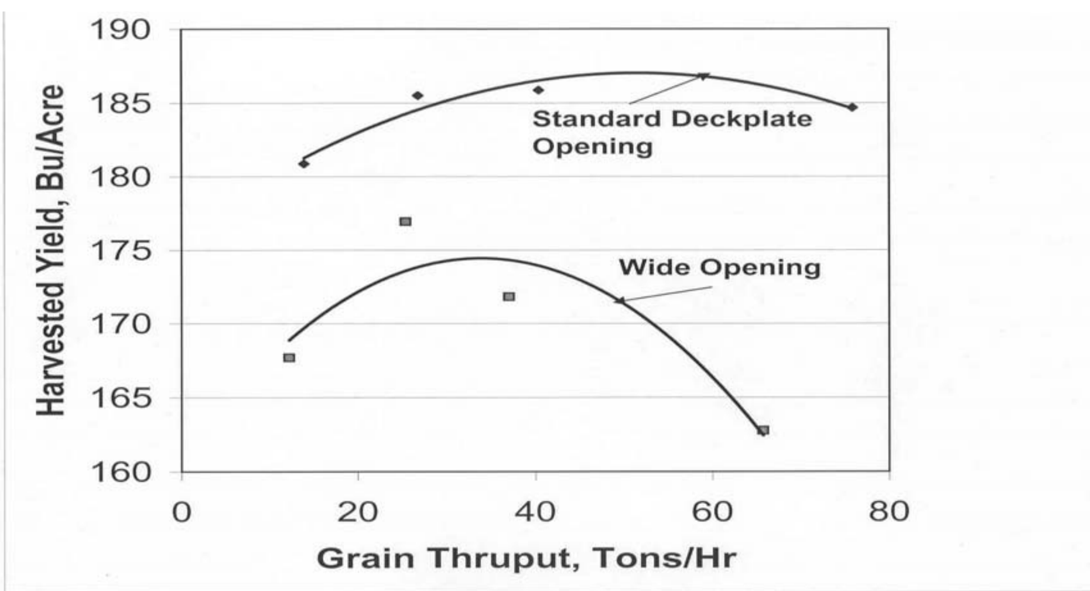

Figure 12. Effects of stripping plate settings on harvested yield (MHY). In this test the standard setting was 1.125 inches and the wide setting was 1.5 inches.

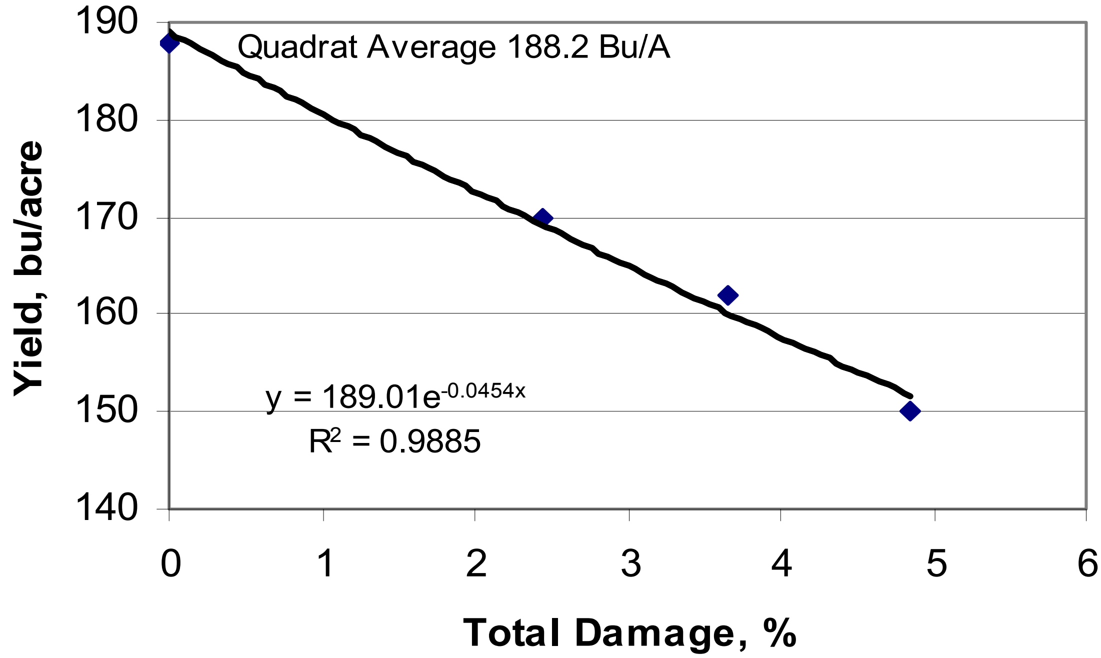

Figure 13. Effects of grain damage on Yield for corn. Deere 4420 (CWT) operated at 3 mph (10 tons.h).

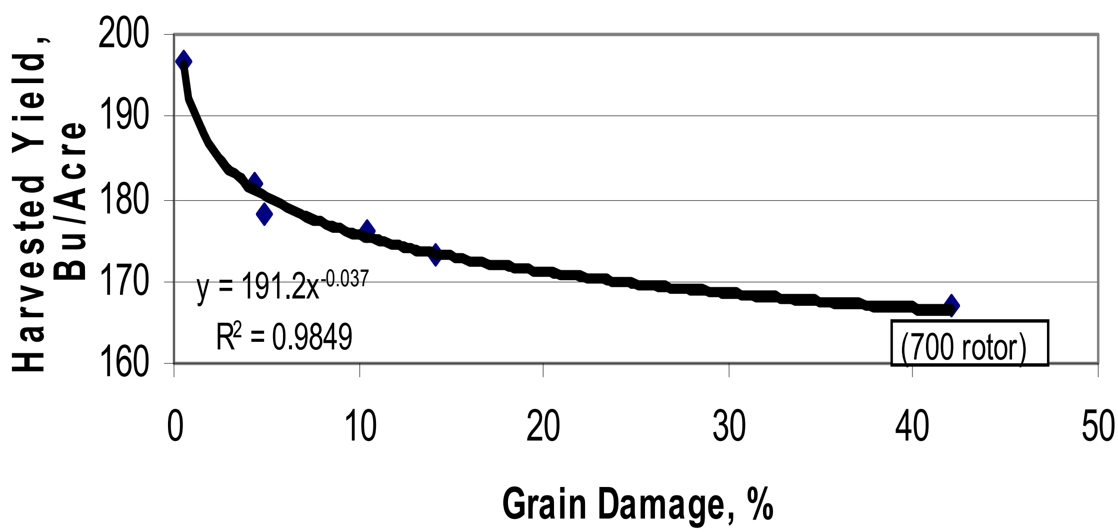

Figure 14. Effects of grain damage on yield for the STS 9750 operated in corn at 4.5 mph. Rotor overspeeded deliberately to obtain the high damage data.