

2001 DRY BEAN YIELD TRIALS

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Twenty-seven yield trials were conducted in 2001 in Saginaw, Montcalm, and Presque Isle counties in addition to 20 acres of early generation nurseries under development in 10 different market classes. At the Saginaw Bean & Sugarbeet Research Farm, 17 yield trials were planted on nine acres. These included four navy bean tests, a 81-entry standard test, two 56-entry preliminary tests, and a 36-entry recombinant inbred backcross population developed from Seafarer; a 30-entry standard black test, two 36-entry preliminary black bean test, and two 30-entry recombinant inbred backcross population developed from Tacana; two pinto bean trials included a 36-entry advanced trial, and a 25-entry preliminary test; two great northern bean trials included a 36-entry advanced test and a 30-entry preliminary test; a 30-entry standard red and pink bean test; a 30-entry preliminary red and pink test, a 9-entry standard vine cranberry test, and a 30-entry Midwest Performance Trial with pintos and great northern from Michigan, Nebraska, North Dakota, and Colorado.

At the Montcalm Research Farm, nine yield trials were planted on five acres. These included a 42-entry standard red and white kidney trial, a 42-entry preliminary red kidney trial, a 30-entry standard bush cranberry test, a 36-entry preliminary bush cranberry test, a 9-entry yellow-eye test, and a 64-entry variety trial to evaluate reaction to white mold was grown under sprinkler irrigation. One 16-entry regional trial was conducted cooperatively in Presque Isle county with new navy, black, great northern and kidney bean varieties to give growers an opportunity to see other market classes.

The 2001 field season was the worst mid-summer drought in mid-Michigan in over 60 years. Although the annual precipitation (29.51") was only 1" below the 28-year average (Table 2), the region went through an extended drought from June 24-August 15 with only 0.68" of rain (Table 1). No precipitation fell during a 28-day period from late June to mid-July. The July total of 0.53" was the lowest rainfall recorded in the 28-year average (Table 2). High temperatures confounding the lack of rainfall, 1521 GDD were recorded in July compared to an average of 1404 (Table 4). Rainfall in August - October exceeded the average, resulting in the reflowering and regrowth of bean plants that had not set an adequate pod load during the extended dry period. As a result, bean plants had a double set which prevented normal harvest and a killing frost (28F on Oct. 7) prevented the green pods from reaching maturity. The few early-season varieties that did not regrow, produced yields from 3-5 cwt/acre and yield data was not collected on those plants that regrew as the data was meaningless. No yield data on the trials conducted in Saginaw is reported. Material was harvested to salvage seed, however, and selections were made in early-generation materials. No genotypes were identified that tolerated the extreme stress in 2001.

In Montcalm, however, the stress was less severe and with access to irrigation, plot yields were exceptional. In the white mold trial which was liberally irrigated to promote disease development one black line yield over 53 cwt/acre, a statewide record. Many genotypes with upright architecture avoided white mold, but the highly susceptible varieties did not escape the disease. Only yield data from Montcalm is reported herein. In addition to the standard kidney, cranberry and white mold trials at Montcalm, research was conducted on drought, root rot and genetic resistance to white mold.

The data for all tests are included in an attached section with procedures and details on nursery establishment outlined on the first page. Since the data collected on each test are basically the same, a brief discussion of each variable measured is presented below for clarification purposes.

1. Yield is clean seed weight reported in hundred weight per acre (cwt/acre) standardized to 18% moisture content.
2. Percent site mean is the percent above or below the mean value for the test, set at 100% of all entries in the trial.
3. Pounds per acre per day is a measure of yield efficiency where the actual yield per acre is divided by the number of days that particular variety required to mature.
4. Hundred seed weight is a measure of seed size, determined by weighing in grams a pre-counted sample of 100 seeds.
5. Days to flower is the number of days from planting to when 50% of plants in a plot have one or more open flowers.
6. Lodging is scored from 1 to 5 where 1 is erect while 5 is prostrate or 100% lodged.
7. Days to maturity is the actual number of days from planting until date when all the plants in a plot have reached harvest maturity.
8. Height is determined at physiological maturity, from soil surface to the top of plant canopy, and is recorded in cms.
9. Desirability score (DS) is a visual score given the plot at maturity that takes into consideration such plant traits as; height, lodging, pod load, pod to ground distance, uniformity of maturity, and disease, if any. The higher the score (from 1 to 9) the more desirable the variety, hence DS serves as a subjective selection index.

At the bottom of each table, the mean or average of all entries in a test is given to facilitate comparisons between varieties. In order to better interpret data, certain statistical factors are used. The LSD values refer to the Least Significant Difference between entries in a test at two levels of probability. The LSD value is the minimum difference by which two entries must differ before they can be considered significantly different. Two entries differing in yield by 1 cwt/acre cannot be considered as performing significantly different if the LSD value is greater than 1 cwt/acre. Such a statement is actually a statement of "probable" difference. We could be wrong once in 20 times ($p=.05$), on the average, or once in 100 times ($p=.01$) depending on the level of probability. The other statistic, Coefficient of Variation (CV), indicates how good the test was in terms of controlling error variance due to soil or other differences within a location. Since it is impossible to control all variability, a CV value of 10% or less implies excellent error control and is reflected in lower LSD values. Under the pedigree column, all released or named varieties are always preceded by a comma (,); when preceded by a slash (/), the variety was used only as a parent to produce that particular breeding line.

Expt. 1215: Standard Kidney Bean Yield Trial

This 42-entry trial was conducted on the Montcalm Research Farm to compare the performance of standard and new light red kidney (LRK), dark red kidney (DRK) and white kidney (WK) bean varieties under supplemental irrigation. Variability was very high at this location due to the weather and disease factors (CV>21%) resulting in a large LSD value (6.4 cwt/acre) needed for significance. Yields were lower than other tests at Montcalm and ranged from 9 to 32 cwt/acre with a mean of 21 cwt/acre. Two lines significantly out-yielded the test mean and these included a DRK selection of LRK line K00605, and the indeterminate LRK from the USDA program in WA. Interestingly the three high-yielding lines from WA were all floppy type-III vines types so the yield potential associated with this growth habit needs to be effectively transferred to determinate bush habit preferred by growers. In 2000, K00605 the highest yielding entry in PYT, ranked 11th in this trial and continues to show potential particularly the DRK line K01405 (selected out of K00605) that significantly outyielded the Red Hawk check. In the WK class, K00922 and K90924 showed yield potential over Beluga but future advance will depend on their processing quality. The highest-yielding check was Chinook 2000 followed by Cabernet, Montcalm, Beluga and Red Hawk.

Expt. 1216: Preliminary Kidney Bean Yield Trial

The 42-entry trial was conducted to evaluate new kidney bean lines under development. Yields ranged from 18 to 40 cwt/acre with a mean of 31 cwt/acre. Variability was high (CV>14%) which reflected in a large LSD value (8.8 cwt/acre) needed for significance. The trial was significantly higher yielding than test 1215 which averaged 21 cwt/acre. The dramatic difference in yield is demonstrated by the check varieties Red Hawk (36 versus 20 cwt/acre in test 1215), and Chinook 2000 (35 versus 26 cwt/acre in test 1215), suggesting that care needs to be exercised in the evaluation of new lines in test 1216. Canning tests will be conducted on all new entries prior to advance or future testing.

Expt. 1217: Standard Bush Cranberry Bean Yield Trial

This 30-entry trial was conducted to compare new and standard bush cranberry bean varieties. Yields ranged from 19 to 35 cwt/acre with a mean of 27 cwt/acre. Variability was high (CV=18%) in this test and the LSD needed for significance was high (7 cwt/acre). Two lines significantly outyielded the test mean including the check, Taylor Hort. The two top yielding entries had maturities (92 days) similar to the check yet had a significantly higher seed size (59 versus 52 g/100 seeds). The CPC lines entered in this test were among the lowest yielding. The highest yielding check in this test was Hooter.

Expt. 1719: Regional Dry Bean Yield Trial, Presque Isle County

This 16-entry trial was conducted annually in grower's fields near Hawks by David Glenn (MCES) with the primary focus of identifying different bean seed types with adaptation and potential for that region. Growing conditions were less favorable in this region in 2001, and as a result yields were lower, ranging from 10 to 18 cwt/acre with a mean yield of 14 cwt/acre. Variability was not well controlled (CV>21%) resulting in a high LSD value (4.1 cwt/acre) needed for significance. Only the black bean B98306 significantly out-yielded the test mean, followed by the black bean breeding line B00103. Both black bean lines significantly out-yielded the new black bean variety, Jaguar in this test. Four DRK lines grouped with

Red Hawk (15-17 cwt/acre) followed by the new navy bean line N97774 that topped this trial in 2000. Matterhorn great northern continues to show potential in this production area. Despite the long and successful production of dark red kidney beans in this region, other seed types are potential alternatives to the current kidney bean varieties.

Expt. 1220: Standard Yellow-eye Bean Yield Trial

This 9-entry trial was planted in Montcalm to identify yellow-eye breeding lines with improved yield performance and adaptation over Steuben yellow-eye check. The lines in this test were bred to carry the *bc-3* gene for resistance to mosaic virus to which Steuben is highly susceptible. Since the lines were developed through backcrossing they resemble Steuben, the recurrent parent in appearance, agronomic traits and adaptation. All the lines are later-maturing, with a viny (type III) growth habit similar to Steuben and showed problems with white mold and common bacterial blight (CBB). Yields ranged from 8.5 to 15 cwt/acre with a mean of 13 cwt/acre. Variability was high in this test due to white mold and CBB (CV>28%) and a high LSD value of 5.1 cwt/acre was needed for significance. As a result no lines significantly out-yielded the test mean or the check variety Steuben which topped the trial. One entry Y00121 showed less CBB but did not show a yield increase. Overall yields were very disappointing given the fact that yields in excess of 40 cwt/acre were commonplace in other trials in Montcalm in 2001.

Expt. 1221: Preliminary Cranberry Bean Yield Trial

This 36-entry trial was conducted to evaluate new cranberry bean lines under development. Yields ranged from 12 to 35 cwt/acre with a mean of 26 cwt/acre. Variability was high (CV=13%) and a LSD value of 6.6cwt/acre was needed for significance. Three lines significantly outyielded the test mean including the check, Taylor Hort. The top yielding entry was a long season line (101 days) from USDA, WA and two sib lines from MSU were equivalent in yield (34 cwt/acre) and similar in seed size and maturity. Three lines of interest were I01799, I01797, and I01800 from North Dakota had significantly larger seed size (>60 g/100 seeds) and exhibited a vine growth habit.

Expt. 1222: White Mold Variety Yield Trial

This 64-entry trial was conducted at Montcalm to evaluate a range of diverse dry bean varieties and breeding lines for reaction to white mold under field conditions. The test ranged in yield from 11 to 53 cwt/acre (a record yield) with a mean yield of 35 cwt/acre. Variability was well controlled despite white mold pressure (CV>13%), yet a high LSD value (7.2 cwt/acre) was needed for significance due to high yield potential of the trial. Genotypes included commercial navy and black bean cultivars, parents and lines from a recombinant inbred line population where marker assisted selection was being practiced, elite MSU lines, and new sources of white mold resistance entered as part of the National Sclerotinia Bean Trial. Those lines were developed at the Universities of Guelph, Nebraska, MSU, OSU and NDSU. Entries were planted in two row plots with two rows of Midland (susceptible spreader) between plots. Supplemental overhead irrigation was used to maintain adequate levels of moisture for favorable disease development at the critical flowering period. Natural white mold infection occurred across the entire trial and was extremely severe in certain plots. A sample of 30 plants from the two center rows in each plot and

replication was rated for disease incidence (% infected among 30 plants sampled) and percent disease severity at harvest maturity using the same 30 plant sample. In addition a visual white mold score was rated on a 1 to 9 scale for each plot and it correlated well with DSI. Disease incidence ranged from 1 to 95% (CV=28%) whereas disease severity ranged from 0.3 to 74% (CV=38%). Unlike previous years, plant architecture played a significant role in white mold avoidance in 2001. Despite the high disease pressure, nine lines significantly out yielded the test mean. These included Vista navy bean variety but more importantly MSU pinto, GN, black and navy breeding lines were identified that performed despite high levels of white mold infection. As in 1999 and 2000, navy line N97774, developed from the cross of Bunsu/Huron designed to combine different resistance mechanisms, was a member of this group of nine lines. Bunsu, itself yielded 5cwt/acre less than N97774. Black bean line, B00101 was the best MSU black line compared to Phantom and T-39. B98306 which yielded equivalent to Phantom and T-39, continues to show less white mold infection (DSI=9% vs. 50% for T-39) as in past years. Pinto line P99120 continues to perform well under white mold pressure (DSI=18%). Other pinto lines in the test were dramatically lower yielding and higher DSI scores (74%). In the GN class, G99750 was the best entry for the second year, low DSI =9%, 9 cwt/acre better yield than Matterhorn which had a DSI=49%. Laser navy which showed low DSI=12% as in past years, did not achieve the yield of other navies like Vista. The line, MO 162 with the lowest DSI (0.3%) was the lowest yielding entry suggesting that this line avoided white mold through small plant structure and its value as a parent in breeding for white mold resistance would be questionable due to association with low yield. Overall the trial confirmed results from previous years and this trial will continue to be a vital part of the breeding effort to improve tolerance to white mold in dry beans.

The biggest surprise in this test was the record yield of 53.1 cwt/acre set by breeding line I01892. This line was developed through backcrossing to the variety Tacana from Mexico as the recurrent parent using a wild bean from Colombia as the donor. I01892 outyielded the recurrent parent by over 11 cwt/acre and was significantly better than the best MSU line B00101. Clearly I01892 must possess genes for yield from the wild donor parent and these may prove useful in future breeding efforts in other bean classes at MSU. I01892 is the property of the International Center, CIAT where the cross was made. Original selections were made in Mexico and in Michigan in 2000.

Expt. 1223: White Mold Genetic Yield Trial

This 100-entry trial was conducted at Montcalm to evaluate the genetic resistance in 98 recombinant inbred lines (RILs) developed from the cross of Bunsu/Raven. The test consisted of 4-reps and included the 98 RILs and the two parents. The test ranged in yield from 19 to 50 cwt/acre with a mean yield of 37 cwt/acre. Variability was moderately well controlled despite white mold pressure (CV>19%), yet a high LSD value (10 cwt/acre) was needed for significance due to high yield potential of the trial. Only data from the parents and the 10 best and 10 worst entries are shown in the table for Expt. 1223. Only two lines significantly outyielded the test mean, but yields were very high in this trial despite the white mold. These yields compared favorably with those in the white mold trail, test 1222. Disease ratings ranged from 30-43% in the top yielding entries and as expected were significantly higher in the low yielding entries (DSI = 50-73%). Bunsu has the lowest DSI of 30% yet was significantly lower yielding than the best entries. The susceptible parent, Raven with a DSI =37% yielded well at 42cwt/acre suggesting that it avoided the negative impact of white mold due to plant architectural escape. These data will be used to conduct a genetic mapping experiment to find markers associated with white mold resistance in navy and black beans.

Expts. 1224 & 1225: Drought/Irrigated Selection Trials

Two 36-entry trials were conducted at Montcalm to evaluate the drought tolerance in 36 lines previously evaluated under moisture stress in Honduras in Spring 2001. Lines evaluated in the previous trial were placed in two groups, drought resistant (based on geometric yield) and drought susceptible and these lines were tested under moisture stress and with irrigation in Montcalm in 2001. Two moisture treatments are needed to identify drought resistance and compute geometric means for each entry. The Montcalm location was selected due to the availability of irrigation and the fact that the sandy soil creates a natural soil moisture stress in years of below average precipitation. Two populations of RILs developed from the cross of B98311/TLP-19 and B98311/VAX 5. B98311 is a MSU line with good level of drought tolerance and the other lines are tropical black beans with different disease resistance characteristics. The moisture-stress test (Expt.1224) ranged in yield from 17 to 36 cwt/acre with a mean yield of 26 cwt/acre, where the irrigated test (Expt.1225) ranged from 15 to 39 cwt/acre with a mean of 27 cwt/acre. Variability was slightly lower under stress ($CV > 17\%$) compared to the irrigated test ($CV > 19\%$). Despite the hot dry summer, there was little moisture stress in expt. 1224. B98311 placed second behind L88-69, demonstrating its yield potential under stress. There was some correspondence between the performance of lines in each trial. For example, L88-69 placed 1st and 5th; L91-10 placed 3rd and 1st; L88-30 placed 8th and 3rd in tests 1224 and 1225, respectively. Despite the lack of drought stress, yield potential of lines did correspond across these tests and the test conducted earlier in Honduras. We believe that progress in breeding for tolerance to drought can be made even in those seasons when the stress is not expressed.

Genetic Studies conducted in Michigan in 2001

One genetic study to determine the inheritance of resistance to Fusarium root rot in large seeded dark red kidney and cranberry populations was conducted at Montcalm in 2001. The study involved two RIL populations developed by the inbred backcross method. Two inbred backcross populations consisting of 91 and 78 $BC_2F_{3,4}$ individuals each were developed between Red Hawk*2/Negro San Luis(NSL) and C97407*2/NSL and grown in the field for agronomic evaluation, seed increase and generation advance. NSL was originally selected for root rot tolerance in Mexico and was initially crossed into Red Hawk DRK and cranberry breeding line to transfer resistance to these highly susceptible market classes. The RILs harvested from the field will be evaluated for resistance to Fusarium in a greenhouse screen. Based on both greenhouse and field data, studies to detect markers linked to resistance will be initiated. The inbred BC method was used to develop populations where the plant and seed type was close to commercial kidney and cranberry standards expected by the industry. Prior work on root rot resistance using single crosses had not resulted in the identification of resistance in large seeded types with satisfactory commercial seed or plant types.

Early Generation Breeding Materials grown in Michigan in 2001.

F₃ through F₅ lines.

Navy and Black - 466 lines
Pinto - 156 lines
GN - 130 lines
Pinks and Reds - 120 lines
Kidney (DR, LR, White) - 784 lines
Cranberry (bush, vine) - 421 lines

F₂ populations

Navy and Black - 146 populations
Pinto - 33 populations
GN - 49 populations
Pinks and Reds - 11 populations
Kidney (DR, LR, White) - 15 populations
Cranberry (bush, vine) - 27 populations

F₁ populations: 140 different crosses among four contrasting seed types.