2003 DRY BEAN YIELD TRIALS

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Sixteen yield trials were conducted in 2003 in Saginaw, Montcalm, East Lansing and Presque Isle counties in addition to 20 acres of early generation nurseries under development in 10 different market classes. At the Saginaw Valley Bean & Sugarbeet Research Farm, eight yield trials were planted on nine acres. These included a 72-entry standard navy bean test; a 72-entry standard black test, and a 72-entry preliminary black and navy bean test; a 36-entry standard pinto bean test; a 36-entry standard great northern test; a 42-entry standard red and pink bean test; a 12-entry standard vine cranberry test, and a 25-entry Midwest Performance Trial with pintos and great northerns from Michigan, Nebraska, North Dakota, and Colorado. At the Montcalm Research Farm, six yield trials were planted on five acres. These included a 20-entry standard red and white kidney trial, a 20-entry standard bush cranberry test, a 64-entry variety trial to evaluate reaction to white mold was grown under sprinkler irrigation, a second 64-entry genetic study to evaluate for resistance to white mold, and two genetic studies for root rot resistance in cranberry beans (72-entry) and kidney beans (100-entry). A 16-entry regional trial was conducted cooperatively in Presque Isle County with new navy, black, great northern and kidney bean varieties to give growers in this region an opportunity to see other market classes. A 42-entry genetic study for reaction to common blight was grown in East Lansing and inoculated to evaluate the potential of use of marker-assisted selection in breeding for resistance to common bacterial blight.

The 2003 field season proved to be quite favorable for bean production despite an extended dry period after mid August through harvest in September. Rainfall was 4.68" below normal for August and September and 6.45" below normal for the year. No significant quantity of precipitation fell after August 6 until September 15. Below average temperatures during the season resulted in a cumulative GDD 6% lower than the 30-year average. The extreme drought dramatically hastened maturity despite the cooler temperatures earlier in the season and favored the production of the earlier-maturing entries such as pintos and great northerns whereas the full season navy and black bean lines did not reach full potential due to stress hastened maturity. Both yield and quality were above average in 2003, although dry conditions resulted in seed coat check problems and small seed size in the commercial crop as was observed in data on seed size in the attached tables. Yield data from Saginaw ranged from high of 33 to 35 cwt/acre and average yields fell below 30 cwt/acre, compared to a statewide average of 15 cwt/acre for the commercial crop. The preliminary navy and black bean trials were direct harvested due to overall erect stature and uniform drydown. Despite some apparent harvest losses in the field the overall yields in these trials did not reflect significant reduction in yield due to harvest method, despite the unknown yield potential of lines in preliminary trials. Seed splitting was more obvious in black bean trials that were direct harvest and will provide a basis to eliminate lines with this undesirable tendency. In Montcalm, with access to irrigation, plot yields were average. In the white mold trial that was liberally irrigated to promote disease development top yields were close to 40 cwt/acre, whereas the productivity of kidney and cranberry beans was low (16 cwt/acre). Many genotypes with upright architecture avoided white mold, but the highly susceptible varieties did not escape the disease. In addition to the standard kidney, cranberry and white mold trials at Montcalm, research was conducted genetic resistance to white mold and root rot.

The data for all tests are included in an attached section. Procedures and details on nursery establishment and harvest methods is 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 hundredweight per acre (cwt/acre) standardized to 18% moisture content. Dry beans are commercially marketed in units of 100 pounds (cwt).

2. Seed weight is a measure of seed size, determined by weighing in grams a pre-counted sample of 100 seeds, known as the 100-seed weight. To convert to seeds per 100g (10,000/100 seed wt); for example 100-seed weight of 50 converts to 200 seeds per 100 g (used in marketing).

3. Days to flower is the number of days from planting to when 50% of plants in a plot have one or more open flowers.

4. Days to maturity is the actual number of days from planting until date when all the plants in a plot have reached harvest maturity.

5. Lodging is scored from 1 to 5 where 1 is erect while 5 is prostrate or 100% lodged.

6. Height is determined at physiological maturity, from soil surface to the top of plant canopy, and is recorded in cms.

7. Desirability score is a visual score given the plot at maturity that takes into consideration such plant traits as; moderate height, lodging resistance, good pod load, favorable pod to ground distance, uniformity of maturity, and absence of disease, if present in the nursery. 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=0.05), on the average, or once in 100 times (p=0.01) 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 **bolded** and 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. 3101: Standard Navy Bean Yield Trial

This 72-entry trial included standard commercial navy bean varieties, breeding lines entered through the Cooperative Dry Bean Nursery and advanced lines from the MSU breeding program, which carry the N-prefix. Yields ranged from 24 to 36 cwt/acre with a mean of 30 cwt/acre. The trial was very uniform hence variability was well controlled (CV=7.9%) and the LSD needed for significance was only 3.4 cwt/acre. Despite the overall excellent performance only seven entries significantly out-yielded the test mean and these included the varieties, Schooner, and the newly released variety, Scepter but neither variety was significantly different from Seahawk. Full season varieties such as Vista and Mayflower were significantly lower yielding due to the drought. Among the seven top-yielding lines were two sister lines derived from the cross of Seahawk/Jaguar and two other sister lines derived from a 3-way cross with Huron. Some of the top yielding entries in 2002, for example N00710, N00711, and N00712 derived from the cross of the white mold tolerant line from NDSU (ND-88-106-04) and a MSU breeding line failed to yield up their previous potential.

Expt. 3102: Standard Black Bean Yield Trial

This 72-entry trial included the standard commercial black bean varieties including advanced breeding lines. Yields ranged from 22 to 33 cwt/acre with a mean for the test of 28 cwt/acre. Variability was well controlled in this test, (CV=8.5%) and the LSD was 3.3 cwt/acre. Seven lines included 115 M (I01892) derived from a cross with a wild bean were significantly higher yielding than the test mean. The top entry was B01741 also topped test 2106 in 2002. This line derived from cross of Tacana black bean from Mexico and Jaguar continues to show potential. Two new sister lines B01792 and B01793 with demonstrated resistance to common blight also showed potential in 2003. B00101 being considered for release as the variety Condor yielded above all commercial entries. Commercial varieties, Midnight, Jaguar, Blackhawk, Onyx and T-39 were significantly lower yielding in this test due to the late season moisture stress.

Expt. 3103: Preliminary Navy & Black Bean Yield Trial

This 72-entry trial included new black bean breeding lines (prefix B03---) and navy breeding lines (prefix N03---) from the MSU program with potential resistance to common bacterial blight (CBB). Yields ranged from 19 to 34 cwt/acre with a mean for the test of 27 cwt/acre. Variability was well controlled in this 3-rep test (CV=7.7%) despite being direct harvested and the LSD was 3.4 cwt/acre. Nine lines including B98306 significantly out-yielded the test mean including the check variety, T-39 (22 cwt/acre). The seven top lines were bred for common blight resistance and their leaf and pod reactions to CBB were recorded. In addition the SU91 marker linked to CBB resistance was recorded and five out of the seven lines carried the marker suggesting they possess enhanced resistance to CBB. Previous studies had suggested a negative linkage between the SU91 marker and yield but these data suggest no such linkage. In fact the majority of the lower yielding entries in this test did not carry the marker. B00101 yielded 29 cwt/acre and was very competitive in this test outyielding 115M, Vista, Jaguar and T-39. The low yield of T-39 may be a result of seed loss due to direct harvest of its prostrate growth habit. Another observation in the preliminary black bean trials that were harvested directly was the high level of seed coat splitting that occurred in certain lines. None of the checks or advanced lines exhibited this problem, but this information will be valuable in eliminating lines with a tendency toward splitting. Only those entries with improved canning quality

over T-39 will be advanced in 2004.

Expt. 3104: Standard Pinto Bean Yield Trial

This 36-entry trial included standard commercial pinto bean varieties, breeding lines entered through the Cooperative Dry Bean Nursery and advanced lines from the MSU breeding program that carry the P-prefix. The trial ranged in yield from 21 to 35 cwt/acre with a mean of 29 cwt/acre. Variability was well controlled (CV=8.4%) and the LSD needed for significance was 3.4 cwt/acre. Yields were competitive with the black and navy tests since many of the entries matured earlier and were less affected by the drier conditions in August and September. Only five entries significantly out-yielded the test mean and these included the varieties Buster and Kodiak. Two full-sib lines P02646 and P02647 showed potential in 2003 along with P02630 as possessing high yield, early maturity and architecture similar to Matterhorn. Long season lines such as P00227 that out-yielded the checks in past years, significantly under performed in 2003. One parental BelDakMi-RMR-11that has proven to be valuable as a good combiner that brings along earliness and rust resistance was the parent of P00218 the top yielding entry. Only those entries with equivalent canning quality to Othello will be advanced in 2004.

Expt. 3105: Standard Great Northern Bean Yield Trial

This 36-entry trial included MSU great northern breeding lines and standard commercial check varieties and breeding lines entered as part of the Cooperative Dry Bean Nursery. The test ranged in yield from 22 to 33 cwt/acre with a mean yield of 28 cwt/acre. Variability was well controlled (CV=8.1%) resulting in a modest LSD value (3.2 cwt/acre) for significance. Only four breeding lines significantly outperformed the test mean but not the check variety Matterhorn. One promising line G02454 is a full-sib of pinto lines P02646 and P02647 which also showed potential in test 3104 in 2003 as possessing high yield, early maturity and architecture similar to Matterhorn. The fifth entry G02453 is another full-sib which suggests that this pedigree has potential for enhancing yield of both pinto and great northern beans. Many of the other lines, however, are derived from Matterhorn and do not appear to offer significantly improved potential for yield over the Matterhorn parent. Only those entries with improved canning quality over Matterhorn will be advanced in 2004.

Expt. 3106: Standard Pink and Small Red Bean Yield Trial

This 42-entry trial included small red and pink breeding lines from the USDA program at MSU (USDA-MI), new pink lines from MSU, standard commercial check varieties and breeding lines entered as part of the Cooperative Dry Bean Nursery and small reds known as Honduran small reds (HSR) from Central America. The test ranged in yield from 16 to 33 cwt/acre with a mean yield of 25 cwt/acre. Variability was well controlled (CV=9.1%) resulting in a LSD value (3.3 cwt/acre) for significance. Nine lines significantly outperformed the test mean including the new small red variety, Merlot. The new pink line S00809 continued to show potential and ranked 8th within the group ahead of the small red variety Lebaron. One surprise was the high yield of flor-de-mayo line K124467from ADM. One small red from the USDA-MI program R02205 performed above average and demonstrated common blight resistance in the field. Commercial red and pink varieties Roza and Brooks yielded below the test mean. Full-sib pink lines S02753 ranked 1st, S02752 –3rd and S02751 –7th whereas S02753 ranked 3rd in 2002. The HSR variety Rojo Chiquito and Tio Canela

were all lower yielding and grouped near the bottom of the trial suggesting they lack yield potential for production in temperate regions. Seed size in the HSR group was small at 21g/100seeds illustrating the difference in seed characteristics from the small red market class grown in the U.S. Only those small red entries equivalent to Merlot and pink lines equivalent to Roza in canning quality will be advanced in 2004.

Expt. 3107: Standard Vine Cranberry Bean Yield Trial

This 12-entry trial was grown in Saginaw to identify those lines with improved performance over the check, Michigan Improved Vine Cranberry (MIC). The test included lines from MSU, including some bush cranberry lines, lines from USDA-WA and NDSU (coded ND). Yields ranged from 17 to 24 cwt/acre with a mean of 21 cwt/acre. Variability was high in this test (CV>10%) and LSD value of 3.1 cwt/acre was needed for significance. As in past years, only one line C00301 significantly outyielded the test mean. In past years I01815 from the USDA program in Washington performed better but it may be too small (41g/100seeds) for the commercial trade. The lines from NDSU yielded equivalent to MIC and all had the advantage of larger seed size (>55g). The biggest surprise in this test was the performance of the bush cranberry lines C00301, C99804 and Taylor Hort ranked 1st, 2nd and 3rd, whereas C99833 ranked 11th in yield as compared to 2nd in test 2216 in 2002 in Montcalm. If the line continues to perform in diverse soil types and cans equivalent to MIC, it may meet the international market needs of vine cranberry trade. The fact that the bush types outyielded the vine types may be a reflection of the dry fall conditions. Testing of the vine types will be concluded since the more recent vine cranberry entries with the C01-prefix did not meet the yield expectations for this class. Future materials may come from the root rot study where the indeterminate growth habit was introduced from black beans into the bush cranberry bean background.

Expt. 3108: Midwest Regional Performance Nursery (MRPN) Yield Trial

This 25-entry trial is conducted annually in cooperation with North Dakota (ND prefix), Nebraska (GN prefix) and Colorado (CO) in order to test new pinto and great northern lines from all four programs and access their potential in the different regions. Yield ranged from 21 to 31 cwt/acre with a mean of 27 cwt/acre. Variability was well controlled (CV=9.3%) resulting in a LSD value (4 cwt/acre) for significance. Only one line Buster was significantly higher in yield than the test mean, followed by the variety Matterhorn. The top four lines included the MSU pinto line P00227 that topped the standard pinto test 2109 in 2002, but produced lower yields in 2003 due to the drought. The ABCP (Advanced Back-Cross Pinto) lines bred for CBB resistance were disappointing performers in this test. This cooperative trial continues to be valuable as it allows an evaluation of potential new lines prior to release in other states.

Expt. 3209: Standard Kidney Bean Yield Trial

This 20-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. Yields ranged from 12 to 20 cwt/acre with a mean of 16 cwt/acre. Variability was very high at this location due to soil and disease factors (CV>17%) resulting in a large LSD value (4 cwt/acre) needed for significance. Overall yields in this test were

lower than other tests at Montcalm and the seed size of all entries in the test was dramatically lower (39-47 g/100 seeds) than normal suggesting that stress reduced productivity overall. Only Red Hawk significantly out-yielded the test mean followed by Chinook 2000 and the new Redcoat Soldier bean. The highest yielding entry K01974 is a white kidney line which ranked 2nd after Chinook in test 2217 in 2002. Despite the long history of breeding of red kidney class, the yield potential appears to exist in the white kidney class. Use will be made of the WK lines as parents to improve performance of the red kidney classes. The lowest yielding entry was CELRK with 11.5 cwt/acre.

Expt. 3210: Standard Bush Cranberry Bean Yield Trial

This 20-entry trial was conducted to compare new and standard bush cranberry bean varieties. Yields ranged from 10 to 22 cwt/acre with a mean of 18 cwt/acre. Variability was high (CV=15%) in this test and the LSD needed for significance was high (3.6 cwt/acre). Only three lines significantly outyielded the test mean and these included two lines from USDA-WA program along with check variety, Hooter. The two top yielding entries were siblings but C00302 has a small seed size (55g/100seeds) whereas C00305 had an acceptable larger seed size (61g/100seeds). The third highest-yielding line was C99833 that has shown consistent performance over years and was one of the top yielding entries in test 2116 grown without irrigation in Saginaw. Seed size of C99833 of 64g is also highly acceptable compared to 57g seed size of the check Taylor Hort. Similar to last season the lowest yielding entry in this trial was a yellow bean variety from California that demonstrated lack of adaptation due to their late maturity.

Expt. 3721: 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 northern region. Growing conditions were not very favorable in this region in 2003 due to an extended dry period after planting which resulted in plant stand problems, and increased variability. Yields ranged from 13 to 25 cwt/acre with a mean yield of 20 cwt/acre. Variability was not well controlled (CV=13%) resulting in a high LSD value (3.6 cwt/acre) needed for significance. Only one line, Seahawk significantly out-yielded the test mean, which previously topped this trial in 2001. The new black bean breeding lines B01741 and B00101 showed potential in this region along with the new pink line S00809 and the pinto P00227 both of which performed well above the average. Redcoat and Red Hawk were the highest yielding kidney beans in the trial but kidney bean lines were among the lowest yielding entries. 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. 3222: 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 7 to 40 cwt/acre with a mean yield of 29 cwt/acre. Variability was well controlled despite white mold pressure (CV>13%), yet a high LSD value (6.2 cwt/acre) was needed for significance. Genotypes included commercial navy and black bean cultivars, parents and lines from a recombinant inbred line (RIL) population of Bunsi/Raven 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 MSU, OSU, CSU, Cornell, NDSU and USDA-WA. 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. White mold was rated on a per plot basis on a scale of 1 to 9 based on disease incidence and severity where 9 had 90+% incidence and high severity index. White mold ranged from 2.0 to 8.6. Despite the high disease pressure, six lines outyielded the test mean and these included 115M and three full-sib lines from the RIL population of Bunsi/Raven. This is the third year that 115M has significantly outperformed all other entries suggesting that this material has genes that could be exploited for yield potential and white mold resistance. For the second year, a new pinto line AN37 from NDSU showed the lowest DSI score and shows potential to introduce improved levels of tolerance to white mold into this market class. B01741 and B00101 black lines continue to show potential over the check T-39 (33 versus 29 cwt/acre) under white mold pressure for the third year. The great northern varieties Matterhorn and Beryl did not escape mold in 2003 (6.6 to 8.6) and the disease is reflected in the low yields. 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.

Expt. 3223: White Mold Genetic Yield Trial

This 64-entry trial was conducted at Montcalm to evaluate the genetic resistance to white mold in two recombinant inbred lines (RILs) developed from the cross of Tacana*/PI 313850 and Tacana*2/PI 318695. The two PI accessions have shown resistance to white mold in the greenhouse but do not flower under temperate long day conditions hence they cannot be field tested. PI 313850 is a landrace cultivar whereas PI 318695 is a wild accession. Twenty RILs from each population with tolerance to white mold based on the straw test and 10 susceptible RILs were planted for field evaluation. The test ranged in yield from 9 to 37 cwt/acre with a mean yield of 27 cwt/acre. Variability was moderate due to the white mold pressure and the adaptation of the RILs (CV>15%), so a high LSD value (6.7cwt/acre) was needed for significance. Nine lines significantly outyielded the test mean, and included the 115M line. None of the lines were significantly higher yielding than the Tacana parent (31 cwt/acre) but yields of four lines from the landrace parent and three from the wild parent were higher yielding in this trial despite the white mold. These yields compared favorably with those in the white mold trial test 3222, which had more adapted advanced lines. Disease ratings ranged from 2.0 to 6.6 and Tacana had an intermediate value of 4.5. A small group of lines were not well adapted due to extreme late maturity and these will be eliminated from future studies. These data will be used to conduct a genetic mapping experiment to find markers associated with white mold resistance in the landrace and wild bean PI accessions.

Expt. 3224: Cranberry Bean Root Rot Yield Trial

This 72-entry trial was conducted to determine the inheritance of resistance to *Fusarium* root rot in the cranberry population C97407*2/NSL grown in disease infested soils in Montcalm in 2003. The study involved $BC_2F_{4:6}$ RILs developed by the inbred backcross method. The test ranged in yield from 10 to 30 cwt/acre with a mean of 20 cwt/acre. Variability was moderate (CV=14%) and LSD was 4.6. Root rot was scored over 3-reps on a 1-7 scale and values ranged from 2.2 =R to 6.3 =S with a mean of 4.9 and the C97407 parent was 4.1.

Expt. 3225: Kidney Bean Root Rot Yield Trial

This 100-entry trial was conducted to determine the inheritance of resistance to *Fusarium* root rot in the cranberry population Red Hawk*2/Negro San Luis (NSL) grown in disease infested soils in Montcalm in 2003. The study involved $BC_2F_{4:6}$ RILs developed by the inbred backcross method. The test ranged in yield from 11 to 32 cwt/acre with a mean of 19 cwt/acre. Variability was high (CV=18%) and LSD was 5.6. Root rot was scored over 3-reps on a 1-7 scale and values ranged from 3.0 to 6.6 with a mean of 5.3 and the Red Hawk parent was 5.6 and the resistant parent NSL had a value of 1.1.

Expt. 3326: Common Bacterial Blight Genetic Yield Trial

This 42-entry trial was conducted to determine the inheritance of resistance to common bacterial blight (CBB) in navy and black bean populations derived from the original VAX5 resistance source. The pedigree of the lines is shown in the attached table. The test ranged in yield from 13 to 25 cwt/acre with a mean of 20 cwt/acre. Variability was moderate (CV=11%) and LSD was 3.6. The CBB reaction on the leaf and pods was recorded along with the presence/absence of SU91 marker linked to resistance. Only three lines significantly outyielded the test mean and the top yielding entry B03625 also topped test 3103. B03625 was significantly higher yielding than the parents B98306 and it also carries the SU91 marker linked to the QTL for CBB resistance on B8. Lower yielding entries included the very susceptible Midland variety, and the highly resistance line HR45 from Ag. Canada. In general the black beans were higher yielding than the best navy lines, such as N03614.

Early Generation Breeding Material grown in Michigan in 2003

F3 through F5 lines

Navy and Black - 953 lines
Pinto - 11 lines
GN - 30 lines
Pinks and Reds - 6 lines
Kidneys (DR, LR, White)- 23 lines
Cranberry (bush, vine) - 19 lines

F2 populations

Navy and Black -108 populations
Pinto - 38 populations
GN - 2 populations
Pinks and Reds - 15 populations
Kidneys (DR, LR, White) - 152 populations
Cranberry (bush, vine) - 87 populations

F1 populations: 255 different crosses among six contrasting seed types.