**Final Report to MPSG**

**Project Title: Evaluation and selection of Adzuki beans for adaptation and production in Manitoba (2017-2019)**

Investigators: Anfu Hou, Robert Conner
AAFC Morden Research and Development Centre
Tel: (204) 822-7528
Email: anfu.hou@canada.ca

**Executive Summary:**
The introduction and evaluation of adzuki beans may lead to a new alternative economic crop and benefit the Manitoba pulse growers and industry with sustainable value-added production. Adzuki bean is an important pulse crop worldwide, especially in oriental countries including China, Japan and Korea. Production of adzuki beans has increased significantly in recent years in Ontario, but no acreage has been reported in Manitoba or western Canada. Research and development of adzuki beans in North America is very limited. Currently, there are no adzuki bean varieties available that are adapted to Manitoba growing conditions. The objective of this project was to investigate the feasibility of growing adzuki beans in southern Manitoba. A collection of 94 adzuki lines were introduced from USDA, and 65 lines from China. In 2017, 24 select lines were successfully tested at two sites (i.e., Morden, Winkler). In 2018, 22 of the lines were re-evaluated at three locations (i.e., Morden, Winkler, Portage). In 2019, 20 of the lines were selected and evaluated at Morden, Portage, and Winkler, along with Envoy and T9905 as checks. In general, the adzuki bean yield was significantly lower than the edible bean checks. Whereas environmental challenges were encountered in 2018 and 2019, the successful test in 2017 revealed that the average yield ranged from 684 kg/ha to 1820 kg/ha, with a mean of 1353 kg/ha among 24 entries. The highest yield was 82% of the navy bean check Envoy. The average seed weight of the entries ranged from 162 g/1000 seeds to 207 g/1000 seeds, which was similar to the seed size of navy beans. The adzuki bean lines showed a high level of resistance to dry bean common bacterial blight and bacterial brown spot as screened in the inoculated disease nurseries.

**Background information:**
Adzuki bean (or azuki, *Vigna angularis*) is also called small red bean, originated in the Orient. Adzuki bean contains high protein (~25%, similar to edible beans), low fat, high starch (41.8-59.9%), as well as many minerals and essential amino acids for human health. Adzuki bean is often used in conventional East Asian foods, bean sprouts, ingredients for starch, and fillings for various confections. The legume crop is grown in many countries, but the major producers and markets are China, Japan and Korea. The annual production in China is estimated at 350,000 MT. The annual Japanese adzuki bean consumption is approximately 100,000 MT, and about 30% of which is imported mainly from China, as well as from U.S., Canada, and Australia. The Korean adzuki bean annual production is approximately 15,000 MT, and the annual import is about 20,000 MT. Southeast Asian and some other countries also import various amounts of

adzuki beans each year. In Canada, adzuki bean production in Ontario reached 13,000 acres in 2014. No production had been reported in western Canada.

Adzuki bean is known to grow under a broad range of climate conditions including temperate, short growing season and dry conditions. The growth of adzuki bean is similar to that of the other edible beans. In Manitoba, the bean can be seeded in late May to mid-June, and harvested in early to late-September, and October. The adzuki plants have either determinate or indeterminate growth types, and can reach maturity during a short period of time. The early maturing types can potentially be grown in western Manitoba. The seeds are usually red, light red, gray or cream colour, with a large seed size often being preferred by consumers. Trials in Minnesota and Wisconsin suggested that a plant density of 6 plants per square foot or 105,000 plants per acre is desirable for commercial production. Research plots in Minnesota achieved a seed yield of 1400 lb/ac. In a field experiment conducted in Washington State, plants were grown at a row spacing of 28 and 56 cm, and at plant densities of 5, 7.5, and 10 cm apart within a row. The well-adapted cultivar 'Hatsune' yielded as high as 3600 lbs per acre under irrigated conditions. In trials conducted in North Dakota during 1978-1980, adzuki beans showed uneven maturity and shattered badly. The yield was lower than other edible beans. Producers were recommended to grow adzuki beans only with a contract to purchase. Preliminary screening at Morden has shown that the growing conditions for edible beans may be suitable also for adzuki beans. In two years of evaluation at Morden(2015-2016), no obvious effects were observed when Edge or Treflan was pre-sprayed. Poast and/or Basagran sprays caused injury to the adzuki bean plants, however, the plants apparently recovered well afterwards. The research by Soltani et al. (2015) in Ontario has identified several pre-emergence herbicides including cloransulam-methyl, imazethapyr and fomesafen that can be used in adzuki bean production under Ontario growing conditions. In Australia, it is a common recommendation to use Treflan, Glyphosate, Select, and some other chemicals for weed control in adzuki bean production. Roundup and Reglone are often used for desiccation, in combination with windrowing for adzuki harvest. Direct harvest also is a common practice. More research is needed to establish the appropriate production conditions, especially under short growing season conditions in Manitoba.

In Ontario, AC Gemco was released exclusively to Gemco Inc. for commercial production in 1997. However, no adzuki bean varieties have been developed in western Canada. Adzuki bean cultivars from Japan or China might have been used for contractual production in Canada and the U.S.; so screening and selection of adzuki beans with adaptation to Manitoba may provide growers with additional varietal options for pulse production.

**Materials and Methods**

Adzuki germplasm lines were introduced from breeding programs in China (65 lines) and the genetic resources at USDA-ARS (94 lines). The materials were seed-increased in the greenhouse at Morden in Spring, 2015. Single rows of each line were grown in the field during the summer of 2015, at Morden. The lines were evaluated for flowering date, plant height, maturity, yield potential and seed size. While some materials were photo-period sensitive or very late maturing, most lines matured at a similar time to that of the other edible bean types. In 2016,

45 lines were selected and grown in 4 row plots and 21 selections were grown in single rows. Agronomic performance of the lines was evaluated, and single plant selections also were made. These materials varied in seed size and seed color. The maturity ranged from very early to late. The plant growth included determinate and indeterminate types, and plants generally were very upright. In 2017, 24 lines were selected and grown at three sites (i.e., Morden, Winkler, Carman). Envoy was included as a check.

In 2018, 22 of the select lines were evaluated at Morden, Winkler, and Portage. Envoy and T9905 were included as checks. Each entry was planted in four rows with three replications in a randomized complete block design. The row length was 5 m, and row spacing was 50 cm. The plant density was approximately 110,000 plants per acre. The field was pre-sprayed with Edge®; and with Centurian® and Basagran® after emergence. All four rows were harvested and used for seed yield and seed quality analysis. Field notes were taken for flowering date, plant height, growth type, lodging, shattering, disease resistance, maturity, seed yield, size, color and quality following standard breeding protocols.

In 2019, 20 selections were re-evaluated at Morden, Winkler, and Portage. Envoy and T9905 were included as checks. The field designs and maintenance were the same as in 2018.

The lines were also evaluated for resistance to common bacterial blight (CBB) in 2018, and bacterial brown spot in 2019 in the inoculated disease nurseries at Morden. The entries were grown in one 5 m single row plots with three replications in a randomized complete block design. OAC Rex and HR45 were included as resistant checks. The plots were inoculated at the fourth trifoliate leaf stage with suspensions of *Xanthomonas axonopodis* pv. *phaseoli* (isolates BXP118, BXP18, and BXP98) in 2018, and *Pseudomonas syringae* pv. *Syringae* in 2019 from dry bean. The inoculation was performed by spraying the leaves with a suspension of $10^7$ CFUs $ml^{-1}$ inoculum. In the absence of rains, the nursery was sprinkler-irrigated once a week from flowering to maturity. The incidence of leaves with symptoms (percent of leaves infected) and CBB and brown spot severity were rated between R4-5 to R7. The disease severity was rated based on leaf area infection with a 0 to 5 scale where 0 = no symptoms, 1 = <5%, 2 = 5-10%, 3 = 10-25%, 4 = 25-50%, and 5 = 50-100%.

**Results and Discussion**

In 2017, the trials at Morden and Winkler were successfully conducted. However, the test at Carman was discarded due to geese damage to the plots. The lines displayed both determinate and indeterminate growth types. No shattering or significant diseases were observed in the tests. The average yield ranged from 684 kg/ha to 1820 kg/ha, with a mean of 1353 kg/ha among 24 entries. The highest yield was 82% of the navy bean check Envoy. At Morden, the yield ranged from 806 kg/ha (MAZ-3333) to 2277 kg/ha (MAZ-3303), while Envoy yield was 3180 kg/ha. The yield of Envoy was on the high end in 2017 at Morden. At Winkler, the yield ranged from 487 kg/ha (MAZ-3333) to 1700 kg/ha (MAZ-3323), compared to 1244 kg/ha of Envoy. The low-yielding lines were generally determinate type with short plant architecture. The average seed weight of the entries was 162 g/1000 seeds, which was not significantly different from Envoy (174, *P=0.05*). The largest seed weight was 207 g/1000 seeds, which was

similar to a large size of navy bean or soybean. There was a strong negative correlation between the yield and seed weight (r = -0.4874). Future breeding may be needed to break this correlation in order to select for high yield and large seed size.

Photos: Adzuki bean seed and field plants at maturity

In 2018, due to the dry soil conditions during seeding, the emergence rate at all sites was poorer than in 2017. The trial at Morden was heavily infested with weeds despite repeated spraying with herbicides and hand hoeing. However, the trials at Winkler and Portage were successful. At Winkler, the yield ranged from 229 kg/ha (MAZ-3329) to 960 kg/ha (MAZ-3320), compared to 1102 kg/ha of Envoy and 1817 kg/ha of T9905. At Portage, the yield ranged from 192 kg/ha to 687 kg/ha (MAZ3316), compared to 2840 kg/ha of Envoy and 3188 kg/ha of T9905. The low-yielding lines were generally determinate type with short plant architecture. The average seed weight of the entries (Winkler) was 126 g/1000 seeds, which was significantly smaller than Envoy (158 g/1000 seeds, $P = 0.05$) and T9905 (160 g/1000 seeds). The largest seed weight was 155 g/1000 seeds, which was similar to navy beans.

In 2019, the trials were affected by excess moisture conditions before and during harvests. The plots at Morden and Portage were discarded due to snow cover. The plots at Winker site were harvested, but with high variation for the yield data. The Winkler test site was on an alkaline land, and the beans appeared to be stressed due to the soil conditions.

In the CBB (2018) and bacterial brown spot (2019) inoculation screenings, the adzuki bean lines generally showed similar or better ratings than the CBB resistant checks of HR45 and OAC Rex; and significantly higher levels of resistance than Envoy. The new bean type may provide a good alternative for pulse production in areas with serious CBB or bacterial brown spot infection.

Some adzuki bean lines, including MAZ-3303, MAZ3320, MAZ3323, and MAZ-3311, showed competitive yield potential to dry bean cultivars grown in southern Manitoba. The elite lines will continue to be tested in the future yield trials at Morden to provide additional evaluations and production information.

The 2018 and 2019 adzuki bean trials were severely affected by adverse environmental conditions. The seeding was affected by dry soil conditions in both years, resulting in low and uneven germination. The plots were also affected by weedy conditions, revealing the poor competition of the adzuki beans compared to dry beans against weeds especially during seedling stages. The average yield was significantly lower than Envoy in each year. The adzuki beans were generally later maturing than dry edible beans. Slightly earlier seeding may be

needed to accelerate maturity. The adzuki plants also retained green leaves much longer than dry beans, after the pods were matured. Desiccation is needed to speed the harvest.

*Summary table: Agronomic performance, common bacterial blight (CBB) and bacterial brown spot (BBS) resistance of the adzuki bean selections along with Envoy and T9905.*

| ID | Plant Height (cm) | Days to Matu -rity | 1000 Seed Weight | 2019 Yield kg/ha | 2018 Yield kg/ha | 2017 Yield kg/ha | CBB Severity (1-5) 2018 | CBB Incidence (%) 2018 | BBS Severity (1-5) 2019 | BBS Incidence (%) 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Envoy | 41 | 89 | 159 | 583 | 1971 | 2212 | 5 | 77 | 3 | 37 |
| T9905 | 54 | 92 | 161 | 1532 | 2502 | - | - | - | 3 | - |
| MAZ-3303 | 45 | 112 | 141 | 251 | 762 | 1820 | 0 | 0 | 3 | 7 |
| MAZ-3320 | 40 | 109 | 117 | 306 | 773 | 1767 | 0 | 0 | 3 | 3 |
| MAZ-3335 | 40 | 112 | 113 | 250 | 390 | 1741 | 1 | 0.3 | 2 | 5 |
| MAZ-3323 | 43 | 111 | 119 | 148 | 568 | 1733 | 0 | 0 | 3 | 4 |
| MAZ-3311 | 47 | 112 | 112 | 69 | 551 | 1711 | 0 | 0 | 3 | 4 |
| MAZ-3345 | 38 | 111 | 121 | 387 | 314 | 1561 | 1 | 0.3 | 3 | 6 |
| MAZ-3338 | 41 | 112 | 108 | 675 | 429 | 1539 | 1 | 0.3 | 3 | 5 |
| MAZ-3304 | 48 | 112 | 116 | 38 | 530 | 1439 | 0 | 0 | 3 | 4 |
| MAZ-3340 | 39 | 108 | 120 | 319 | 502 | 1406 | 3 | 1.7 | 3 | 5 |
| MAZ-3317 | 39 | 104 | 110 | 56 | 483 | 1393 | 0 | 0 | 3 | 7 |
| MAZ-3344 | 35 | 107 | 117 | 192 | 329 | 1311 | 2 | 0.7 | 3 | 6 |
| MAZ-3339 | 23 | 104 | 134 | 36 | 212 | 1299 | 3 | 9 | 3 | 10 |
| MAZ-3301 | 48 | 112 | 111 | 24 | 407 | 1292 | 0 | 0 | 3 | 1 |
| MAZ-3330 | 31 | 107 | 118 | 138 | 460 | 1280 | 1.7 | 3.7 | 3 | 4 |
| MAZ-3307 | 46 | 113 | 155 | 44 | 463 | 1171 | 0 | 0 | 3 | 3 |
| MAZ-3316 | 32 | 104 | 128 | 83 | 630 | 1157 | 0 | 0 | 3 | 3 |
| MAZ-3329 | 39 | 113 | 128 |  | 287 | 1148 | 0 | 0 | 3 | 7 |
| MAZ-3318 | 25 | 103 | 155 | 226 | 305 | 1033 | 3 | 7 | 3 | 6 |
| MAZ-3313 | 33 | 110 | 123 | - | 436 | 1030 | 1 | 0.3 | 3 | 4 |
| MAZ-3301 | 49 | 112 | 106 | 24 | 550 | 684 | 0 | 0 | 3 | 1 |
|  |  |  |  |  |  |  |  |  |  |  |
| Overall Mean | 40 | 108 | 126 | - | 639 | 1353.4 | - | - | - |  |
| C.V.% | 6.5 | 3.8 | 8.5 | - | 36 | 18.7 | 11.2 | 45.1 | 4.3 | 62 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| LSD (.05) | 5.4 | 3.8 | 21.1 | - | 461 | 383.2 | 0.5 | 2.3 | 0.6 | 7.4 |

**References:**


Agricultural Marketing Research Centre, 2014, http://www.agmrc.org/commodities-products/vegetables/adzuki-beans.

Cheng, X., and Tian, J. 2007. Status of adzuki bean production and future perspectives, China Hebei Academy of Agricultural Sciences.

Hang, A.N., McClary, D.C., Gilliland, G.C. and Lumpkin, T.A. 1993. Plant configuration and population effects on yield of azuki bean in Washington State. p. 588-590. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

Hardman, L.L., Oplinger, E.S., Doll, J.D., and, Combs, S.M. 1989. Adzuki Bean, Alternative Field Crop Manual, University of Wisconsin and University of Minnesota.

Motley, K., McCaffery, F.D., McConnon, D. Adzuki Beans: Irrigated Planting Guide 2004-2005, NSW Department of Primary Industries.

Park, S.J., and Anderson, T.R.. 1997. AC Gemco azuki bean. Can. J. Plant Sci. 1997, 77(1): 109-110, https://doi.org/10.4141/P96-062.

Soltani et al. 2015. Tolerance of adzuki bean to pre-emergence herbicides. Can J Plant Sci. 95:959-963.