

**Expansion of the jack pine pedigreed seed
orchard for south-eastern Manitoba.**

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March 1996

Introduction

A jack pine tree improvement program for the Prairie provinces was initiated in 1967 "to produce genetically improved seed, seedlings, scions, grafts, or rooted cuttings for seed orchards in the program area" (Klein, 1982). A pedigreed jack pine seed orchard for south-eastern Manitoba was established in 1988 on a site near Oakbank. Eighteen control pollinated progenies of top ranking trees based on analysis of 10 year growth and form (Klein, 1983) in a series of family test plantations were planted in a permutated neighbourhood design at 5x5 m spacing. 5.4 ha of a larger site were planted with a total of 2140 trees. A total of 10 ha are required to supply seed for a projected 3.2 million seedlings planted annually in the eastern breeding zone early in the 21st century (Dojack, 1991). This report documents the 1994 orchard expansion to 10 ha using full-sib progenies from controlled breeding of family-test trees selected by analysis of measurements at 15 years from planting. Four progenies in the 1988 portion were replaced with progenies used in the expansion.

Seedlots

Controlled pollination of superior trees in the eastern breeding district family test plantations took place in the spring of 1992. The best individuals among trees scoring highest in their families, based on analysis of 15 year growth, form and gall rust resistance, were used as parents at three sites in southeastern Manitoba. The mating design (Klein, 1992) called for pairing the best individual in the best family with the best individual in the second best family, the third best with the fourth best and so on. The second and sometimes third best trees in a family were also identified as backups in case of lack of flowering or pollen production in the selected tree. The three locations of the test plantations were up to 140 km apart so there was a difference of up to a week in timing of flowering between them. Substitutions were made as necessary, attempting to minimize departure from the plan. The best available individuals from the breeding plan were control pollinated.

By the time the seed was collected in fall of 1993 the 20 year growth, form, wood density and gall resistance data had been analyzed, and some changes in ranking were found. The age 20 analysis was used to select the best 18 of the completed crosses for use in the orchard expansion. By early 1994 a decision was made to include grafts of some of the best individuals in the family test plantations which are unrelated to the control pollinated families. Grafts made in 1995 and 1997 will be planted in 1997 and 1998. Clones have been assigned to an additional 6 entries for the expansion orchard and for the possible replacement of two of the new orchard families.

In the following list (table 1) the seed parent of each mating is listed first, followed by the identification of the pollen parent. The family number, replicate of origin and plot tree uniquely identifies the individual tree in the family test plantation. Layout of the family test plantations is documented by Nanka (1989). Due to operational constraints of trees in differing plantations being receptive at different times the backcrosses are not always with the identical individuals, one or both parents may be different trees of the same superior families. Two of the seedlots have no reciprocal cross, but enough seed to make an orchard entry. In the case of entry 34 two

reciprocal crosses and a single unrelated cross were combined to form a single entry since neither seedlot had sufficient seed otherwise. Seedlots were individually marked in the greenhouse but were not identified further than by entry number in the field, so there will be no opportunity to cull within entries in the future. Where seed was abundant equal numbers of seeds from each cross were used, however seven entries are unbalanced due to differing amounts of seed available (table 2).

Stock was grown at the Pineland nursery in the tree improvement greenhouses under high pressure sodium lights in styroblock 20's (336 cm³) in a 3:1 ratio of peat to vermiculite. Seeding took place on Dec. 6, 1993. The crop had germinated by the next week and was grown under increasing rates of fertilizer for 11 weeks. Photoperiod, temperature and fertilizer were reduced over the next 4 weeks after which the stock was chilled a further 5 weeks at 3° C in the nursery cooler. Stock was transferred to a shade frame May 16 for holding until planting.

Site

The site is part of the old Oakbank Field Station and is located north of Oakbank, Manitoba at the corner of Sandhill Road and Hillside Road. The legal description of the site is the NE quarter, section 3 township 12 range 5 E.

The soils of the site are medium to fine sands of slightly alkaline to alkaline nature (Zoltai 1968). Parts of the site have a high water table for all or part of the year. The undesirable characteristics of the site generally occur together. The effect of these site deficiencies has been to reduce growth and survival in portions of the 1988 orchard. Portions of the expansion site share these poor qualities and will no doubt limit growth and seed production.

The planting site was prepared by clearing and intensive cultivation before establishment of the 1988 portion of the orchard. It was surrounded by chain link fence and gate. There is an established grass cover on the site which has a very heavy root mat on the moister portions. The expansion area has received regular maintenance by mowing.

Soil amendment prescriptions for the site have included acidification and addition of high acid fertilizers to lower pH and aid nutrient availability and drilling vertical rock filled drainage holes in the wetter areas to lower the perched water table. However the poorest portion of the 1988 site has shown no positive response to date to treatments in 1993 and 1994. Weyerhaeuser's Prince Albert seed orchard has similar problems and responded well to application of granular sulphur at a rate of 2200 kg/ha. An important component of sulphur application is incorporation into the soil.

Layout

Forty-six rows of trees running west to east were planted on the south portion of the site in 1988. The expansion was made up of 33 rows beginning just north of the older portion.

The orchard layout was created using computer organized orchard layout (COOL) software

Table 1 Crosses used in seed orchard expansion.

Orchard entry number	Family	Replicate	Plot tree	Score	Family	Replicate	Plot tree	Score
19(a)	442	42	2	6.048	423	52	3	7.611
19(b)	423	52	3	7.611	442	41	1	4.161
20(a)	613	12	4	2.082	136	31	1	5.775
20(b)	136	33	2	4.935	613	32	1	6.470
21(a)	656	12	4	4.246	363	23	4	8.772
21(b)	363	23	4	8.772	656	12	4	4.246
22(a)*	311	11	2	4.959	341	13	1	2.746
23(a)*	212	33	3	4.197	441	31	3	3.279
24(a)	253	13	3	2.654	414	13	3	4.701
24(b)	414	13	3	4.701	253	13	3	2.654
25(a)*	464	31	2	2.606	525	32	4	6.380
26(a)*	555	13	3	4.532	535	12	4	4.563
27	444	31	4	3.460	621	32	2	5.129
28(a)	156	11	3	5.214	364	11	4	5.269
28(b)	364	11	4	5.267	156	11	4	4.910
29(a)*	312	43	1	3.490	132	42	1	5.436
30(a)	644	52	2	5.805	246	52	1	5.475
30(b)	246	52	1	5.475	644	51	3	5.577
31(a)*	323	51	4	7.702	326	53	1	4.568
32(a)*	512	43	2	3.434	145	52	1	5.218
33(a)	433	21	2	5.413	256	23	3	1.638
33(b)	256	32	1	3.784	433			
34(a)	126	53	1	2.781	626	51	4	5.216
34(b)	626	51	4	5.216	126	53	1	2.781
34(c)	362	52	2	6.481	166	53	1	4.739
35(a)*	643	53	1	1.176	622	51	1	5.561
36	314	33	3	2.609	356	32	4	1.962

* Backcross (b) is reciprocal of cross (a).

Table 2. Ratio of seedlots used in unbalanced orchard entries.*

Orchard entry number	19	20	31	32	33	34	35
Seedlot ratio (a:b:c)	2:5	4:9	4:1	4:1	1:2	7:1:3	1:14

*Based on 150 cavities seeded (1 seed/cavity) for each of these lots.

(Bell and Fletcher 1978). This software attempts to maintain a user specified distance between related individuals as well as balance the number of times unrelated families occur as neighbours. A design was selected that would maintain a minimum distance of 20 m between related individuals (at 5 m spacing). The final output required some manual adjustment to meet the design specifications. Since the COOL program was unable to take into account the presence of related trees on the boundary of the existing orchard the design for the south edge was adjusted manually to maintain a minimum of 10 m between related trees in the two sections. Families in the older section of the orchard were numbered from 1-18 so expansion family numbering began at 19. Control pollinated families run from 19-36 and the 6 future graft entries number 37-42. A final output map of the orchard expansion was created (appendix 1).

Planting positions were marked with 1 m long aluminum pigtail pins at 5x5 m spacing continuing the rows used in the 1988 portion. The start and end of each column was established with a transit and chain, the positions within rows were located with an aircraft cable marked every 5 meters. Numbered aluminum tags were hung on each pigtail marker.

The analysis of the 20 year measurement was used to score the 18 families in the 1988 orchard. Four of the crosses were only average in genetic value using the more accurate recent information so were replaced by 4 of the new crosses that were unrelated to any parents used for the 14 remaining families (Table. 3). Rogued trees were pulled from the ground with a tractor and hauled off the site for disposal. In order to maintain the design one new family was assigned to each rogued family although the old numbered pin with family, row and column was left in place.

Table 3. Families used to replace original selections in 1988 portion of orchard.

Original pin number	5	6	14	17
Replacement family number	23	25	28	29

Planting

Several rows of spare trees had been planted on the edge of the 1988 orchard where the expansion orchard was to start. These trees were transplanted into the old orchard as much as possible to replace trees that had died. Transplanting was primarily directed at locations in the orchard where survival was expected to be high. Initially a bobcat mounted tree spade was used for transplanting, however excessive moisture (caused by heavy spring rains) in some parts of the orchard contributed to rutting and several locations were unnavigable due to standing water. Remaining trees were balled and burlapped by hand, moved by ATC with trailer, hand planted

and staked immediately. All transplanted trees were moved with the original steel pin and aluminum tag with family number.

The seedlings were moved by covered transport from Pineland nursery to the Birds Hill nursery site May 30, 1994. Containers were placed on the north side of a windbreak on the ground. Trees were transported from this holding area to the planting site by truck as needed, generally daily. Watering was provided as directed by the Provincial tree improvement staff at the nursery. Nursery expansion planting began May 30. A crew of three worked up and down the columns with 8 of the 16 seedlots in a trailer pulled by an ATC. Once all 8 seedlots had been planted the second set of 8 seedlots was planted. Planting positions were identified off the layout map, the aluminium tag number was checked and the spot prepared by removing the sod to a 15 cm radius around the pin. In the finer sands the sod cover was particularly heavy with a deep root mat so soil was brought in from between the rows to fill the resulting depression to surrounding ground level. A planting hole was created with a narrow planting shovel and the assigned seedling taken from the container. The seedlings were planted in the center of the spot with the top of the plug covered by a few mm of sand. Each planted spot was checked off on the planting diagram. The area that had contained the spares was planted last. There were many holes where trees had been balled and burlapped which were filled in with a medium sand obtained from the north west corner of the planting site. Planting the expansion was completed by June 17. The four replacement families were planted in the 1988 portion of the orchard between June 22-24.

Vegetation control

All planted seedlings were protected by installation of fabric mulch to reduce weed competition. One meter squares of deWitt fabric mulch were centred over each tree. The seedling was carefully pulled through a 'T' shaped opening cut in the center of the fabric. Six-inch-long wire staples were used to hold down the 4 corners and to close the center. This material has been tested on the older portion of the site and provides good control for several years.

Spares

Individually numbered spares were planted at 1 m spacing on a gap between the interim mass selection seed orchard and the 1988 seed orchard. They were protected with fabric mulch.

Irrigation

Roughed in plumbing was available from the 1988 orchard installation. Irrigation mainline was installed by CFS and then Manitoba tree improvement staff installed spaghetti tubes and connected the mainline to the distribution line. A new well was connected to the existing system. Once the system is tested and the new lines flushed the only remaining task will be connecting the drip emitters to the spaghetti tubes. The mainline was initially attached to the distribution line with brass saddles. Several weeks after attachment the brass saddles fractured from an unknown cause and were replaced with threaded inserts.

Production

The 1988 portion of the orchard produced 2.7 hectolitres of cones in the fall of 1993. Seed yield was 2.9 kg and production by family was well balanced with 16 families producing between 100 and 200 g and two other families producing almost 300 g each. A smaller crop was observed in 1994 and arrangements were made to have seed collected if time was available. Until larger crops are available it may be acceptable to collect bi-yearly from trees with closed cone habit. Some trees with open cone habit should be collected in late September annually. These trees will be conspicuous since they will retain open cones from previous years. Open cone habit is often a juvenile trait that is outgrown.

Based on the development of the 1988 portion of the orchard seed collection from the expansion orchard should commence by 1999.

Orchard treatments and upgrading

The addition of grafts of supplementary selections from the family test plantations should begin in 1997.

A grouping of existing and planned grafts into orchard entry lots 37-42 (appendix 2) will guide planting. Ten high scoring clones are assigned to each entry. Related clones are always assigned the same entry number and will be separated by a minimum distance of 20 m by the existing design. Within each entry the different ortets should be evenly distributed across the orchard to as great an extent as possible, while keeping records of the ortet used in each position. Two additional entry lots are listed. These may be used to upgrade the genetic quality of the orchard by replacing entries 23 and 36 which have lower 20-year scores.

Seventytwo grafts will be needed for each entry. 429 of the grafts have been made and are growing at the Pineland Nursery, however 297 more grafts will be needed for the proposed completion and upgrading (appendix 2).

Post planting attention must be paid to the grafts to ensure timely removal of understock material as the graft develops. Needle development in the first few years after planting will differ with the rootstock needles being relatively thin and long, the scion having shorter thicker needles.

Analysis of a trial to test effects of pruning and fertilization treatments on seed and pollen production in a seedling plantation in south-eastern Manitoba suggest that a program of height control in the orchard to facilitate ease of collection will not reduce cone production significantly. Application of high levels of nitrogen in the same study had a negative impact on pollen production on all trees and significantly increased cone production only on trees at close spacing, but not at the wide spacing used at the orchard (Klein and Chapman 1996). A fertilization program at the orchard site would have a benefit of lowering soil pH to a more suitable range for jack pine. A nitrogen fertilization study with 4 levels of nitrogen at the orchard can be continued to determine the response to treatment on the site. Any response to fertilization will take several years to appear as the heavy sod cover will initially intercept much of the fertilizer.

Disease control should be carried out as required. Occasional incidence of western gall rust and commandra blister rust should be pruned to reduce spread and damage to individual trees. Resources should be made available to monitor insect populations so appropriate treatments may be made to reduce damage to the orchard. It is expected that populations of terminal weevil, sawflies and pitch blister moth will periodically impair orchard health and seed production.

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Appendix 2. Grafts of highest scoring family test trees unrelated to orchard seedlots for expansion and replacement in jack pine seed orchard.

Family	Replicate	Block	Plot	Tree	Score	In Family Rank	Family Rank	Design entry	Grafts Existing	Needed Jan 97
663	33	13	2	2	6.25	1	31	23	5	3
663	11	11	1	4	5.49	2	31	23	8	0
663	22	10	6	1	5.47	3	31	23	4	5
453	23	24	4	4	6.14	1	32	23	0	11
661	52	34	6	4	6.14	1	33	23	10	0
565	11	12	2	3	6.14	1	34	23	1	8
645	53	32	1	4	6.13	1	35	23	8	0
645	43	14	1	2	5.90	2	35	23	9	0
645	22	17	1	2	5.85	3	35	23	7	0
424	42	5	3	3	6.01	1	40	23	7	0
646	12	17	4	3	6.04	1	38	36	0	10
646	12	17	4	2	5.54	2	38	36	10	0
146	53	3	1	1	5.85	1	41	36	10	0
141	23	3	3	4	5.82	1	42	36	3	6
666	33	23	1	1	5.76	1	43	36	6	2
514	43	35	2	3	5.76	1	44	36	10	0
412	42	8	3	2	5.70	1	45	36	10	0
513	41	5	4	3	5.56	1	47	36	9	0
356	22	13	6	4	5.56	1	48	36	3	5
123	33	34	1	1	5.46	1	53	36	5	3
314	23	32	2	2	9.03	1	5	37	0	10
314	41	11	5	4	7.73	2	5	37	11	0
314	43	35	6	4	5.59	3	5	37	1	10
611	22	11	1	1	7.93	1	10	37	5	3
611	12	3	1	1	6.59	2	10	37	3	6
266	22	25	6	1	7.71	1	13	37	3	6
266	21	20	6	4	6.42	2	13	37	5	3
266	42	17	2	1	5.97	3	13	37	8	0
266	53	28	1	1	5.77	4	13	37	2	7
214	33	1	1	2	5.53	1	51	37	1	9
551	11	4	3	3	8.36	1	9	38	2	7
551	33	5	2	2	8.35	2	9	38	0	10
551	53	20	6	4	7.69	3	9	38	4	4
551	22	4	4	4	7.54	4	9	38	9	0
551	23	11	6	1	7.31	5	9	38	1	9
551	13	10	5	2	6.82	6	9	38	9	0
551	21	7	4	4	6.54	7	9	38	7	0
551	23	11	6	2	5.94	8	9	38	0	10
635	23	28	1	4	6.57	1	25	38	10	0
635	12	7	5	4	6.17	2	25	38	7	0
626	11	9	4	4	7.56	1	14	39	0	10
626	31	16	1	4	6.19	2	14	39	0	10
626	51	34	4	4	5.88	3	14	39	9	0
511	51	31	5	1	7.42	1	16	39	10	0
511	42	29	2	1	6.14	2	16	39	9	0
511	13	32	6	3	5.69	3	16	39	0	10
362	52	26	4	2	7.18	1	19	39	4	4
362	53	11	5	2	6.45	2	19	39	9	0
362	42	34	3	3	5.93	3	19	39	8	0
463	32	28	3	1	5.52	1	52	39	7	0
166	43	28	6	1	7.25	1	17	40	8	0
166	33	23	6	3	6.08	2	17	40	0	10
166	22	19	4	2	5.86	3	17	40	9	0
166	51	14	6	1	5.80	4	17	40	8	0
166	31	5	3	3	5.73	5	17	40	10	0
311	42	35	1	4	7.21	1	18	40	7	0
311	41	11	1	3	6.77	2	18	40	9	0
311	11	15	1	2	5.97	3	18	40	0	10
345	53	32	2	4	5.54	1	49	40	6	2
345	23	21	1	4	5.48	2	49	40	0	11
631	33	35	2	1	6.90	1	22	41	0	10
631	41	36	6	1	5.95	2	22	41	5	3
631	33	35	2	4	5.57	3	22	41	6	2
631	53	21	4	1	5.46	4	22	41	10	0
256	33	33	3	1	6.88	1	23	41	0	10
256	13	7	1	1	6.46	2	23	41	8	0
256	53	12	5	3	6.13	3	23	41	10	0
256	52	23	3	1	5.92	4	23	41	9	0
211	11	28	1	1	6.55	1	26	41	2	8
251	51	23	1	2	6.08	1	36	41	3	6
242	11	35	2	3	6.52	1	27	42	2	8
643	52	17	5	2	6.48	1	28	42	0	10
643	43	7	2	4	5.58	2	28	42	0	10
433	11	17	6	2	6.40	1	29	42	7	0
433	21	2	1	2	5.79	2	29	42	2	8
621	22	11	2	1	6.34	1	30	42	9	0
621	52	34	5	2	5.69	2	30	42	10	0
325	32	3	6	2	6.04	1	39	42	9	0
622	21	33	5	1	5.54	1	50	42	1	8
622	51	34	3	1	5.47	2	50	42	10	0
Totals								429	297	