

## Chickpea Seeding Date x Cultivar and Seeding Date x Seeding Rate Studies at Amsterdam, MT

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### What was the soil-climate context during this 3-yr study?

The 30-yr average precipitation at Amsterdam is 374 mm (14.7 in.) with 180 mm (7.1 in.) during the May - Aug growing season (Table 1a). The 2002 and 2004 growing seasons had precipitation and temperature values near long-term average values, but in 2003 precipitation was 57 mm (2.2 inches) lower than normal and July/August temperatures were 2.8°C warmer than average. So the 2002 and 2004 growing seasons experienced typical drought patterns while 2003 was more severe. Physical site characteristics are presented in Table 1b below.

Table 1a. Monthly weather summary for Amsterdam, MT 2002-04, described as 30-yr normal and departures from normal.

	<i>1971-2000</i>	2002	2003	2004	<i>1971-2000</i>	2002	2003	2004	<i>1971-2000</i>	2002	2003	2004
	Precipitation				Average maximum monthly temperature				Average minimum monthly temperature			
	mm				°C							
	-----				-----				-----			
	-				--							
Mar	26	-15	-1	-8	7.4	-5.4	-0.2	4.8	-5.8	-4.8	-0.7	1.5
Apr	36	-17	51	9	12.9	-0.9	0.3	2.4	-1.5	-2.7	0.9	-0.1
May	59	26	-14	-1	18.1	-1.5	-0.1	-1.5	2.9	-1.8	-0.3	-0.4
Jun	60	26	-8	-1	23.4	-0.9	-0.7	-1.9	6.7	-0.5	-0.5	-0.7
Jly	32	7	-20	10	28.4	2.3	4.0	0.0	9.3	0.5	1.6	-0.1
Aug	29	0	-15	11	27.9	-1.1	3.8	-1.0	8.7	-2.4	1.6	-0.7
<b>Total</b>	<b>242</b>	<b>27</b>	<b>-6</b>	<b>-19</b>	<b>19.7</b>	<b>-1.3</b>	<b>1.2</b>	<b>0.5</b>	<b>3.4</b>	<b>-2.0</b>	<b>0.4</b>	<b>-0.1</b>



Table 1b. Physical site parameters for chickpea seeding date and seeding rate studies at Amsterdam, MT 2002-04.

Year	Field condition	Lat / Long	Elev m	Soil texture	NO <sub>3</sub> -N* ppm	pH**	SOM %
2002	Chemical fallow	45° 45' 28"	1490	Silty clay loam	1.4	8.1	1.3
	Wheat stubble	111° 25' 17"	“	“	11.2	8.3	1.1
2003	Chemical fallow	45° 44' 58"	“	Silt loam	4.6	8.8	0.9
	Wheat stubble	111° 25' 57"	“	“	na	na	na
2004	Chemical fallow	“	“	”	4.6	8.4	1.4
	Wheat stubble	“	“	”	10.3	8.4	1.2

\* Average of 4 reps to 0.6-m depth.

\*\* Average of 4 reps to 0.3-m depth.

#### What methodology did we use?

All sites were managed as a no-till system using a low-disturbance 1.8-m wide disc seeder with 7 rows and independent disc coulters for side-banding fertilizer. Chickpea and pea were treated with recommended rates of Allegiance fungicide and wheat was treated with recommended rates of Raxil MD. Commercial herbicides were used at recommended rates and supplemented with hand weeding to achieve weed control. Additional details appear in Table 1c below.

Table 1c. Seeding management for chickpea seeding date and seeding rate studies at Amsterdam, MT 2002-04.

Year	Date	Calendar	Soil * °C	Fertilizer** kg ha <sup>-1</sup>
2002	1	9-Apr	4/6	11-7-24-10
	2	23-Apr	5/6	
	3	13-May	> 15	
	4	27-May	> 15	
2003	1	8-Apr	13/13	3-7-21-9
	2	22-Apr	15/16	
	3	8-May	11/12	
	4	21-May	> 15	
	5	30-May	> 15	
2004	1	25-Mar	11/12	5-9-17-7
	2	13-Apr	12/12	
	3	2-May	14/16	
	4	21-May	16/17	
	5	4-June	>15	

\* Measured at 5 cm depth. First number is fallow, second number is stubble.

\*\* Fertilizer N-P-K-S applied at seeding in the seed furrow. Nitragin Soil Implant strain-specific peat granular inoculant applied in seed furrow at a rate of 6 kg ha<sup>-1</sup>. In 2002 spring wheat received an additional 88 kg ha<sup>-1</sup> of N (46-0-0) and in 2003 and 2004 wheat received an additional 111 kg ha<sup>-1</sup> of N (46-0-0) side-banded at seeding.

#### Did seeding date affect the emergence time of chickpea?

**Yes.** Degree days to emergence showed that the effect of spring seeding date was two to three times as important as the year or cultivar effects in both fallow and recropped wheat stubble (Tables 2, 3). The earliest seeding date required 20 to 37 calendar days to emerge while the latest seeding date required 9 to 11 days. Degree day requirements generally increased from earliest to latest seeding dates each year on a much smaller percentage basis than calendar days. Averaged for years and seeding dates, the large-seeded unifoliate-leaved kabuli type, Dwelley, required one more day to emerge than the other three chickpea varieties. Pea emerged one to two days sooner than chickpea and spring wheat emerged two days earlier than pea.

#### Did seeding date affect the flowering time of chickpea?

**Yes and No.** Earlier seeding required more calendar days but not more degree days. In contrast with emergence, degree days for the emergence to flowering period showed that the effect of spring seeding date was nine times less important than the year or cultivar effects in both fallow and recropped wheat stubble (Tables 2, 3). The earliest seeding date required 76 to 91 calendar days from seeding to flowering while the latest seeding date required only 45 to 47 calendar days. However, degree day requirements showed no consistent pattern among spring seeding dates. Varietal differences in time to flowering were due to genetic differences and were not related to seed size. Flowering time for pea was similar to chickpea while wheat required an additional 10 calendar days.

#### Did seeding date affect the maturation time of chickpea?

**Yes and No.** Earlier seeding required more calendar days but not more degree days. The year effect was 10 to 18 times more important than either spring seeding date or chickpea cultivar (Tables 2, 3). The earliest seeding date required 111 to 144 calendar days from seeding to physiological maturity while the latest seeding date required 79 to 103 calendar days. It's important to note that typically an additional 10 to 14 days of drydown time are required for chickpea to be ready for harvest. Degree day requirements showed no consistent pattern among spring seeding dates. The large seeded kabuli varieties were two to three days later maturing than the smaller seeded types. Pea matured 16 to 18 days earlier than chickpea while wheat was similar to chickpea.

#### Did seeding date affect the length of flowering and seed fill periods?

**No.** The year effect was most important for both the flowering and seed fill periods (Tables 2, 3). Seeding date was two to three times more important than cultivar for flowering period but cultivar was three to four times more important than seeding date for the seed fill period. The flowering period for chickpea was 71 to 109% greater than pea and the seed fill period for chickpea was 47 to 70% greater than for pea. So despite similar thermal time requirements to flower, chickpea had much greater requirements than pea to complete the flowering and seed fill periods.

Table 2. Calendar and thermal time ( $T_{\min} = 0^{\circ}\text{C}$ ) for crop emergence and development (degree days after emergence) of chickpea and dry pea cultivars when grown in chem fallow, Amsterdam, 2002-04.

	Emergence		Flower		Flower period <sup>†</sup>		Maturity <sup>‡</sup>		Seed fill <sup>‡</sup>
	d	DD <sub>0</sub>	d	DD <sub>0</sub> <sup>e</sup>	d	DD <sub>0</sub>	d	DD <sub>0</sub> <sup>e</sup>	DD <sub>0</sub>
<i>Model MS %</i>									
Year	38**	31**	23**	58**	84**	79**	66**	79**	60**
Seed date (yr)	61**	52**	73**	5**	12**	15**	32**	7**	6**
Cultivar	1**	17**	4**	36**	3**	5**	1**	8**	26**
SD x C (yr)	0**	0**	0**	1**	1**	1**	0**	3**	5**
<i>Seed dates</i>									
Apr 9, 2002	37	185	80	578	19	381	125	1457	879
Apr 23, 2002	25	149	67	565	17	350	112	1432	868
May 13, 2002	15	160	53	584	14	311	95	1390	806
May 28, 2002	9	132	45	596	17	358	88	1384	788
Apr 8, 2003	21	168	77	673	-	-	115	1483	799
Apr 22, 2003	21	141	70	694	-	-	108	1526	834
May 8, 2003	17	163	57	633	-	-	94	1444	804
May 21, 2003	8	147	49	643	-	-	84	1435	785
May 30, 2003	10	119	46	643	-	-	88	1565	920
Mar 25, 2004	29	206	91	650	29	541	144	1634	984
Apr 13, 2004	21	167	78	649	27	499	127	1579	930
May 3, 2004	17	161	67	656	21	415	116	1575	920
May 21, 2004	15	157	54	588	18	365	104	1496	909
Jun 4, 2004	11	129	47	608	21	390	103	1537	929
LSD <sub>0.10</sub> - date (yr)	0.3	4	0.4	9	0.9	17	1.4	21	23
<i>Chickpea phenotypes</i>									
Kabuli, large - uni	19	166	65	646	19	378	109	1513	866
Kabuli, large - fern	18	151	62	616	19	380	108	1514	891
Kabuli, small - fern	18	151	64	652	20	396	105	1454	802
Desi, small - fern	18	157	60	577	22	430	107	1481	904
LSD <sub>0.10</sub> - cultivar	0.2	2	0.3	5	0.6	11	0.8	12	13
<i>CDC Mozart pea</i>	17	141	62	634	12	221	89	1169	533
<i>McNeal spring wheat</i>	15	122	73	835	na	na	109	1545	699

<sup>†</sup> Flower period data not collected in 2003, or for wheat.

<sup>‡</sup> LKF chickpea phenotype omitted in 2003.

<sup>e</sup> Degree days for flower and mature stages after emergence.

Table 3. Calendar and thermal time ( $T_{\min} = 0^{\circ}\text{C}$ ) for crop emergence and development (degree days after emergence) of chickpea and dry pea cultivars grown in wheat stubble, Amsterdam, 2002-04.

	Emergence		Flower		Flower period <sup>†</sup>		Maturity		Seed fill
	d	DD <sub>0</sub>	d	DD <sub>0</sub> <sup>e</sup>	d	DD <sub>0</sub>	d	DD <sub>0</sub> <sup>e</sup>	DD <sub>0</sub>
<i>Model MS %</i>									
Year	38**	16**	20**	47**	89**	87**	75**	90**	88**
Seed date (yr)	61**	59**	75**	5**	9**	9**	25**	5**	3**
Cultivar	1**	24**	4**	46**	2**	4**	1**	5**	9**
SD x C (yr)	0**	1**	0**	1**	0**	0*	0**	1**	1**
<i>Seed dates</i>									
Apr 9, 2002	35	174	79	567	18	373	120	1374	807
Apr 23, 2002	25	140	67	576	17	347	108	1386	809
May 13, 2002	15	159	54	589	14	308	92	1340	750
May 28, 2002	10	136	46	602	17	353	-‡	-‡	-‡
Apr 8, 2003	20	165	76	659	-	-	111	1383	724
Apr 22, 2003	21	144	69	673	-	-	100	1354	681
May 8, 2003	16	154	57	629	-	-	88	1315	686
May 21, 2003	8	149	49	631	-	-	80	1331	700
May 30, 2003	10	121	46	637	-	-	79	1395	758
Mar 25, 2004	28	201	90	640	30	551	144	1633	993
Apr 13, 2004	20	155	76	643	27	511	126	1579	936
May 3, 2004	16	153	65	631	23	442	111	1506	875
May 21, 2004	14	148	53	584	20	404	101	1468	884
Jun 4, 2004	10	126	46	593	21	390	98	1489	897
LSD <sub>0.10</sub> - date (yr)	0.3	3	0.4	7	0.8	15	1.1	18	20
<i>Chickpea phenotypes</i>									
Kabuli, large - uni	19	161	64	639	19	382	106	1430	794
Kabuli, large - fern	18	145	61	609	20	397	106	1453	846
Kabuli, small - fern	18	147	64	646	20	394	104	1396	751
Desi, small - fern	18	153	60	569	22	437	104	1398	829
LSD <sub>0.10</sub> - cultivar	0.2	2	0.2	4	0.6	10	0.6	10	11
<i>CDC Mozart pea</i>	17	137	62	635	11	209	89	1142	512
<i>McNeal spring wheat</i>	14	117	72	820	na	na	103	1469	648

<sup>†</sup> Flower period data not collected in 2003, or for wheat.

<sup>‡</sup> Last seeding date was heavily damaged by deer predation.

<sup>e</sup> Degree days for flower and mature stages after emergence.

Did very early seeding reduce plant density?

**No.** There was no general effect of seeding date on plant density despite some emergence times greater than one month (Tables 4 - 6). In 2002, on fallow only, there was a small reduction in plant stand at the earliest seeding date when 37 days were required for emergence. All chickpea seed was treated with a fungicide containing metalaxyl (Allegiance or Apron). **One conclusion from this study is that if seed is properly treated with metalaxyl cold soil temperatures are not a barrier to seeding chickpea.**

Did seeding date affect seed yield?

**Yes, but not as much as for pea or wheat** (Figure 2). Averaged for all site-years (excluding 2002 stubble due to missing data) chickpea yield declined 31% from the earliest to the latest seeding date while pea and wheat declined 55%. **Earlier seeding leads to increased yield potential in chickpea but delayed seeding may be damage yield greater in other crops.**

Were chickpea yields on stubble lower than fallow?

**Yes and No.** In 2002, stubble yield (1510 lb/ac) for chickpea averaged only 68% of fallow (2210 lb/ac) in an adjacent field (Table 4). However, in 2003 (the driest year), stubble yield (840 lb/ac) averaged 121% of fallow and in 2004 stubble yield (1870 lb/ac) averaged 105% of fallow (Table 5, 6). There was no indication that farmers would critically reduce chickpea production risk by growing it on fallow.

Did seeding date affect average seed size?

**No.** In 2002, seeding date did not affect seed size (Table 4). In 2003, at the stubble site only, the latest seeding date, with the lowest yield, had 7% larger seed size (Table 5).

Did seeding date affect the seed size fraction > 9 mm for Dwelley?

**Inconsistently,** Figure 3. In 2002, at the stubble site only, April seeding resulted in 82% of the seed > 9 mm, while May seeding resulted in only 70% (Table 4). In the drought year of 2003 only a minor portion of the seed was > 9 mm at either site but the earliest April seeding consistently had the lowest seed fraction > 9 mm (20%) (Table 5). The 2004 response was the opposite of 2002. Late March/early April seeding resulted in 61% (fallow) and 58% (stubble) of seed > 9 mm, May seeding resulted in 74% (fallow) and 69% (stubble) of seed > 9 mm, and early June seeding resulted in 84% (fallow) and 79% (stubble) > 9 mm (Table 6). Seed size is the final component of yield formation and will be largely controlled by precipitation timing prior to and during seed fill.

What yield component did seeding date affect most?

**Pods per plant.** Yield component measurements were taken only in 2004 (Table 7). A generally progressive decline in the number of pods per plant occurred as seeding was delayed.

Figure 1. Seed yield of chickpea (average of 4 cultivars), Mozart pea and McNeal wheat at different spring seeding dates when grown on fallow at Amsterdam, MT, 2002-04.

Figure 2. Fraction of Dwelley chickpea > 9 mm at different spring seeding dates when grown on fallow and wheat stubble sites at Amsterdam, MT, 2002-04.

Table 4. Chickpea and dry pea plant density, shoot biomass and seed yield, harvest index, and seed size fraction (Dwelley only) responses to spring seeding date and cultivar at Amsterdam, MT, 2002.

	Stand plts m <sup>-2</sup>	Shoot t ha <sup>-1</sup>	Yield	HI	Seedwt mg	Seed size fractions (%)			
						<8 mm	8-9	9-10	>10
<b>Chem fallow experiment</b>									
Model MS %									
Seeding date	20*	27*	13*	6*	0	ns	ns	ns	ns
Cultivar	72**	14	78**	90**	100**	-	-	-	-
SD x C	2	44**	6	3	0	-	-	-	-
Seeding dates									
Apr 9	41	5.08	2.21	0.52	353	3	19	43	35
Apr 23	49	5.16	2.24	0.48	354	3	19	41	37
May 13	45	5.00	2.19	0.48	355	5	21	41	33
May 28	47	4.66	2.05	0.51	344	4	17	43	36
LSD <sub>0.10</sub>	4	na	0.12	0.04	ns				
Cultivars									
Dwelley	41	5.18	1.92	0.40	458	4	19	42	35
Yuma	41	5.00	2.10	0.47	453				
Amit	45	4.89	2.34	0.54	284				
Myles	54	4.83	2.34	0.57	211				
LSD <sub>0.10</sub>	4	na	0.12	0.04	9				
<i>Mozart pea</i>	103	5.42	2.53	0.39	216				
<i>McNeal wheat</i>	139	8.13	3.45	0.44	32				
<b>Recropped wheat stubble experiment<sup>3</sup></b>									
Model MS %									
Seeding date	1	27*	31**	2	0	**	ns	*	ns
Cultivar	96**	39**	57**	93**	99**	-	-	-	-
SD x C	3	15	3	2	1**	-	-	-	-
Seed dates									
Apr 9	43	4.01	1.54	0.46	336	2	18	52	28
Apr 23	43	3.82	1.62	0.48	342	2	14	43	41
May 13	44	3.56	1.38	0.47	346	4	25	43	28
May 28	44	-	-	-	-	8	25	38	30
LSD <sub>0.10</sub>	ns	0.21	0.09	ns	ns	1	ns	5	ns
Cultivars <sup>3</sup>									
Dwelley	39	4.15	1.29	0.40	447	3	19	45	32
Yuma	39	3.70	1.42	0.43	445				
Amit	42	3.89	1.68	0.49	273				
Myles	53	3.44	1.66	0.55	201				
LSD <sub>0.10</sub>	4	0.24	0.10	0.03	8	1	ns	5	ns
<i>Mozart pea</i>	98	6.14	2.22	0.39	195				
<i>McNeal wheat</i>	124	7.02	2.36	0.40	29				

<sup>3</sup> Cultivar means were calculated for first three dates only, except for plant stand, since the latest seeding date was grazed by antelope.

\*, \*\* Significant at  $P < 0.10$  and  $P < 0.01$  according to ANOVA F-test.

Table 5. Chickpea and dry pea plant density, shoot biomass and seed yield, harvest index, pods per plant and seed size fraction (large kabuli only) responses to spring seeding date and cultivar at Amsterdam, MT, 2003.

	Stand plt m <sup>-2</sup>	Shoot t ha <sup>-1</sup>	Yield	HI	Seed wt mg	Seed size percentages (mm)			
						< 8	8-9	9-10	> 10
<b>Chem fallow experiment</b>									
Model MS %									
Seeding date	19**	81**	38**	4**	0	**	ns	**	**
Cultivar	69**	16**	57**	92**	100**	-	-	-	-
SD x C	4	2	4**	3**	0	-	-	-	-
Seeding dates									
Apr 8	42	2.91	0.86	0.32	250	40	42	16	2
Apr 22	42	2.66	0.77	0.33	252	20	47	27	6
May 8	39	2.29	0.80	0.36	249	29	47	19	5
May 21	43	1.86	0.64	0.39	243	30	43	21	6
May 30	47	1.61	0.43	0.34	260	23	46	23	8
LSD <sub>0.10</sub>	3	0.13	0.05	0.02	ns	5	ns	2	2
Cultivars									
Dwellely	40	2.45	0.52	0.24	329	28	45	21	6
Yuma	39	-	-	-	-	-	-	-	-
Amit	50	2.24	0.74	0.36	-	-	-	-	-
Anna	42	2.10	0.83	0.45	173	-	-	-	-
LSD <sub>0.10</sub>	3	0.10	0.04	0.02	8	na	na	na	na
<i>Mozart pea</i>	115	3.40	0.93	0.28	-	-	-	-	-
<i>McNeal wheat</i>	201	4.51	1.12	0.33	-	-	-	-	-
<b>Recropped wheat stubble experiment</b>									
Model MS %									
Seeding date	15**	79**	54**	12**	3**	36**	26*	24**	43**
Cultivar	76**	14**	40**	84**	97**	42**	29	41**	49**
SD x C	4	3	1	1**	0**	10*	43*	24**	5**
Seed dates									
Apr 8	42	2.71	0.99	0.40	245	27	50	20	2
Apr 22	37	2.55	0.94	0.40	253	16	51	28	5
May 8	39	2.28	0.90	0.44	256	15	51	29	5
May 21	43	2.00	0.76	0.45	259	12	52	30	6
May 30	42	1.63	0.59	0.45	272	9	45	33	13
LSD <sub>0.10</sub>	3	0.11	0.04	0.01	4	4	4	3	1
Cultivars									
Dwellely	39	2.25	0.68	0.35	366	12	49	31	8
Yuma	35	2.00	0.73	0.41	357	19	51	25	4
Amit	47	1.97	0.87	0.50	224	-	-	-	-
Anna	41	1.89	0.92	0.53	167	-	-	-	-
LSD <sub>0.10</sub>	2	0.10	0.03	0.01	4	2	2	2	1
<i>Mozart pea</i>	113	3.04	0.97	0.35	171	-	-	-	-
<i>McNeal wheat</i>	207	4.34	1.44	0.34	-	-	-	-	-

\*,\*\* Significant at  $P < 0.10$  and  $P < 0.01$ , according to ANOVA F-test.

Table 6. Chickpea and dry pea plant density, shoot biomass and seed yield, harvest index, and seed size (large kabuli only) responses to spring seeding date and cultivar at Amsterdam, MT, 2004.

	Stand plts m <sup>-2</sup>	Shoot t ha <sup>-1</sup>	Yield	HI	Seed size percentages (mm)			
					< 8	8-9	9-10	> 10
<b>Chem fallow experiment</b>								
Model MS %								
Seeding date	11**	42**	20**	36**	48**	40**	17	21**
Cultivar	84**	5*	25**	54**	48**	37**	46*	59**
SD x C	1	3*	1	1	2	4**	6	1
Seeding dates								
Mar 25	41	5.58	2.09	0.44	8	33	45	15
Apr 13	38	4.96	1.92	0.47	7	30	47	15
May 3	40	4.54	1.81	0.49	3	22	48	27
May 21	44	3.65	1.54	0.53	4	24	51	21
Jun 4	33	3.72	1.54	0.52	2	14	50	34
LSD <sub>0.10</sub>	4	0.26	0.07	0.01	1	2	ns	4
Cultivars								
Dwellely	31	4.51	1.59	0.45	3	21	46	29
Yuma	32	4.14	1.58	0.47	6	28	50	16
Amit	42	4.72	1.92	0.50	-	-	-	-
Anna	52	4.60	2.05	0.54	-	-	-	-
LSD <sub>0.10</sub>	4	0.24	0.06	0.01	1	2	2	3
<i>Mozart pea</i>	96	5.72	2.12	0.37	-	-	-	-
<i>McNeal wheat</i>	183	7.39	2.94	0.40	-	-	-	-
<b>Recropped wheat stubble experiment</b>								
Model MS %								
Seeding date	23**	91**	51**	22**	59**	62**	11*	25**
Cultivar	71**	2	38**	73**	18*	0	75**	58**
SD x C	2	3	2**	3**	9*	3	7	2
Seed dates								
Mar 25	41	5.70	2.23	0.47	6	32	48	15
Apr 13	40	5.16	2.07	0.47	6	33	49	13
May 3	32	4.15	1.80	0.50	3	25	55	17
May 21	49	3.76	1.68	0.53	4	30	52	14
Jun 4	43	3.49	1.56	0.51	2	19	52	27
LSD <sub>0.10</sub>	4	0.28	0.06	0.01	1	3	3	3
Cultivars								
Dwellely	31	4.28	1.63	0.45	4	28	48	21
Yuma	34	4.41	1.78	0.49	5	28	55	13
Amit	47	4.52	1.94	0.50	-	-	-	-
Anna	51	4.59	2.13	0.56	-	-	-	-
LSD <sub>0.10</sub>	4	ns	0.06	0.01	1	ns	2	2
<i>Mozart pea</i>	87	5.83	2.30	0.41	-	-	-	-
<i>McNeal wheat</i>	197	7.39	2.89	0.40	-	-	-	-

\*, \*\* Significant at  $P < 0.10$  and  $P < 0.01$ , according to ANOVA F-test.

Table 7. Chickpea yield component responses to spring seeding date and cultivar in fallow and wheat stubble experiments at Amsterdam, MT, 2004.

	Plants m <sup>-2</sup>	Pods m <sup>-2</sup>	Pod/plt	Seed/pod	Plants m <sup>-2</sup>	Pods m <sup>-2</sup>	Pod/plt	Seed/pod
	<i>Chem fallow experiment</i>				<i>Recropped wheat stubble experiment</i>			
Model MS %								
Seeding date	8*	19**	20**	6**	4	14**	32**	8**
Cultivar	89**	66**	13*	87**	90**	83**	57**	88**
SD x C	2	2	5	3*	3	1	5	3**
Seeding dates								
Mar 25	44	829	18.9	1.12	41	819	20.2	1.18
Apr 13	42	729	17.7	1.22	42	793	18.8	1.21
May 3	35	531	15.9	1.13	39	595	15.7	1.14
May 21	39	623	16.1	1.17	37	630	16.9	1.21
Jun 4	41	575	14.1	1.08	36	562	15.4	1.05
Cultivars								
Dwellely	32	465	14.8	1.08	30	423	14.5	1.06
CDC Yuma	30	525	17.3	0.93	31	548	17.8	0.95
Amit	47	748	16.5	1.21	45	736	16.9	1.24
CDC Anna	52	892	17.5	1.35	51	1011	20.4	1.38
LSD <sub>0.10</sub>	8	110	2.9	0.09	8	98	2.6	0.07

\*,\*\* Significant at  $P < 0.10$  and  $P < 0.01$ , according to ANOVA F-test.

Did seeding date affect soil water use by chickpea?

**No.** Post-harvest soil water measurements revealed small differences in residual soil water among seeding dates for each site-year but no consistent patterns were evident (Tables 8, 9). For example, in 2004, residual soil water decreased with delayed seeding on fallow but increased with delayed seeding at the stubble site. Chickpea generally did not extract soil water below 0.9 m in this study.

Did chickpea cultivar affect soil water use by chickpea?

**No,** not in any of four site-years (Tables 8, 9). Chickpea soil water use was consistently but only slightly greater (5.5 mm) than pea averaged for four site-years. Chickpea soil water use was similar to spring wheat except under stubble in 2004 where wheat chickpea used 13 mm less soil water than wheat.

Did chickpea seeding date affect fall soil nitrogen?

**Maybe.** In one of three site-years (2004 - fallow site) where soil N was measured a very late seeding date (June 4) had 12 kg ha<sup>-1</sup> less NO<sub>3</sub>-N than very early or mid-spring seeding dates (Table 9). A similar but non-significant trend occurred at the two remaining sites (Tables 8, 9). This pattern would be consistent with anticipated soil N mineralization dynamics.

Did chickpea cultivar affect fall soil nitrogen?

**Maybe.** In one of three site-years (2002 - stubble site) Dwelley, a large-seeded kabuli cultivar, had 3 - 5 kg ha<sup>-1</sup> less NO<sub>3</sub>-N than three other chickpea cultivars (Tables 8, 9). A similar but non-significant trend was observed at both sites in 2004 where soil N under Dwelley was 5 kg ha<sup>-1</sup> less than Anna, a small seeded-desi cultivar. This potential finding is unexpected and may merit further investigation. Soil N under pea stubble averaged 8 kg ha<sup>-1</sup> greater than chickpea in 2004, consistent with earlier reports in southern Saskatchewan. The high amounts of residual soil N under wheat stubble in 2004 was unexpected.

Table 8. Post-harvest (4 Oct) soil water and soil nitrogen for chickpea sown at four different dates in chem fallow and recropped wheat stubble experiments at Amsterdam, MT, 2002.

	Soil water					NO <sub>3</sub> -N 0 - 0.6 m kg ha <sup>-1</sup>
	0 - 0.3 m	0.3 - 0.6 m	0.6 - 0.9 m	0.9 - 1.2 m	0 - 1.2 m	
	mm					
<b><i>Chem fallow experiment</i></b>						
Model MS %						
Seeding date	60**	ns	21*	ns	37*	
Cultivar	6	ns	53**	ns	29	
SD x C	17	ns	8	ns	12	
Seeding dates						
Apr 9	43	32	41	51	167	
Apr 23	41	33	37	51	163	
May 13	40	33	39	51	163	
May 28	39	31	37	51	158	
LSD <sub>0.10</sub>	2	ns	2	ns	4	
Cultivars						
Dwellely	41	32	35	50	159	
Yuma	42	32	39	52	164	
Amit	40	31	39	52	162	
Myles	40	33	42	51	166	
LSD <sub>0.10</sub>	ns	ns	2	ns	ns	
Mozart pea	42	37	42	52	172	
McNeal wheat	47	38	34	43	162	
<b><i>Recropped wheat stubble experiment</i></b>						
Model MS %						
Seeding date	51**	ns	11	ns	22*	5
Cultivar	22	ns	39**	ns	18	14*
SD x C	10	ns	16*	ns	9	2
Seeding dates						
Apr 9	51	37	40	45	172	26
Apr 23	49	35	40	45	169	25
May 13	47	35	37	43	162	23
May 28	50	37	37	46	169	22
LSD <sub>0.10</sub>	2	ns	3	ns	5	ns
Cultivars						
Dwellely	50	35	38	44	168	21
CDC Yuma	49	36	36	44	166	24
Amit	47	36	37	45	165	24
Myles	49	36	42	46	174	26
LSD <sub>0.10</sub>	ns	ns	3	ns	ns	3
CDC Mozart	50	37	42	46	175	25
McNeal wheat	45	30	38	42	155	21

\*, \*\* Significant at  $P < 0.10$  and  $P < 0.01$  according to ANOVA F-test.

Table 9. Post-harvest (18 - 22 Nov) soil water for chickpea sown at different dates in chem fallow and recropped wheat stubble experiments at Amsterdam, MT, 2004.

	Soil water					NO <sub>3</sub> -N 0 - 0.6 m kg ha <sup>-1</sup>
	0 - 0.3 m	0.3 - 0.6 m	0.6 - 0.9 m	0.9 - 1.2 m	0 - 1.2 m	
	mm					
Chem fallow experiment						
Model MS %						
Seeding date	56**	52**	34*	ns	<b>68**</b>	<b>66*</b>
Cultivar	7	6	13	ns	<b>11</b>	<b>23</b>
SD x C	3	2	27	ns	<b>7</b>	<b>1</b>
Seeding dates						
Mar 25	18	16	17	18	<b>70</b>	<b>42</b>
May 3	17	15	17	18	<b>67</b>	<b>38</b>
Jun 4	15	13	16	18	<b>63</b>	<b>28</b>
LSD <sub>0.10</sub>	1	1	1	ns	<b>2</b>	<b>6</b>
Cultivars						
Dwelley	17	15	17	18	<b>66</b>	<b>33</b>
Anna	17	15	17	18	<b>67</b>	<b>38</b>
Mozart pea	19	16	17	18	<b>69</b>	<b>47</b>
<i>McNeal wheat</i>	19	16	17	18	<b>70</b>	<b>103</b>
Recropped wheat stubble experiment						
Model MS %						
Seeding date	68**	64**	58**	80**	<b>91**</b>	ns
Cultivar	22*	1	1	4	<b>1</b>	ns
SD x C	3	2	0	2	<b>0</b>	ns
Seeding dates						
Mar 25	19	15	17	19	<b>70</b>	<b>45</b>
May 3	18	15	17	19	<b>69</b>	<b>41</b>
Jun 4	21	18	21	22	<b>82</b>	-
LSD <sub>0.10</sub>	1	1	1	1	<b>2</b>	
Cultivars						
Dwelley	19	16	18	20	<b>73</b>	<b>41</b>
Anna	20	16	18	20	<b>74</b>	<b>45</b>
LSD <sub>0.10</sub>	1	ns	ns	ns	<b>ns</b>	
Mozart pea	20	17	19	20	<b>77</b>	<b>49</b>
<i>McNeal wheat</i>	21	16	18	19	<b>75</b>	<b>56</b>

\*, \*\* Significant at P < 0.10 and P < 0.01 according to ANOVA F-test.

## **Crop Sequence Effects of Chickpea**

This research project was partially motivated by questions from producers about the comparative cropping sequence effects on spring wheat by different chickpea cultivars. To gather data to help answer this question spring wheat was uniformly recropped, with full recommended rates of fertilizer N application, on each of the chickpea stubble sites, to simulate a continuous cropping system.

### Did chickpea seeding date or cultivar affect grain **yield** in a subsequent spring wheat crop?

**No.** Tables 10 - 12. However a typical yield reduction for wheat grown on wheat stubble was observed in both years where this was measured. In 2003, wheat grown in chickpea stubble averaged 12% greater yield, and in 2004, 4% greater yield than wheat grown in wheat stubble (Tables 10, 11). Grain yields in chickpea stubble did not differ from pea stubble.

### Did chickpea seeding date or cultivar affect grain **quality** in a subsequent spring wheat crop?

**No.** However, in 2003, protein in pea stubble was greater, and protein in wheat stubble was less, compared with chickpea stubble (Table 10).

Table 10. Spring wheat yield, grain protein and grain nitrogen yield following chickpea, dry pea and spring wheat sown at four different dates in 2002, at Amsterdam, MT, 2003.

	Yield t ha <sup>-1</sup>	Protein g kg <sup>-1</sup>	N yield kg ha <sup>-1</sup>	Grain density		Seed weight mg
				kg m <sup>-3</sup>	lb bu <sup>-1</sup>	
Model MS %						
Seeding date	ns	ns	ns	ns	ns	ns
Cultivar	ns	ns	ns	ns	ns	ns
SD x C	ns	ns	ns	ns	ns	ns
Seeding dates						
Apr 9	1.88	176	58	671	52.1	21.0
Apr 23	1.90	174	58	677	52.6	21.4
May 13	1.86	174	57	673	52.3	21.0
May 28	1.94	174	59	677	52.6	21.6
Cultivars						
Dwelley	1.89	174	58	677	52.6	21.4
Yuma	1.91	174	58	679	52.7	21.4
Amit	1.90	174	58	671	52.2	21.2
Myles	1.93	170	58	677	52.6	21.7
LSD <sub>0.10</sub>	ns	ns	ns	ns	ns	ns
Mozart pea	1.85	180	58	667	51.9	20.7
<i>McNeal wheat</i>	1.70	166	49	683	53.0	20.9

\*\* Significant at  $P < 0.01$  according to ANOVA F-test.

Table 11. Spring wheat yield, grain protein and grain nitrogen yield following chickpea, dry pea and spring wheat sown at five different dates in 2003, at Amsterdam, MT, 2004.

	Yield	Protein	N yield	Grain density		Seed weight
	t ha <sup>-1</sup>	g kg <sup>-1</sup>	kg ha <sup>-1</sup>	kg m <sup>-3</sup>	lb bu <sup>-1</sup>	mg
Model MS %						
Seeding date	ns	ns	ns			
Cultivar	ns	ns	ns			
SD x C	ns	ns	ns			
Seeding dates						
Apr 8	2.26	166	65			
Apr 22	2.24	166	65			
May 8	2.31	166	67			
May 21	2.32	166	68			
May 30	2.29	167	67			
Cultivars						
Dwelley	2.28	166	66			
Yuma	2.29	167	67			
Amit	2.29	165	66			
Anna	2.30	166	67			
Mozart	2.27	167	66			
<i>McNeal wheat</i>	2.20	167	64			

Table 12. Spring wheat yield, grain protein and grain nitrogen yield following chickpea, dry pea and spring wheat sown at five different dates in 2004, at Amsterdam, MT, 2005.

	Yield	Protein	N yield	Grain density		Seed weight
	t ha <sup>-1</sup>	g kg <sup>-1</sup>	kg ha <sup>-1</sup>	kg m <sup>-3</sup>	lb bu <sup>-1</sup>	mg
Model MS %						
Seeding date	ns					
Cultivar	ns					
SD x C	ns					
Seeding dates						
Mar 25	2.03					
Apr 13	2.04					
May 3	2.07					
May 21	2.15					
Jun 4	2.13					
Cultivars						
Dwelley	2.05					
Yuma	2.06					
Amit	2.11					
Anna	2.10					
LSD <sub>0.10</sub>	ns					
Mozart pea	2.01					

## Seeding Rate x Date Study

The cultivar CDC Yuma was chosen to represent a normal fern leaf large-seeded kabuli cultivar. Recommended plant density is 30 plants  $m^{-2}$ . In 2002, four plant populations were targeted (15, 30, 45 and 60 plants  $m^{-2}$ ). Due to a lack of yield response at the lowest plant density in subsequent years we revised out methods to target 10, 20, 30, 40, and 50 plants  $m^{-2}$ . Data from 2003 were omitted because of an unknown soil effect that negatively affected the normal growth and development of Yuma.

### Did we achieve targeted stand densities?

**No.** In 2002, we exceeded targets by 29 to 47% resulting in a range of plant populations from 22 to 78 plants  $m^{-2}$  (Table 13). In 2004 we were very near targets at the highest plant populations but still exceeded the three lowest target densities by 20% (Table 14). Thus, the following interpretation of chickpea response to plant population does not include densities below 12 plants  $m^{-2}$ .

### Did seeding rate affect seed yield?

**Yes, but in contrasting ways.** In 2002, the highest plant density (78 plants  $m^{-2}$ ) yielded 11% less than lower plant densities ranging from 22 to 58 plants  $m^{-2}$  (Table 13). In 2004 the lowest plant density (12 plants  $m^{-2}$ ) yielded 31% less and the second lowest plant density (24 plants  $m^{-2}$ ) yielded 9% less than the middle seeding rate (36 plants  $m^{-2}$ ) (Table 14). **Thus optimal yield was achieved between 22 and 36 plants  $m^{-2}$ .**

### Did seeding rate affect seed quality?

**Yes.** Seed size and plant density were inversely related. In 2002 the greatest average seed size (437 mg/seed) occurred at the lowest density (22 plants  $m^{-2}$ ) and declined to 430 and 418 mg/seed, respectively, at the highest densities (58 and 78 plants  $m^{-2}$ ) (Table 13). Similarly, in 2004, the greatest average seed size (441 mg/seed) occurred at the lowest density (12 plants  $m^{-2}$ ) and declined to 433 mg/seed at mid densities (24 and 36 plants  $m^{-2}$ ) and declined further to 421 mg/seed at the highest densities (42 and 51 plants  $m^{-2}$ ) (Table 15).

In 2004, the proportion of seed sized  $> 9$  mm was greatest (59%) for the lowest seeding rate (12 plants  $m^{-2}$ ) and declined to 50% at the second lowest rate (24 plants  $m^{-2}$ ) and then to 45 to 48% at the highest seeding rates (Table 15, Figure 3). However the proportion of green seed at the lowest seeding rate was twice the allowable limit (1%) for U.S. No. 1 grade chickpea (Table 15, Figure 3). Green seed content at all higher seeding rates was half or less than the allowable limit.

### Did seeding rate affect harvestability?

**Yes.** In 2002, physiological maturity was delayed by more than a day at the lowest plant density (22 plants  $m^{-2}$ ) compared with all higher densities (44 - 78 plants  $m^{-2}$ ) (Table 13). However, in 2004, delays in physiological maturity were much more pronounced (Table 14). The lowest seeding rate (12 plants  $m^{-2}$ ) required 14 additional days to reach maturity compared with the next lowest seeding rate (24 plants  $m^{-2}$ ). Increasing density from 24 to 36 plants  $m^{-2}$  hastened maturity by 4 days, and then by 2 additional days at each of the next two plant densities. Chickpea maturity is similar to spring wheat at mid to high plant densities (36 - 51 plants  $m^{-2}$ ) but can be substantially prolonged at low plant densities (12 - 24 plants  $m^{-2}$ ). It is possible that prolonged drydown time after physiological maturity might further exacerbate harvest delays.

### What yield component did seeding rate affect most?

**Pods per plant,** besides final plant density. Table 15.

### Did seeding rate affect soil water use?

**No.** Table 16.

Table 13. Seeding date and rate effects on Yuma chickpea sown in chem fallow at Amsterdam, MT, 2002.

	Stand	Shoot	Yield	Harvest	Seed	Flower		Maturity	
	m <sup>-2</sup>	t ha <sup>-1</sup>		index	weight	days	DD <sub>0</sub>	days	DD <sub>0</sub>
<b>Model MS %</b>									
Date	1	72**	6	39**	45**	48**	42**	99**	84**
Rate	97**	11	28**	44**	31**	50**	56**	0**	12**
D x R	1*	12*	13*	4	11	1**	1*	0*	2*
<hr/>									
<b>Seeding Date</b>									
Apr 9	54	4.33	1.89	0.45	430	19.5	389	125.9	1463
Apr 23	51	4.50	1.84	0.39	422	16.3	321	112.5	1457
May 13	50	4.39	1.93	0.41	442	12.4	258	95.2	1379
May 28	47	3.67	1.82	0.49	422	14.4	298	88.6	1372
LSD <sub>0.10</sub>	ns	0.18	ns	0.02	7	0.4	9	0.5	8
<hr/>									
<b>Seeding Rate (targeted plant m<sup>-2</sup>)</b>									
15	22	4.21	1.92	0.49	437	20.1	407	107.1	1443
30	44	4.07	1.92	0.45	431	15.4	315	105.1	1409
45	58	4.19	1.93	0.42	430	13.9	282	104.6	1401
60	78	4.42	1.72	0.38	418	13.1	263	105.5	1417
LSD <sub>0.10</sub>	4	ns	0.09	0.02	7	0.4	9	0.5	8

\*\*,\* Significant at  $P < 0.01$  and  $P < 0.10$  according to ANOVA F-test.

Table 14. Seeding date and rate effects on growth and yield of Yuma chickpea sown in chem fallow at Amsterdam, MT, 2004.

	Stand	Biomass	Yield	Harvest index	Flower period		Emergence to maturity		Flower to maturity
	m <sup>-2</sup>	t ha <sup>-1</sup>			days	DD <sub>0</sub>	days	DD <sub>0</sub>	
Model MS %									
Date	3*	40**	10**	71**	69**	65**	78**	27**	14**
Rate	94**	25**	48**	5*	30**	34**	19**	63**	75**
D x R	2*	4	0	4*	1	1	1**	2**	3**
Seeding Date									
Mar 25	35	4.80	1.61	0.42	30.3	564	149	1733	1082
Apr 13	34	4.38	1.49	0.44	26.5	494	133	1681	1023
May 3	33	3.95	1.45	0.47	23.1	448	124	1684	1031
May 21	34	3.67	1.43	0.50	19.6	397	110	1574	989
Jun 4	28	3.53	1.34	0.49	20.6	383	104	1560	947
LSD <sub>0.10</sub>	3	0.24	0.07	0.01	0.7	12	2	20	20
Seeding Rate (targeted plant m <sup>-2</sup> )									
10	12	3.41	1.09	0.45	28.8	546	139	1839	1208
20	24	3.91	1.43	0.48	24.3	464	125	1662	1031
30	36	4.37	1.58	0.47	23.3	442	121	1603	972
40	42	4.28	1.59	0.46	22.4	426	119	1579	948
50	51	4.36	1.63	0.46	21.4	408	117	1550	919
LSD <sub>0.10</sub>	3	0.24	0.07	0.01	0.7	12	2	20	20

\*\*,\* Significant at P < 0.01 and P < 0.10 according to ANOVA F-test.

Table 15. Seeding date and rate effects on yield components and grain quality of Yuma chickpea sown in chem fallow at Amsterdam, MT, 2004.

	Final stand	Pod density	Pods per plant	Seed per pod	Seed size fractions (mm)				Seed weight	Green seed
					m <sup>-2</sup>					
					< 8	8 - 9	9 - 10	> 10		
Model MS %										
Date	3*	37**	0	65**	81**	35**	73**	45**	71**	7**
Rate	95**	33**	92**	11	14**	36**	17**	23**	6**	85**
D x R	1	6	0	17**	3	2	4	2	1	4*
Seeding Date										
Mar 25	32.1	553	22.3	0.91	13	55	20	12	394	0.7
Apr 13	33.1	539	22.4	0.95	11	50	23	16	402	0.4
May 3	26.9	453	23.9	0.97	8	44	27	21	439	0.6
May 21	30.2	466	22.0	0.97	5	43	28	24	446	0.7
Jun 4	27.0	430	21.8	0.94	4	32	30	34	465	1.0
LSD <sub>0.10</sub>	2.8	34	ns	0.02	2	3	2	3	8	0.3
Seeding Rate (targeted plant m <sup>-2</sup> )										
10	9.5	411	45.6	0.93	10	31	28	31	441	2.1
20	18.9	476	25.8	0.95	8	42	27	23	433	0.5
30	29.8	487	16.8	0.95	7	47	26	20	432	0.3
40	41.9	526	13.0	0.95	7	48	26	19	420	0.1
50	49.2	542	11.4	0.96	8	55	23	15	421	0.2
LSD <sub>0.10</sub>	2.8	34	2.7	ns	2	3	2	3	8	0.3

\*\*,\* Significant at P < 0.01 and P < 0.10 according to ANOVA F-test.

Figure 3. Seed size and green seed response to plant density at Amsterdam, 2004. Green seed tolerance in U.S. No. 1 chickpea is 1%.

Table 16. Seeding date and rate effects on residual soil water (sampled 3 Dec) after Yuma chickpea sown in chem fallow at Amsterdam, MT, 2004.

----- Soil water -----					
	0 - 0.3	0.3 - 0.6	0.6 - 0.9	0.9 - 1.2	0 -
----- mm -----					
-----					
Model MS %					
Date	65**	37**	ns	ns	ns
Rate	10*	32**	ns	ns	ns
D x R	1	3	ns	ns	ns
-----					
Seeding Date					
Mar 25	19	16	18	18	60
May 3	17	16	18	18	60
Jun 4	16	15	18	18	60
LSD <sub>0.10</sub>	1	1	ns	ns	ns
-----					
Seeding Rate (targeted plant m <sup>-2</sup> )					
10	18	16	18	18	60
30	17	16	18	18	60
50	17	15	18	18	60
LSD <sub>0.10</sub>	1	1	ns	ns	ns

\*\*,\* Significant at P < 0.01 and P < 0.10 according to ANOVA F-test.