

# Dry Pea, Lentil, Chickpea, and Winter Legume Breeding 2015 Progress Report



Prepared by the  
Grain Legume Genetics and Physiology Research Unit  
U.S. Department of Agriculture  
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Pullman, WA 99164

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## Acknowledgements

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## Personnel, Cooperators and Cooperating Growers

### Personnel

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## 2015 PROGRESS REPORT

The 2015 Pacific Northwest growing season was significantly hotter and drier than average. Precipitation recorded at the WSU Spillman Research Farm from 1 October 2014 to 31 September 2015 was approximately 16.2 inches, which is nearly 4.25 inches less than normal for that period. This precipitation deficit combined with the 2013-2014 crop year deficit of 6.5 inches resulted in extremely drought stressed conditions. Late spring through summer was especially dry - May to October received only 53% of the historic precipitation. Summer time temperatures were hot and it was very dry. During the 2014-2015 winter, there was limited snow cover and moderate temperatures. Soil moisture levels were low going into the spring. Summer 2015 was one of the hottest on record. The high temperatures combined with low precipitation and soil moisture resulted in below average seed yield and seed size.

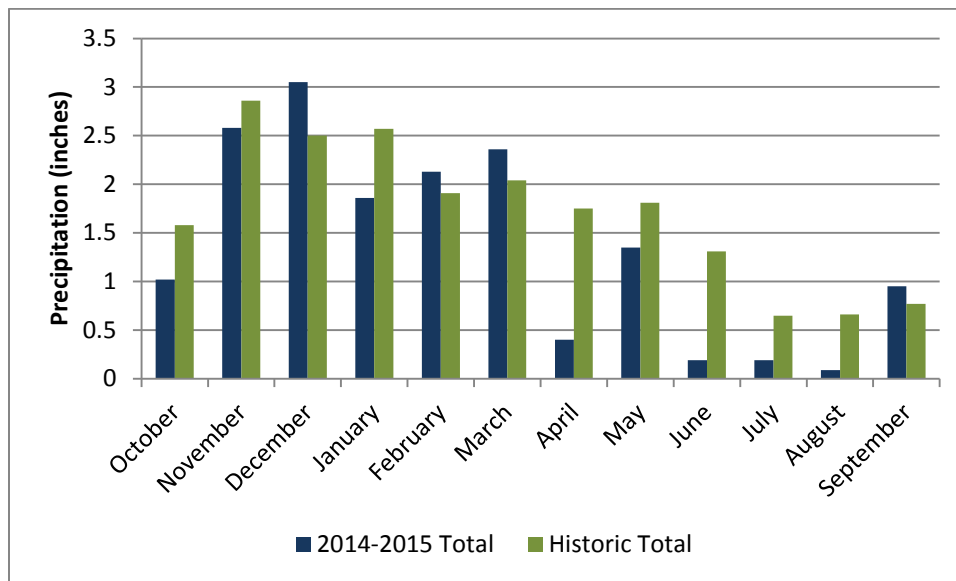


Figure 1. Monthly Precipitation at Pullman, WA. Historical (1940-2005) and 2014-2015 Averages. (Historical data from Western Regional Climate Center, [www.wrcc.dri.edu](http://www.wrcc.dri.edu); 2014 - 2015 data from WSU AgWeatherNet [www.weather.wsu.edu](http://www.weather.wsu.edu)).

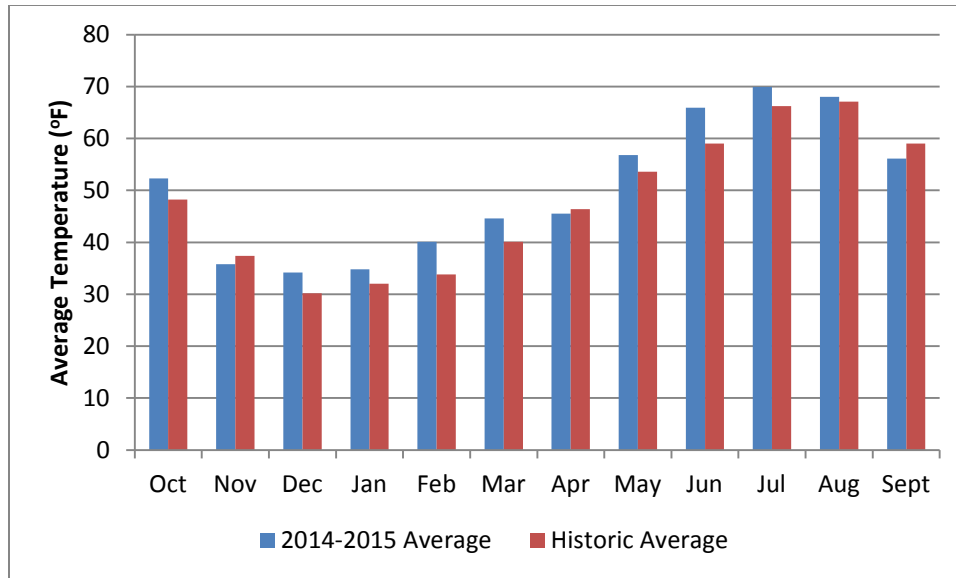


Figure 2. Monthly Temperatures at Pullman, WA. Historical (1940-2005) and 2014 - 2015 Averages. (Historical data from Western Regional Climate Center, [www.wrcc.dri.edu](http://www.wrcc.dri.edu); 2013-2015 data from WSU AgWeatherNet [www.weather.wsu.edu](http://www.weather.wsu.edu)).

Prior to planting, all seeds were treated with Maxim 4FS (0.9 oz/cwt), Apron XL LS (.61oz/cwt), Mertec LSP (3.0oz/cwt), Molybdenum (as sodium molybdate) (16g/cwt) and Cruiser (30ml/cwt). All advanced and preliminary yield trials were planted in a RCB design with plots 1.4 m x 4.9 m. Target population density for spring lentils was 8 sds/ft<sup>2</sup>. Weed control in the spring planted fields was accomplished using Sencor (6 oz/acre) and Lorox (1.25lbs/acre) applied post-plant, pre-emergence. Due to the very dry spring, herbicides were not adequately activated and weed control was less than optimal. Insecticides, Mustang (4 oz/acre), Dimethoate (1 pt/acre) and Warrior (2 oz/ac) were applied as required to control aphids, pea leaf weevils and pea seed weevils. Data were analyzed with the Nearest Neighbours module of Agrobases (Agronomix Software, Inc., Winnipeg, MB).

## SPRING PEA BREEDING UPDATE

In 2015, 18 advanced breeding lines, 3 outside varieties and four check varieties (Aragorn, Ariel, Banner and Columbian) of green peas were evaluated in the advanced yield trials. Identical trials were planted at the Washington State University Spillman Research Farm (Pullman, WA) (26 April 2015), Fairfield, WA (28 April 2015), Genesee, ID (21 April 2015) and Dayton, WA (21 April 2015). In previous years, the Dayton trial suffered serious depredation by elk and deer – in 2015, we fenced the Dayton trials with solar powered electric fence. Average yield was lower than usual at all locations, due primarily to the very hot, dry conditions. The Spillman trials were planted on ground that had very high levels of several soil borne pathogens. The Spillman trials also experienced an early flight of aphids carrying Pea Enation Mosaic Virus and Bean Leaf Roll Virus. The yields and overall performance at Spillman was extremely low. Mean yields were: Spillman 554 kg/ha; Fairfield 1672 kg/ha; Genesee 1660 kg/ha; Dayton 1112 kg/ha. Due to the disease pressure at Spillman, agronomic data for all pea trials was taken at the Fairfield trial. Seed size of the checks ranged from 16.6g/100 seeds (Ariel) to 19.8g/100 seeds (Columbian). Seed size of the advanced lines ranged from 16.7 to 22.3g/100 seeds. The earliest check to flower, Columbian, flowered in 41 days; the earliest breeding line, PS10100131, flowered in 53.7 days. Banner and Columbian were the earliest checks in the trial to reach harvest maturity in 71 days. Four breeding lines (PS03101445, PS07100471, PS08100133, and PS09100052) reached harvest maturity in 72 days.

Ten breeding lines, two outside lines and four check varieties (Universal, DS Admiral, Delta and Carousel) of yellow peas were evaluated in the yellow pea advanced yield trials. Identical trials were planted at the Washington State University Spillman Farm (Pullman, WA) (26 April 2015), Fairfield, WA (28 April 2015) and Genesee, ID (21 April 2015). The mean yields were: Pullman 522 kg/ha; Genesee 1699 kg/ha; and Fairfield 1552 kg/ha. Yields of the yellow peas were also much lower at all locations in 2015, especially at Spillman. Across all locations, yields of the checks were: DS Admiral 1059 kg/ha; Delta 1043 kg/ha; Universal 1200 kg/ha and Carousel 1307 kg/ha. The yields of the advanced lines ranged from 1594 kg/ha to 1080 kg/ha. As in 2013 and 2014 across all locations, the highest yielding breeding line, PS08101004, out-yielded Delta (21% in 2015; 12% in 2013-2014). Seed size of the check varieties ranged from 19.9g/100 seeds (Universal) to 21.8g/100 seeds (DS Adviral). Seed size of the advanced lines ranged from 17.6g/100 seeds (PS12100111) to 23.8g/100 seeds (PS08100950). There was not a significant difference in days to flower or days to maturity between the earliest check (Delta) and 6 of the 10 breeding lines.

The breeding lines were evaluated for resistance to *Aphanomyces* root rot at the Spillman Farm Nurseries and Pea Enation Mosaic Virus, Powdery Mildew and Pea Seed-borne Mosaic Virus in Corvallis, OR. In 2015, we decided to 'rest' the Fusarium wilt, Race 1 nursery. Selected advanced breeding lines were also evaluated for reaction to Pea Enation Mosaic Virus and Bean Leaf Roll Virus using viruliferous aphids and in pure culture for partial resistance to Fusarium root rot (*Fusarium solani*) by Dr. Lyndon Porter (USDA-ARS, Prosser, WA).

Potential product quality of the green pea breeding lines was assessed visually. All entries in the green pea advanced yield trials were subjected to a simulated high temperature, high humidity bleach test. All entries in the green and yellow advanced yield trials were subjected to cooking quality tests and will be evaluated for nutritional quality by Dr. Dil Thavarajah Clemson University, Clemson, SC).

#### AN UPDATE ON HAMPTON

2015 was the sixth year in the advanced trials for the two sister lines PS05100735 and Hampton. These two lines have consistently had top yields in the USDA-ARS trials and the Washington State Variety Trials, the Idaho State Variety Trials and the Western Regional Trials. Both are resistant to both Pea Enation Mosaic Virus (PEMV) and Bean Leaf Roll Virus (BLRV). Resistance to PEMV and BLRV has previously not been available in field peas. Hampton has extremely high levels of resistance to BLRV. The data in Table 1 provide comparisons of the performance of Hampton with Aragorn, Ariel and Banner. In the 2015 Foundation seed was made by WSCI, Breeder’s seed was renewed by ARS and Registered seed was made by Wild Horse Seed, Havre, MT. Approximately 600,000 lbs of seed has been harvested. The variety has been licensed to WSCIA and a PVP has been applied for.

Seed of Hampton was inadvertently mis-labeled and all trials planted with Hampton received from the USDA-ARS in spring 2015 was incorrect.

Table 1. Comparison of the performance of Hampton with three commercial varieties in 29 location-years.

Entry	FW R1	PM	PEMV	BLRV	Days to Flr	Days to Mat	Vine Length (cm)	Plnt Ht (cm)	PHI	Sd Wt (g/100sd)	Yield (kg/ha)
Hampton	R	R	R	R	62	93	68	59	0.88	20.6	2281
Aragorn	R	R	S	S	60	90	72	66	0.92	20.2	2012
Ariel	R	S	S	S	61	90	70	64	0.91	17.7	2027
Banner	S?	S	S	S	59	91	82	70	0.86	20.3	2054



Location Yield Summary for the 2015 Advanced Green Pea Yield Trials (1501)

Entry	Dayton	Fairfield	Genesee (kg/ha)	Pullman	Mean	% of Aragorn
PS05100735	1051	1778	2067	1212	1527	143
PS10100131	1383	1604	1780	1080	1462	137
Pro 081-7161	1468	1936	1820	492	1429	134
PS10100558	1213	1838	1807	841	1425	134
Ginny	1220	1796	1756	702	1369	128
PS10100158	1211	1935	1582	575	1326	124
Greenwood	1149	1829	1726	567	1318	124
PS05100840	1247	1271	1744	901	1291	121
Hampton	1142	1764	1829	406	1286	121
PS08100133	1213	1606	1820	430	1267	119
PS12100095	992	1934	1600	517	1261	118
PS08100582	1147	1719	1753	420	1260	118
PS12100035	635	1914	1643	782	1244	117
PS12100058	1043	1807	1598	523	1243	117
Banner	1317	1576	1762	309	1241	116
PS07100471	1486	1347	1609	343	1196	112
PS09100052	1051	1842	1519	361	1193	112
PS12100121	1063	1744	1466	444	1179	111
PS10100184	1144	1470	1688	383	1171	110
PS03101445	1146	1571	1628	320	1166	109
Ariel	1110	1585	1566	399	1165	109
PS12100106	813	1684	1450	528	1119	105
Columbian	1093	1254	1575	534	1114	105
Aragorn	1080	1328	1486	351	1061	100
PS12100011	393	1669	1233	433	932	87
Grand Mean	1112	1672	1660	554	1250	
CV	15.4	13.0	7.0	18.1	12.7	
LSD (0.05)	282	359	191	165	107	

Yield data are the means of three replications at each location.

Mean Yields of the Advanced Green Pea Yield Trials 2011-2015

Entry	Leaf Type	Vine Type	2015	2014	2013	2012	2011
			(kg/ha)				
Ariel	-	-	1164	1694	2250	2073	2072
Columbian	+	+	1114	1407	1895	1734	1544
PS03101445	-	-	1166	1847	2479	2486	2190
PS05100735	-	-	1526	1898	2416	2606	2438
Hampton	-	-	1285	1803	2410	2668	2432
PS05100840	-	-	1290	1852	1875	2363	2147
Aragorn	-	-	1061	1609	2199	2206	2209
Banner	-	-	1240	1642	2223	2483	2096
PS07100471	-	-	1196	1953	2149	2545	2193
PS08100582	-	-	1259	1726	2362	2586	2380
PS08100133	-	-	1267	1773	2283	2703	2268
PS09100052	-	-	1193	1562	2241	2535	
PS10100158	-	-	1325	1956	2397		
PS10100184	-	-	1171	1590			
PS10100131	-	-	1461				
PS10100558	-	-	1424	1881			
Ginny	-	-	1368	1994	2264	2637	
Greenwood	-	-	1317	1740	2367	2513	
Pro 081-7161	-	-	1429	2058	2255		
PS12100011	-	-	932				
PS12100035	-	-	1243				
PS12100058	-	-	1242				
PS12100095	-	-	1260				
PS12100106	-	-	1118				
PS12100121	-	-	1179				
<b>Trials Average</b>			<b>1250</b>	<b>1466</b>	<b>2076</b>	<b>2416</b>	<b>2148</b>
CV			12.7	18.1	13.8	10.0	11.6
LSD (0.05)			107	255	224	145.8	264

Leaf Type: + = normal leaf; - = semi-leafless

Vine Type: + = tall vine; - = semi-dwarf

Yield data are the means of three replications at 3-4 locations each year.

Agronomic Data for the 2015 Advanced Green Pea Yield Trial (1501)

Entry	FW1	PM	PEMV	Day Flr	Day Mat	Flr Node	Pods/ Peduncle	Pod		Pod Ht Indx	Vine Lngth (cm)	Can Ht (cm)	Plnt Ht Index	# Repr Nodes	100 Sd Wt (g)
								Pod Ht (cm)	Pod Mat (cm)						
Aragorn	R	S	S	55	72	15	2	38	36	0.94	64	60	0.95	5.5	18.5
Ariel	R	S	S	56	72	16	2	48	42	0.89	67	60	0.89	4.7	16.6
Banner	S	S	S	54	71	15	2	45	36	0.80	68	62	0.92	4.7	17.3
Columbian	R	S	S	41	71	8	1	41	17	0.50	113	40	0.37	8.5	19.8
Ginny	R			57	74	16	2	41	40	0.98	69	62	0.90	5.8	20.1
Greenwood	R/S			58	72	17	2	48	39	0.84	70	65	0.94	6.2	18.6
Hampton	R	R	R												
PS03101445	R	R	S	59	72	16	2	39	31	0.85	66	61	0.92	5.2	19.2
PS05100735	R	R	R	58	74	15	2	47	36	0.79	71	53	0.75	5.8	18.7
PS05100840	R	R	S	54	74	13	2	38	29	0.76	62	54	0.89	4.7	19.9
PS07100471	R	R	S	57	72	17	2	43	35	0.81	65	56	0.86	5.3	16.7
PS08100133	R	R	R	56	72	14	2	45	34	0.77	68	59	0.88	5.3	19.2
PS08100582	R	R	S	58	73	16	2	47	39	0.86	74	65	0.88	7.0	19.7
PS09100052	R	S		57	72	16	2	60	53	0.91	81	75	0.93	5.2	21.0
PS10100131	R		S	54	73	17	1	53	45	0.87	76	63	0.84	4.7	19.4
PS10100158	R			58	73	15	2	45	38	0.86	76	53	0.71	6.8	18.6
PS10100184	R			56	72	18	2	48	38	0.80	74	61	0.83	5.8	17.7
PS10100558	R			59	74	15	2	52	39	0.78	76	63	0.83	5.0	19.5
PS12100011	R		R	57	75	17	2	57	47	0.83	75	69	0.93	5.8	21.4
PS12100035	R			56	74	19	2	51	40	0.81	71	64	0.90	4.2	19.7
PS12100058	R		R	58	74	19	2	50	43	0.87	74	66	0.91	6.8	19.2

PS12100095	R		R	56	72	17	2	50	39	0.78	79	64	0.81	6.5	17.9
PS12100106	R	R	S	57	74	18	2	55	47	0.85	76	66	0.88	6.0	18.4
PS12100121	R	R	S	58	72	16	2	54	45	0.85	79	67	0.84	4.8	22.3
Pro 081-7161				58	72	16	2	50	47	0.94	75	69	0.93	5.0	17.9
Grand Mean				56	73	16	2	48	39	0.83	74	61	0.85	5.6	19.0
CV				3.3	1.3	7.7	10.6	9.3	12.6	11.6	7.1	8.4	7.3	16.1	3.7
LSD (0.05)				3	1.5	2	0.3	7.3	8	0.15	8.6	8.4	0.10	1.5	1.1

FW 1 = Fusarium wilt Race 1; PM = Powdery Mildew; PEMV = Pea Enation Mosaic Virus

Pod height was measured at the green pod stage and at harvest maturity. Pod Height Index = pod ht at harvest divided by the pod ht at green pod stage. Plant height was measured at the green pod stage and at harvest maturity. Plant height index = plant height at harvest maturity divided by plant height at the green pod stage. Repr nodes = average number of reproductive nodes on a plant. Agronomic data are the means of three replications at Fairfield, WA. Planting Date: Harvest Date:

Location Yield Summary for the 2015 Advanced Yellow Pea Yield Trials (1502)

<b>Entry</b>	<b>Fairfield</b>	<b>Genesee</b>	<b>Pullman</b>	<b>Mean</b>	<b>%of Carousel</b>
	<b>(kg/ha)</b>				
<b>PS08101004</b>	2041	1997	744	1594	121
<b>PS12100111</b>	1749	2233	794	1592	121
<b>Pro 793</b>	1598	2079	658	1445	110
<b>PS07100925</b>	1740	1804	619	1388	106
<b>PS08101022</b>	1783	1686	674	1381	105
<b>Carousel</b>	1747	1698	477	1307	100
<b>PS08100950</b>	1313	1984	450	1249	95
<b>PS10100207</b>	1553	1547	543	1214	92
<b>Universal</b>	1422	1798	380	1200	91
<b>PS12100046</b>	1534	1597	442	1191	91
<b>PS12100047</b>	1785	1326	339	1150	87
<b>PS12100050</b>	1210	1738	346	1098	84
<b>PS12100065</b>	1405	911	922	1080	82
<b>DS Admiral</b>	1344	1561	272	1059	81
<b>Delta</b>	1403	1560	165	1043	79
<b>Pro 103-7402</b>	1205	1655		950	72
<b>Grand Mean</b>	1552	1699	522	1255	
<b>CV</b>	12.3	11.6	31.9	14.8	
<b>LSD (0.05)</b>	320	329	279	146	

Yield data are the means of three replications at each location.

Mean Yields of the Advanced Yellow Pea Yield Trials 2011-2015

<b>Entry</b>	<b>2015</b>	<b>2014</b>	<b>2013</b>	<b>2012</b>	<b>2011</b>
	<b>(kg/ha)</b>				
<b>Universal</b>	1199	2177	2946	2560	2571
<b>Delta</b>	1042	1811	2546	2430	2130
<b>Carousel</b>	1307	2136	2866	2847	2252
<b>DS Admiral</b>	1058	1747	2634	2404	2033
<b>PS07100925</b>	1387	2095	2654	3005	2707
<b>PS08100950</b>	1248	2218	2864		
<b>PS08101004</b>	1594	2407	2872	2915	2452
<b>PS08101022</b>	1381	2165	2623	2651	2318
<b>Pro 793</b>	1445	2074	2614	2974	
<b>Pro 103-7402</b>	950	1884	2679		
<b>PS10100207</b>	1214	1984			
<b>PS12100046</b>	1191				
<b>PS12100047</b>	1150				
<b>PS12100050</b>	1098				
<b>PS12100065</b>	1079				
<b>PS12100111</b>	1592				
<b>Trials Average</b>	1255	2064	2708	2712	2286
<b>CV</b>	14.9	13.8	7.3	10.3	11.7
<b>LSD (0.05)</b>	146	225	192	188	286

Yield data are the means of three replications at 3-4 locations each year.

Agronomic Data for the 2015 Advanced Yellow Pea Yield Trial (1502)

Entry	FW			Days	Days	Flr	Pods/	Pod	Pod	Vine	Canopy	Plant	#	100	
	1	PM	PEMV	Flower	Mat	Node	Peduncle	Ht	Ht						Length
								(cm)	(cm)	(cm)	(cm)	Index	Nodes	Wt	(g)
Carousel	R	S	S	57	72	16	2	52	42	0.80	69	60	0.89	4	21.2
DS Admiral	R	R	S	57	71	16	2	51	44	0.87	71	64	0.91	5	21.8
Delta	R	S	S	53	71	15	2	45	38	0.85	64	57	0.88	4	19.9
PS07100925	R	R	S	53	71	14	2	40	32	0.81	53	49	0.92	4	21.2
PS08100950				58	71	14	2	40	32	0.82	56	50	0.90	4	23.8
PS08101004	R	R	S	58	72	15	2	46	35	0.75	67	54	0.81	5	21.3
PS08101022	S	R	S	53	72	12	2	40	32	0.80	62	56	0.91	6	21.5
PS10100207				55	71	15	2	51	42	0.84	82	67	0.82	6	22.1
PS12100046				53	71	15	2	53	43	0.81	74	64	0.87	6	20.3
PS12100047				55	71	18	2	55	37	0.68	73	58	0.79	5	20.5
PS12100050				54	71	13	2	44	39	0.89	72	67	0.93	5	20.1
PS12100065			R	52	71	15	2	51	43	0.84	74	65	0.88	6	22.0
PS12100111				53	72	14	2	44	36	0.83	73	58	0.81	7	17.6
Pro 103-7402				57	71	14	2	48	38	0.81	74	68	0.91	6	19.3
Pro 793				53	71	13	2	55	42	0.77	77	71	0.93	5	23.6
Universal	R/S	S	S	51	71	15	2	44	37	0.83	71	63	0.90	5	19.9
Grand Mean				55	71	15	2	47	38	0.81	69	61	0.87	5	21.0
CV				3.5	0.8	9.3	7.2	8.8	11.6	9.7	7.5	7.6	7.0	22.1	3.3
LSD (0.05)				3	1	2	0	7	7	0.13	9	8	0.10	2	1.1

FW 1 = Fusarium wilt Race 1; PM = Powdery Mildew; PEMV = Pea Enation Mosaic Virus

Pod height was measured at the green pod stage and at harvest maturity. Pod Height Index = pot ht at harvest divided by the pod ht at green pod stage. Plant height was measured at the green pod stage and at harvest maturity. Plant height index = plant height at harvest maturity divided by plant height at the green pod stage. Repr nodes = average number of reproductive nodes on a plant. Agronomic data are the means of three replications at Fairfield, WA. Planting Date: Harvest Date:

## SPRING LENTILS

In 2015, identical advanced lentil yield trials were planted at Pullman, WA, Garfield, WA and Fairfield, WA. The green seed coat, yellow cotyledon market classes were divided into three groups: Eston Types: small seed size (mean seed size = 3.9g/100 seeds); Richlea Types: medium seed size (mean seed size = 6.0g/100 seeds); and Laird Types: large seed size (mean seed size = 7.3g/100 seeds). Pardina Types (Spanish Brown) have small seeds (mean seed size = 4.5g/100 seeds) with yellow cotyledons and brown seed coats. The Turkish Red Types have small seeds (mean seed size = 4.0g/100 seeds) with red/orange cotyledons and brown seed coats. The Zero Tannin Types have medium-large seeds (mean seed size = 5.3g/100 seeds) with any color cotyledon and clear seed coats. The 2015 lentil yield trials were planted at the WSU Spillman Research Farm on 26 April, at Garfield on 27 April and at Fairfield on 28 April. The lentils were planted in the same pathogen infested field as the peas at Spillman and they also performed very poorly. All agronomic data was taken from the plots at Fairfield. The combination of hot temperatures, very dry conditions and soil-borne pathogens, resulted in lentil yields at Spillman being very low in 2015.

The 2015 small green seeded (Eston) advanced yield trial had four entries and three checks, CDC Viceroy, Athena and Eston. The mean yields at Pullman were 285 kg/ha, at Garfield 624 kg/ha and at Fairfield 1337 kg/ha. The highest yielding breeding line, LC08600005E has seed size of 4.3g/100 seeds compared to Eston and CDC Viceroy seed sizes of 2.9 g/100 and 3.2 g/100 seeds, respectively. Across all locations, it yielded 47% more than Eston and 9% more than CDC Viceroy. LC01602273E, which has been presented to the USADPLC Variety Release Committee for consideration for release and registration, had an average yield of 771 kg/ha (32 % greater Eston) across all locations. Its seed size in 2015 was 3.0 g/100 seeds.

The medium green seeded (Richlea) advanced yield trial had eight entries and two checks, Avondale and Richlea. The average yield at Pullman was 224 kg/ha, at Garfield 776 kg/ha and at Fairfield 1295 kg/ha. Avondale (the lentil previously known as LC01602300R) has performed well in previous years and performed very well in the Washington and Idaho state wide trials. It is broadly adapted to the Palouse region of Idaho and Washington and to NE Montana. It is highly resistant to Stemphylium Blight. It is slightly taller (38.7cm) than Richlea (37.4cm) at harvest and had similar days to maturity. Its seed size is 5.9g/100 seeds, compared to Richlea's 5.3g/100 seeds. Under the direction of the Washington State Crop Improvement Association, registered seed of Avondale was made in Montana in 2015. Approximately 40,000 lbs (field run) of Avondale was harvested in 2015. Avondale has been licensed to WSCIA and has been granted PVP #201400092.

The large green seeded (Laird) advanced yield trial had 15 entries and four checks, Pennell, Merrit, Riveland and Brewer. The average yields were: Pullman: 392 kg/ha; Garfield: 648 kg/ha and Fairfield: 925 kg/ha. Yield of the breeding line LC06601734L has consistently been high from 2009-2015. It seems to be especially well-adapted to the Fairfield area. In 2015, it out-yielded Merrit by 118% (1489 kg/ha vs 683 kg/ha). The seed size of LC06601734L is 6.5 g/100 seeds compared to Merrit 6.1 g/100 seeds. It has been presented to the USADPLC for potential variety release. Seed size of the breeding lines ranged from 5.8 to 7.8 g/100 seeds compared to Merrit 6.1 g/100 seeds. The breeding objectives of this class of lentils include improving seed shape to minimize seed damage during harvest and processing.

The Spanish Brown (Pardina) advanced yield trial had 9 entries and two checks, Pardina and Morena. Mean yield at Pullman was 485 kg/ha; 544 kg/ha at Garfield and 1227 kg/ha at Fairfield. LC09600507P and LC10600494P, the two highest yielding lines, out-yielded Pardina by 21% and 15%, respectively,



across all locations. Their seed sizes are 3.8 g/100 seeds and 4.0 g/100seeds; Morena and Pardina both had seed sizes of 3.6 g/100 seeds, respectively. Breeding objectives of this class of lentils continues to include improved height and standability and increased yield.

The 2015 Turkish Red advanced yield trial contained five entries and one check, Crimson. This trial was planted only at Pullman where the average seed yields were 447 kg/ha. All the retained breeding lines had seed size (3.9-4.4 g/100 seeds) larger than Crimson (3.2g/100 seeds). Acceptability of larger seed size is yet to be determined. We will continue to make improvements in yield and maintain taller, erect plant architecture.

The 2015 Zero Tannin advanced yield trials had six entries and two checks, Shasta and Cedar. This trial was also planted only at Pullman. Two entries, LC99602585RZ and Cedar, have red cotyledons, the others have yellow cotyledons. Average yield was 406 kg/ha – less than 50% of 2014 and less than 30% of 2012. The zero tannin lentils have relatively large seed size (average = 4.9g/100 seeds in 2015) and tend to be tall and have good lodging tolerance. They tend to be late maturing (average days to harvest = 91.2) and the pods tend to drop and shatter more readily than other lentil classes. Consequently, the primary breeding objectives for this class is to make them earlier maturing and to decrease the tendency for pod drop and shatter.

#### **Avondale Update**

Avondale (LC01602300R) has been a top performer in the medium green lentil advanced trials since 2004, the Western Regional Trials since 2006 and in the Washington and Idaho State Variety Trials since 2011. It has a seed size similar to Richlea (approximately 5g/100 seeds) and has yielded an average of 1320 kg/ha over more than 50 location years of advanced trials. This represents a yield increase of approximately 10% over Richlea (Table 4.). In 2015, Foundation Seed was made under the direction of WSCIA in Montana, approximately 40,000 lbs of field run seed was harvested. It has been licensed to WSCIA and sublicensed to Montec and Montana State University Foundation Seed Program. The table below (Table 1) presents comparisons of Avondale and Richlea.

Table 1. Comparison of the performance of Avondale (LC01602300R) with Richlea in 50 location-years.

<b>Entry</b>	<b>Canopy Ht (cm)</b>	<b>Days to Mat</b>	<b>Plant Ht Index</b>	<b>Seed Size (g/100 sds)</b>	<b>Yield (kg/ha)</b>
<b>Avondale</b>	34.4	97.5	0.95	4.9	1319
<b>Richlea</b>	33.4	96.5	0.91	5.2	1197

### New Varieties

Breeder's seed was made of two advanced breeding lines, LC06601734L and LC01602273E. Comparisons of the performance of these two lines are presented below in Table 2 and Table 3, respectively.

Table 2. Comparison of the performance of LC06601734L with Riveland, Pennell, Merrit and Brewer.

Entry	Days to Mat	Vine Length (cm)	Canopy Ht (cm)	Plnt Ht Index	HSW (g/100 sds)	Yield (kg/ha)
<b>LC06601734L</b>	98	41	36	0.88	6.7	1287
<b>Riveland</b>	97	42	35	0.85	7.0	1213
<b>Pennell</b>	95	39	34	0.89	6.4	1194
<b>Merrit</b>	94	40	33	0.83	6.3	877
<b>Brewer</b>	94	38	32	0.85	5.7	1109
<b>Grand Average</b>	96	40	34	0.86	6.4	1228
<b>LSD (0.05)</b>	1.0	1.7	1.5	0.05	0.15	67

Table 3. Comparison of the performance of LC01602273E with Eston.

Entry	Days to Mat	Vine Length (cm)	Canopy Ht (cm)	Plant Ht Index	HSW (g/100 sds)	Yield (kg/ha)
<b>Eston</b>	89	33.9	29.0	0.82	3.1	1162
<b>LC01602273E</b>	89	34.5	29.1	0.84	3.2	1312
<b>Grand Average</b>	90	29.1	24.8	0.94	3.6	1278
<b>LSD (0.05)</b>	1.7	2.1	1.8	0.04	0.1	68

Location Yield Summary for the Eston Type Lentil Advanced Yield Trial (1551E)

Entry	Pullman	Garfield	Fairfield kg/ha	Average	% of Eston
LC08600005E	299	626	1647	857	147
Athena	252	626	1567	815	139
CDC Viceroy	269	692	1457	806	138
LC01602273E	406	565	1343	771	132
LC09600066E	275	686	1255	739	126
LC09600054E	267	612	1132	670	115
Eston	229	559	960	583	100
Grand Mean	749	1343	1671	1257	1371
CV	25.6	8.9	7.0	12.0	14.9
LSD (0.05)	153	118	117	121	258

Mean Yields of the Eston Type Lentil Advanced Yield Trials, 2011-2015

Entry	2015	2014	2013 kg/ha	2012	2011
Eston	582	1272	1583	1083	1291
LC01602273E	771	1362	1676	1319	1429
LC08600005E	857	1341	1817	1316	1574
LC09600054E	670	1431	1715	1206	1450
LC09600066E	738	1437	1622	1204	1384
Athena	814	1295	1610		
CDC Viceroy	805	1256			
Grand Mean	1371	1257	1671	1343	749
CV	14.9	12.0	7.0	8.9	25.6
LSD (0.05)	258	121	117	118	153

Agronomic Data for the 2015 Advanced Eston Type Lentil Advanced Yield Trial (1551E)

Entry	Days Flower	Days Mat	Pods Peduncle	Pod Ht (cm)	Pod Ht Mat (cm)	Pod Ht Index	Vine Length (cm)	Canopy Ht (cm)	Plant Ht Index	100 Sd Wt (g)
Athena	60.0	83.0	2.0	13.0	10.0	0.76	38.5	30.7	0.80	3.9
Eston	60.0	79.0	2.0	10.3	8.2	0.79	33.0	28.7	0.87	2.9
LC01602273E	57.7	78.0	2.0	11.5	9.0	0.79	36.0	31.2	0.87	3.0
LC08600005E	57.7	79.0	2.0	14.3	9.8	0.70	45.5	37.8	0.84	4.2
LC09600054E	56.7	78.0	2.0	12.2	8.2	0.67	35.8	31.2	0.88	3.6
LC09600066E	57.3	78.0	2.0	11.5	8.3	0.74	33.7	31.8	0.95	3.5
CDC Viceroy	61.3	91.0	2.0	14.8	10.3	0.73	35.3	32.2	0.92	3.2
Grand Mean	58.6	80.8	2.0	12.5	9.1	0.74	36.8	31.9	0.87	3.4
CV	3.4	4.1	14.7	15.1	25.1	15.66	9.4	9.2	6.87	6.3
LSD (0.05)	3.5	5.9	0.5	3.3	4.0	0.21	6.1	5.2	0.10	0.3

Pod height was measured at the green pod stage and at harvest maturity. Pod Height Index = pod ht at harvest divided by the pod ht at green pod stage. Plant height was measured at the green pod stage and at harvest maturity. Plant height index = plant height at harvest maturity divided by plant height at the green pod stage. Agronomic data are the means of three replications at Fairfield, WA.

Location Yield Summary for the Richlea Type (Medium Green) Lentil Advanced Yield Trial (1552R).

Entry	Pullman	Garfield	Fairfield	Mean	% of Richlea
	kg/ha				
Avondale	292	851	1444	862	97
LC11600361R	202	925	1355	827	93
LC11600370R	194	944	1224	787	88
LC11600342R	208	705	1389	767	86
LC07600553R	248	520	1432	733	82
LC06601616R	205	694	1250	716	80
LC09600183R	173	685	1241	699	78
LC07600151R	305	786	969	687	77
LC11600360R	142	909	999	683	77
Grand Mean	224	776	1295	765	86
CV	24.3	14.8	15.8	18.1	
LSD (0.05)	94	199	351	109	

Yield data are the means of three replications at each location.

Mean Yields of the Richlea Type (Medium Green) Lentil Yield Trials 2011 – 2015.

<b>Entry</b>	<b>2015</b>	<b>2014</b>	<b>2013 (kg/ha)</b>	<b>2012</b>	<b>2011</b>
Richlea	887	1236	1555	1612	1641
Avondale	862	1521	1574	1568	1804
LC06601616R	716	1532	1586	1512	1632
LC07600151R	686	1460	1843	1572	1754
LC07600553R	733	1417	1829	1520	1487
LC09600183R	699	1445	1545		
LC11600361R	827	1473			
LC11600370R	787	1329			
LC11600342R	767				
LC11600360R	683				
Grand Mean	765	1414	1609	1495	1534
CV	18.1	14.7	11.7	6.0	13.3
LSD (0.05)	109	202	186	71	259

Agronomic Data for the 2015 Richlea Type (Medium Green) Lentil Advanced Yield Trial.

Entry	Days Flower	Days Mat	Pods Peduncle	Pod Ht (cm)	Pod Ht Mat (cm)	Pod Ht Index	Vine Length (cm)	Canopy Ht (cm)	Plant Ht Index	100 Sd Wt (g)
Richlea	57.7	84.0	2.0	16.3	12.0	0.75	42.2	34.8	0.83	4.5
Avondale	58.3	81.0	2.0	16.3	13.8	0.86	41.3	34.5	0.85	4.5
LC06601616R	57.0	83.0	2.0	15.5	12.5	0.82	36.2	32.7	0.91	4.7
LC07600151R	57.0	81.0	2.0	18.0	12.5	0.72	39.7	36.0	0.92	5.2
LC07600553R	55.0	78.0	2.0	17.2	13.3	0.81	40.0	35.2	0.88	5.0
LC09600183R	59.0	93.0	2.0	21.2	10.8	0.56	41.2	32.5	0.79	6.4
LC11600342R	54.3	79.0	2.0	14.2	12.2	0.86	43.3	35.7	0.84	4.8
LC11600360R	54.0	78.0	2.0	19.0	13.3	0.71	42.0	33.3	0.80	4.2
LC11600361R	57.0	81.0	2.0	15.7	12.5	0.82	39.7	31.5	0.81	4.4
LC11600370R	57.7	84.0	2.0	16.5	10.7	0.65	38.7	33.5	0.88	4.3
Grand Mean	56.7	82.1	2.0	16.9	12.3	0.75	40.4	33.9	0.85	4.7
CV	2.0	5.6	8.9	14.1	13.5	17.6	4.7	10.2	11.1	6.5
LSD (0.05)	1.9	8.0	0.3	4.1	2.8	0.22	3.3	5.9	0.16	0.5

Pod height was measured at the green pod stage and at harvest maturity. Pod Height Index = pod ht at harvest divided by the pod ht at green pod stage. Plant height was measured at the green pod stage and at harvest maturity. Plant height index = plant height at harvest maturity divided by plant height at the green pod stage. Agronomic data are the means of three replications at Fairfield, WA.

Location Yield Summary for the 2015 Larid Type (Large Green) Lentil Advanced Yield Trial (1552L)

Entry	Pullman	Garfield	Fairfield	Average	% of Merrit
	(kg/ha)				
LC06601734L	506	752	1489	916	159
LC09600410L	515	838	1136	830	144
LC07600524L	549	755	1047	784	136
LC11600298L	412	779	1073	755	131
LC09600476L	492	718	838	683	118
LC0860B130L	367	785	887	680	118
LC09600408L	559	628	846	678	117
LC07600541L	263	747	982	664	115
LC11600330L	438	501	942	627	108
LC09600481L	449	778	645	624	108
LC09600361L	406	637	804	616	107
Riveland	416	559	871	615	106
Brewer	215	573	1047	612	106
Pennell	225	533	1074	611	106
LC07600536L	377	429	1001	602	104
Merrit	264	778	683	575	100
LC11600228L	243	689	725	553	96
LC11600380L	379	393	820	531	92
LC0860B123L	376	434	659	490	85
Grand Mean	392	648	925	655	
CV	20.3	31.3	21.6	26.1	
LSD (0.05)	132	337	333	134	

Yield data are means of three replications at each location.



Mean Yields of the Laird Type (Large Green) Lentil Advanced Yield Trials 2011-2015

Entry	2015	2014	2013 (kg/ha)	2012	2011
Brewer	611	1311	1307	1395	923
Merrit	575	1216	1435	1366	1091
Pennell	610	1228	1581	1375	1174
Riveland	615	1375	1566	1465	1045
LC06601734L	915	1476	1294	1529	1223
LC07600524L	783	1405	1566	1468	1223
LC07600536L	602	1382	1374	1404	1392
LC07600541L	664	1423	1522	1502	1361
LC0860B123L	490	1239	1349	1297	1169
LC0860B130L	679	1607	1229	1554	1193
LC09600408L	677	1582	1463		
LC09600410L	829	1620	1567		
LC09600476L	682	1297	1334		
LC09600361L	615	1430			
LC09600481L	623	1266			
LC11600228L	552	1291			
LC11600298L	754	1441			
LC11600330L	626	1333			
LC11600380L	530	1509			
Grand Mean	655	1394	1451	1425	1180
CV	2601	10.5	14.1	10.2	13.3
LSD (0.05)	134	140	198	114	259

Agronomic Data for the 2015 Laird Type (Large Green) Lentil Advanced Yield Trial.

Entry	Days Flower	Days Mat	Pods Peduncle	Pod Ht (cm)	Pod Ht Mat (cm)	Pod Ht Index	Vine Length (cm)	Canopy Ht (cm)	Plant Ht Index	100 Sd Wt (g)
Merrit	55.0	84.0	2.0	19.2	13.7	0.74	40.2	35.2	0.88	6.1
Pennell	59.0	93.0	2.0	19.2	14.5	0.79	38.0	30.3	0.81	6.6
Riveland	57.7	90.0	2.0	21.8	14.5	0.71	44.8	37.3	0.83	6.8
Brewer	52.3	80.0	2.0	16.0	10.3	0.66	39.8	33.8	0.86	5.7
LC06601734L	56.7	93.0	2.0	17.3	12.0	0.70	45.3	36.3	0.80	6.5
LC07600524L	58.3	93.0	2.0	15.5	13.2	0.84	39.2	34.2	0.88	7.0
LC07600536L	59.0	93.0	2.0	20.7	15.3	0.76	41.8	38.5	0.93	6.2
LC07600541L	57.3	88.0	2.0	19.0	11.3	0.61	41.0	37.0	0.91	6.8
LC0860B123L	53.0	93.0	2.0	18.2	13.8	0.78	42.5	38.3	0.90	7.8
LC0860B130L	58.3	84.0	2.0	17.8	10.8	0.61	45.5	39.3	0.88	6.4
LC09600361L	53.7	84.0	2.0	18.8	12.3	0.66	43.5	38.8	0.90	6.5
LC09600408L	56.0	93.0	2.0	16.5	13.8	0.85	38.8	34.5	0.90	6.6
LC09600410L	56.0	84.0	2.0	18.3	12.2	0.68	38.3	34.2	0.90	6.6
LC09600476L	53.7	82.0	2.0	16.7	13.2	0.81	41.3	34.8	0.85	6.1
LC09600481L	58.3	90.0	2.0	22.7	15.8	0.73	47.3	42.3	0.90	6.2
LC11600228L	51.3	78.0	2.0	17.5	12.2	0.70	39.3	35.3	0.90	5.8
LC11600298L	52.0	81.0	2.0	17.0	12.3	0.73	40.3	34.0	0.85	6.5
LC11600330L	57.0	93.0	2.0	17.3	14.0	0.81	43.3	33.8	0.79	6.8
LC11600380L	56.7	81.0	2.0	20.0	14.3	0.72	43.5	37.8	0.87	6.3
Grand Mean	55.8	87.1	1.8	18.3	13.1	0.73	41.7	36.1	0.87	6.4
CV	3.6	4.5	15.8	13.6	15.7	17.7	7.7	7.8	7.4	4.0
LSD (0.05)	3.3	6.6	0.4	4.1	3.4	0.21	5.3	4.7	0.10	0.4

Pod height was measured at the green pod stage and at harvest maturity. Pod Height Index = pot ht at harvest divided by the pod ht at green pod stage. Plant height was measured at the green pod stage and at harvest maturity. Plant height index = plant height at harvest maturity divided by plant height at the green pod stage. Agronomic data are the means of three replications at Fairfield, WA.

Location Yield Summary for the 2015 Pardina Type (Spanish Brown) Advanced Yield Trials (1551P)

<b>Entry</b>	<b>Pullman</b>	<b>Garfiled</b>	<b>Fairfield</b>	<b>Mean</b>	<b>% of Pardina</b>
	<b>kg/ha</b>				
LC09600507P	669	559	1410	879	121
LC10600494P	597	687	1207	830	115
LC08600113P	535	535	1334	801	111
LC10600231P	454	580	1309	781	108
LC08600115P	358	527	1391	759	105
Morena	629	573	1052	751	104
Pardina	625	572	965	721	100
LC08600116P	360	462	1295	705	97
LC08600109P	498	580	989	689	95
LC08600114P	267	529	1251	683	94
LC10600260P	340	382	1292	671	93
Grand Mean	485	544	1227	752	
CV	24.8	24.9	24.9	27.3	
LSD (0.05)	205	232	523	162	

Yield data are the means of three replications at each location.

Mean Yields of the Pardina Type (Spanish Brown) Lentil Advanced Yield Trials 2011-2015

Entry	2015	2014	2013 kg/ha	2012	2011
Pardina	720	1342	1535	1407	1214
Morena	751	1387	1649	1225	1196
LC08600109P	688	1325	1807	1428	1223
LC08600113P	801	1405	1908	1525	1374
LC08600114P	682	1248	1679	1401	1221
LC08600115P	758	1329	1846	1470	1373
LC08600116P	705	1449	1982	1584	1434
LC09600507P	878	1395	1894	1405	1319
LC10600260P	670	1382	1826	1447	
LC10600231P	781	1511	1849		
LC10600494P	830	1461	1835		
Grand Mean	752	1396	1768	1378	1228
CV	27.3	8.9	6.9	10.3	13.3
LSD (0.05)	162	120	118	111	175

Agronomic Data for the 2015 Advanced Pardina Type (Spanish Brown) Lentil Yield Trial (1551P)

Entry	Days Flower	Days Mat	Pods Peduncle	Pod Ht (cm)	Pod Ht Mat (cm)	Pod Ht Index	Vine Length (cm)	Canopy Ht (cm)	Plant Ht Index	100 Sd Wt (g)
Pardina	52.0	78.0	2.0	9.7	7.2	0.72	33.5	27.7	0.83	3.6
Morena	56.0	79.0	2.0	10.8	6.8	0.69	38.2	33.8	0.88	3.6
LC08600109P	50.7	78.0	2.0	11.0	8.3	0.77	38.8	28.2	0.73	3.7
LC08600113P	56.0	79.0	2.0	15.3	10.5	0.71	39.8	30.8	0.79	3.7
LC08600114P	51.3	78.0	2.0	12.3	9.0	0.74	34.8	29.3	0.85	4.2
LC08600115P	57.7	79.0	2.0	14.7	9.8	0.68	37.5	31.0	0.84	4.0
LC08600116P	57.7	79.0	2.0	13.7	10.0	0.78	35.3	29.0	0.83	4.1
LC09600507P	54.0	78.0	2.0	14.0	12.0	0.87	36.5	30.3	0.84	3.8
LC10600260P	59.0	93.0	2.0	17.7	12.2	0.69	39.7	35.8	0.91	4.5
LC10600231P	54.3	83.0	2.0	11.5	8.7	0.77	36.0	30.0	0.83	4.1
LC10600494P	56.7	89.0	2.0	12.0	8.3	0.69	37.0	33.5	0.91	4.0
Grand Mean	55.0	81.2	1.9	12.9	9.3	0.73	37.0	30.8	0.84	3.9
CV	2.6	4.3	13.0	14.3	25.2	18.5	9.1	11.6	9.8	6.3
LSD (0.05)	2.4	5.9	0.4	3.1	4.0	0.23	5.7	6.1	0.14	0.4

Pod height was measured at the green pod stage and at harvest maturity. Pod Height Index = pod ht at harvest divided by the pod ht at green pod stage. Plant height was measured at the green pod stage and at harvest maturity. Plant height index = plant height at harvest maturity divided by plant height at the green pod stage. Agronomic data are the means of three replications at Fairfield, WA.

Agronomic and Yield Data for the 2015 Turkish Red Lentil Advanced Yield Trial.

Entry	Days Flower	Days Mat	Pods/ Peduncle	Pod Ht (cm)	Vine Length (cm)	100 Sd Wt (g)	Yield (kg/ha)	% of Crimson
LC09600037T	58.3	90.0	2.0	10.8	25.3	4.3	528	136
LC09600142T	53.7	83.0	2.0	13.7	26.2	3.8	505	130
LC05600043T	56.0	81.0	2.0	14.8	27.5	4.4	504	130
LC09600545T	52.0	78.0	2.0	9.8	24.5	3.7	431	111
Crimson	57.7	88.0	2.0	14.5	26.8	3.2	388	100
LC01602062T	57.7	83.0	2.0	11.2	25.0	3.9	325	83
Grand Mean	55.8	83.7	1.8	12.4	25.8	3.8	447	
CV	3.6	6.0	18.8	15.7	7.5	5.8	13.4	
LSD (0.05)	3.7	9.2	0.4	3.5	3.5	0.4	109	

Pod height was measured at the green pod stage. Plant height was measured at the green pod stage. Agronomic data are the means of three replications at Pullman, WA.

Agronomic and Yield Data for the 2015 Zero-Tannin Lentil Yield Trial (1561)

Entry	Days Flower	Days Mat	Pods Peduncle	Pod Ht (cm)	Pod Ht Mat (cm)	Pod Ht Index	Vine Length (cm)	Canopy Ht (cm)	Plant Ht Index	100 Sd Wt (g)	Yield (kg/ha)	Yield % of Shasta
Shasta	56.7	93.0	2.0	14.0	10.3	0.74	31.8	27.0	0.85	5.0	529	100
Cedar	56.7	84.0	2.0	14.3	10.8	0.76	33.2	28.8	0.87	4.0	448	84
LC07600224YZ	55.0	89.0	2.0	16.8	12.3	0.76	34.8	29.0	0.84	5.8	448	84
LC06600939YZ	53.3	93.0	2.0	14.8	12.5	0.83	30.7	29.2	0.95	4.9	391	73
LC99602585RZ	56.7	93.0	2.0	15.7	11.0	0.73	29.0	25.5	0.89	4.0	385	72
LC04600389YZ	56.7	93.0	2.0	15.7	12.8	0.83	32.0	29.2	0.92	5.7	373	70
LC04600415YZ	57.0	93.0	2.0	15.7	12.3	0.79	32.7	27.0	0.83	5.7	338	64
LC06600930YZ	54.3	93.0	2.0	15.8	12.5	0.80	35.7	26.2	0.74	4.9	332	62
Grand Mean	55.7	91.2	1.9	15.3	11.8	0.78	32.4	27.7	0.86	4.9	406	
CV	3.9	4.1	10.4	9.7	10.9	9.9	11.3	11.3	5.5	3.8	9.1	
LSD (0.05)	3.8	6.5	0.3	2.6	2.2	0.14	6.4	5.5	0.08	0.3	66	

Pod height was measured at the green pod stage and at harvest maturity. Pod Height Index = pod ht at harvest divided by the pod ht at green pod stage. Plant height was measured at the green pod stage and at harvest maturity. Plant height index = plant height at harvest maturity divided by plant height at the green pod stage. Agronomic data are the means of three replications at Fairfield, WA.

## **AUTUMN-SOWN GRAIN LEGUMES**

We have been ramping up the winter legume breeding program since 2010. Prior to 2010, the program was very small and the emphasis was on development of Turkish Red lentils and non-food quality peas. Significant advances were made in improving cold tolerance and plant habit. Since 2010, the programs have been expanded and now the objectives are more focused on development of food quality green and yellow peas and Spanish Brown and Small and Medium Green lentils. In 2015, an OREI grant, 'Creating the Cover Crops that Organic Farmers Need: Delivering Regionally Adapted Varieties across America' was submitted and funded. As a co-PI on this project, we have increased the effort in breeding autumn-sown peas for cover crops. We also continue to work on Austrian Winter Peas. We are systematically incorporating alleles from superior spring varieties and breeding lines into cold hardy backgrounds. The segregating nurseries have more than tripled in size and the yield trials have also grown.

The main segregating nurseries and preliminary yield trials are grown at the Spillman Farm. The advanced yield trials are typically planted at four locations: Spillman Farm, Dayton, WA, Garfield, WA and Genesee, ID. In 2014-2015, there were approximately 1200 entries in the winter pea nursery, 450 entries in the winter lentil nursery and 200 entries in the winter chickpea nursery. There were 32 entries in the advanced winter pea food quality trial, 6 entries in the winter pea cover crop trial, 12 entries in the Austrian Winter Pea trial and 15 entries in the winter lentil yield trial. The nurseries and trials planted at Spillman Farm and the trials planted at Genesee and Dayton were abandoned. Germination was erratic and poor due to the extremely dry summer and autumn of 2014. The Garfield site had timely autumn rain and was a success. The remnant seed from the segregating nurseries was spring planted at Spillman. The WSU and UI Variety Testing Programs each had yield trials with elite pea and lentil varieties planted at Colton, WA and Moscow and Ferdinand, ID, respectively. They also have segregating F<sub>4</sub> populations to evaluate and select for types well suited to the different regions. The bulk populations are typically spring x winter crosses that have been screened and selected only for cold tolerance.

The only surviving winter pea and lentil advanced yield trial was planted at Garfield on 22 September 2014. The food quality winter peas all have clear seed coats, a clear hilum and white flowers. The food quality trials had 19 breeding lines and two checks, Specter and Windham.

The winter lentil advanced yield trials were planted at the same time and locations as the advanced winter pea yield trials. There were 19 entries and one check, Morton, in the trials.



Yield and Hundred Seed Weight of entries from the 2014-2015 winter pea advanced yield trial, Garfield, WA.

<b>Entry</b>	<b>Yield (kg/ha)</b>	<b>HSW (g)</b>
PS11300069W	153	17.1
PS12300026W	203	15.1
PS12300032W	382	21.4
PS07300136W	422	15.0
PS12300010W	837	17.9
PS06300132W	1057	15.5
PS06300028W	1118	17.5
PS03101269W	1199	15.8
PS06300024W	1202	17.7
PS12300045W	1249	15.0
PS12300065W	1425	16.3
PS12300061W	1435	14.0
PS05300180W	1450	14.0
PS12300059W	1474	14.4
Windham	1484	14.4
PS07300125W	1595	16.3
PS12300058W	1619	14.2
PS12300049W	1679	16.0
PS12300013W	1695	14.3
PS11300087W	1719	16.7
PS12300072W	1738	13.8
Specter	1758	13.5
PS11300282W	1937	16.8
PS11300287W	1938	14.6
PS11300240W	1954	15.7
PS12300046W	1980	14.5
PS11300201W	1980	16.0
PS12300048W	2072	15.6
PS07300047W	2077	15.0
PS11300288W	2308	19.7
PS11300289W	2336	19.8
PS11300279W	2359	16.3
Grand Mean	1495	15.9
CV	26.5	3.9
LSD (0.05)	774	1.2

## CHICKPEA YIELD TRIALS

In 2015, 12 café kabuli chickpea breeding lines, two Spanish White kabuli chickpea breeding lines, and four check cultivars were included in the Advanced Chickpea Yield Trials. The check cultivars included three café kabuli types; “Sawyer”, “Sierra”, and “CDC-Frontier” and the small landrace “Billybean”. Trials were planted at four locations: Dayton, WA on 3 April 2015, Genesee, ID on 3 May 2015, at Pullman, WA on 26 April 2015, and at Kendrick, ID on 5 May 2015. Pre-plant seed coat treatments and herbicide applications were as described for pea and lentil yield trials. Three replicated plots (1.5 m x 6.1 m) were planted at a density of 44 seeds/m<sup>2</sup> for each entry at each location. Gramoxone (2 pints-ac<sup>-1</sup>) was applied approximately 14 d before harvest at Pullman and Genesee to promote desiccation.

The trial at Dayton was lost due to herbivore pressure (elk and deer) and was not harvested. The grand mean of all entries over the three harvested trials was 1347 kg-ha<sup>-1</sup> (1201 lb-ac<sup>-1</sup>). Significant differences ( $F = 55.1$ ;  $\text{Prob} > F < .0001$ ) were observed between yields at the three locations. The highest yielding location was Genesee, ID, which was harvested on 26 August 2015, with a mean yield of 1872 kg-ha<sup>-1</sup>. Yields at Genesee ranged from 1490 kg-ha<sup>-1</sup> (CA12900287C) to 2242 kg-ha<sup>-1</sup> (Sawyer). The mean yield for the Kendrick trial, harvested on 29 August 2015, was 1102 kg-ha<sup>-1</sup>. Yields at Kendrick ranged from 820 kg-ha<sup>-1</sup> (CA0890B0551C) to 1337 kg-ha<sup>-1</sup> (CDC-Frontier). The lowest yielding location was Pullman, WA, which was harvested on 27 August 2015, with a mean of 927 kg-ha<sup>-1</sup>. Yields at Pullman ranged from 545 kg-ha<sup>-1</sup> (CA0890B0551C) to 1311 kg-ha<sup>-1</sup> (Billybean).

CDC-Frontier was the highest yielding entry over all locations, averaging 1636 kg/ha. The second highest yielding entry across locations was the breeding line CA0790B0547C (1597 kg ha<sup>-1</sup>). The ten entries with the highest mean yield across locations included seven advanced kabuli café chickpea lines from the ARS breeding program, the small seeded landrace Billybean, the small café kabuli cultivar CDC-Frontier and Sawyer, which produces medium size seed. Yield differences between entries were not significant. Several entries had high yield rankings at all locations. CDC-Frontier, Billybean, Sawyer, and the breeding lines CA0890B0429C and CA0790B0043C ranked among the top ten at all locations. The entry (Genotype) effects accounted for approximately 13% of the total variation in yield, while 76% of the variance was attributed to location (Environment) effects, and the remaining 11% of variance in seed yield was due to Genotype x Environment interaction effects.

All entries in the Pullman, WA yield trial were also evaluated for other important agronomic traits including days to 50% flower, days to maturity, canopy height, plant height index (PHI), and 100 seed weight. The number of days after planting required to reach 50% flowering did not vary considerably among entries, ranging from 58-62 days. The earliest entries to mature were Sawyer and the low yielding breeding line CA12900287C, both of which have simple leaves and matured in 93 days. The latest entries to mature were two large seeded breeding lines, CA11900028C and CA11900031W, both of which have compound leaves and matured in 110 days. PHI, which is the ratio of the total length of the vine of the plant over canopy height,

can range from 0-1 and is a measure of tolerance to lodging, with more tolerant lines having higher index scores. All entries had PHI values  $\geq 0.80$ , which suggests the entries have good tolerance to lodging. 100 seed weight of all entries ranged from 30.4-60.6 g. 100 seed weight of the check cultivars ranged from 30.6 (Billybean)-55.6 g (Sierra). 100 seed weight seed of Sierra was significantly greater than Sawyer (40.5 g), CDC-Frontier (38.2 g), and Billybean (30.4 g). 100 seed weights of CDC-Frontier and Sawyer were not significantly different, while Billybean produced significantly smaller seed than all other entries. 100 seed weight of breeding lines ranged from 52.0 (CA12900287C) to 60.6 g (CA11900028C). Interestingly, CA04900843C, which has been recently released as the cultivar “Nash”, did not have the largest seed of all entries. Plots at the Pullman yield trial exhibited poor establishment as a result of several adverse factors that likely included soilborne diseases, weed pressure, residual effects of herbicide used for wheat, and lack of symbiosis between chickpea and nitrogen-fixing *Mesorhizobium ciceri*. Only two plots were harvested for each entry at Pullman, and the adverse environment appears to have impacted the seed size of CA04900843C. The 100 seed weight for all entries was also determined for the Genesee trial. Similar to results historically observed for CA04900843C across locations throughout the Palouse, at Genesee its 100 seed weight (65.7 g) was significantly greater than that of Sierra (54.2 g). The 100 seed weight of all entries at Genesee ranged from 32.8 (Billybean)–65.8 g (CA12900046W). 100 seed weight of Sawyer (48.1 g) at Genesee was significantly less than Sierra but significantly greater than CDC-Frontier (39.3 g) and Billybean (32.8 g). Nine ARS breeding lines produced larger seed than Sierra at Genesee.

Recently selected chickpea breeding lines were evaluated in a preliminary yield trial conducted at the Washington State University Spillman Farm in Pullman, WA. A total of 24 entries were evaluated including 22 café kabuli breeding lines and the check cultivars Sierra and Sawyer. The trial was planted on 26 April 2015 and harvested on 27 August 2015. Three replicated plots (1.5 m x 6.1 m) were planted for each entry at a density of 44 seeds/m<sup>2</sup>. Pre-plant seed treatment and herbicide applications were done as described above for the Advanced Yield Trial conducted at Pullman, WA.

The mean yield for all entries was 1045 kg/ha. The yield of entries ranged from 713 (CA13900090C)-1296 kg-ha<sup>-1</sup> (CA13900151C). Sierra had a yield of 918 kg-ha<sup>-1</sup> and the yield of Sawyer was 999 kg-ha<sup>-1</sup>. The top ten yielding entries were all ARS breeding lines and on average had yields that were 31% greater than Sierra. All entries in the preliminary yield trial were evaluated for other agronomic traits including days to maturity, canopy height, plant height index, and 100 seed weight. The plant height index was greater than 0.80 for all entries, which indicates the entries have good tolerance to lodging. The entries reached 50% flower between 58-63 days and matured between 93-111 days. The ten highest yielding lines matured in 93-105 days. Sawyer and CA13900049C both matured in 93 days.

The 100 seed weight of the entries in the preliminary yield trial ranged from 34.7 (CA13900049C)-57.7 g (CA13900149C). The 100 seed weight of Sierra and Sawyer were 47.0 g and 41.3 g, respectively. The ten highest yielding lines had 100 seed weights ranging from 46.4-58.9 g. Five breeding lines (CA13900119C, CA13900061C, CACA13900129C, CA13900115C, and

CA13900023C) produced larger seed than Sierra and had yields that were at least 20% greater than Sierra. These and other higher yielding preliminary breeding lines will be included in advanced yield trials in 2016.

## PROMISING KABULI CHICKPEA BREEDING LINES

Several ARS breeding lines appear to be promising candidates for future release as improved germplasm or new cultivars based on their performance in advanced yield trials (Table 1). During 2015 a second cycle of breeder seed was produced of the café kabuli line CA0790B0043C, which consistently has higher yields than Sierra and produces seed similar in size to Sierra. This line may be proposed for release as a new cultivar in 2016. During 2015 approximately 200 single plants were selected for each of three promising breeding lines noted in Table 1: CA0790B0034C, CA0790B0547C, and CA0790B0642C. CA0790B0034C also consistently has higher yields than Sierra and produces seed similar in size to Sierra. CA0790B0547C has the highest average yield of all breeding lines tested over the past four years (2012-2015), although it generally produces seed that is smaller than Sierra. CA0790B0642C appears especially promising as it consistently produces both higher yields and larger seed than Sierra.

Table 1. Yield, days to maturity and seed size of promising ARS kabuli chickpea breeding lines in head-to-head tests with the kabuli cultivars Sierra, Sawyer, and Nash.

Entry	Leaf type	Number of Yield Trials	Yield (kg-ha <sup>-1</sup> ) (% Sierra)		Days to Mature <sup>a</sup>	Seed Size (g/100 seed) <sup>a</sup>
			2010-2015	2012-2015		
Sierra	Simple	12	1393(100)	1352(100)	98	54.0
Sawyer	Simple	19	1611(116)	1574(116)	92	41.2
Nash	Compound	19	1685(121)	1632(121)	99	58.4
CA0790B0043C	Compound	19	1663(119)	1650(122)	100	53.1
CA0790B0034C	Compound	19	1696(122)	1683(124)	101	53.7
CA0790B0547C	Compound	13	-----	1721(127)	97	51.6
CA0790B0642C	Compound	13	-----	1603(119)	101	55.6

<sup>a</sup>Results presented are means of two years of advanced yield trials (2014 and 2015).

Location Yield Summary for the 2015 Large Kabuli Chickpea Advanced Yield Trial (1581)

Entry	Leaf Type	Seed Color	kg/ha			Mean	% of Sierra
			Pullman	Kendrick	Genesee		
CDC Frontier	C	C	1285	1337	2169	1636	123
CA0790B0547C	C	C	1298	1276	2116	1597	120
Billy Beans	C	C	1311	1225	2003	1538	116
Sawyer	S	C	1047	1144	2242	1532	115
CA0790B0034C	C	C	1088	1218	1827	1414	106
CA0890B0429C	C	C	922	1150	1982	1405	106
CA0890B0435C	S	C	1113	976	1944	1373	103
CA04900843C	C	C	904	1207	1835	1367	103
CA0790B0043C	C	C	984	1096	1859	1354	102
CA0790B0642C	C	C	827	1171	1878	1350	102
Sierra	S	C	855	888	2069	1323	100
CA12900046W	C	W	803	1082	1906	1321	99
CA0890B0531C	C	C	764	1101	1817	1285	97
CA11900014C	C	C	761	1052	1753	1242	93
CA11900031W	C	W	665	1033	1646	1171	88
CA11900028C	C	C	718	1040	1597	1168	88
CA12900287C	C	C	789	1027	1490	1141	86
CA0890B0551C	C	C	545	820	1567	1031	78
Grand Mean			927	1102	1872	1348	
CV			8.9	9.8	16.5	14.8	
LSD (0.05)			175	179	498	169	

Leaf Type: C = compound leaf; S = simple leaf. Seed Type: C = café; W = white.  
Yield data are means of three replications at each location.

Entry	2015	2014	2013	2012	2011	Mean
	(kg/ha)					
Sierra	1323	1083	1722	1532	2090	1550
Sawyer	1532	1441	1913	1605	2380	1774
CDC Frontier	1636	1598	2090	1928	2216	1894
CA04900843C	1367	1435	1927	1866	2434	1806
CA0790B0034C	1414	1503	1825	1978	2319	1808
CA0790B0043C	1354	1525	1759	2012	2618	1854
Billy Beans	1538	1709	1949	2068	2473	1947
CA0790B0547C	1597	1462	1956	2099		1779
CA0790B0642C	1350	1503	1799	1846		1625
CA0890B0429C	1405	1381	1770	1878		1609
CA0890B0531C	1285	1457	1817			1520
CA0890B0551C	1031	1304	1781			1342
CA11900028C	1168	1616				1392
CA11900031W	1171	1490				1331
CA12900046W	1321					1321
CA12900287C	1141					1141
CA0890B0435C	1373					1373
CA11900014C	1242					1242
Year Mean	1348	1424	1781	1736	2324	
CV	14.8	11.2	7.1	12.1	11.1	
LSD (0.05)	169	108	121	142	319	

Agronomic Data for the 2015 Large Kabuli Chickpea Advanced Yield Trial (1581)

Entry	Days to Flower	Days to Mat	Pods/Peduncle	Pod Height (cm)	Pod Ht Maturity (cm)	Pod Ht Index	Vine Length (cm)	Canopy Height (cm)	Plant Ht Index	100 Sd Weight (g)
Sierra	62.0	99.0	1.0	26.0	21.0	0.82	41.3	38.3	0.94	55.6
Sawyer	59.0	93.0	1.0	28.3	15.3	0.54	45.8	40.0	0.89	40.5
CDC Frontier	59.0	101.0	1.0	22.8	21.3	0.94	41.5	37.3	0.91	38.2
Billy Beans	58.3	96.0	1.0	24.8	18.0	0.76	45.0	35.8	0.80	30.4
CA04900843C	60.3	99.0	1.0	25.0	17.8	0.74	47.8	37.8	0.80	54.5
CA0790B0034C	59.7	105.0	1.0	25.8	21.3	0.83	43.3	40.0	0.93	54.9
CA0790B0043C	61.3	103.0	1.0	26.8	21.5	0.81	46.5	43.3	0.94	53.9
CA0790B0547C	60.3	98.0	1.0	22.5	17.5	0.78	42.0	37.8	0.91	50.8
CA0790B0642C	61.3	105.0	1.0	22.8	18.0	0.79	42.0	37.8	0.91	58.6
CA0890B0429C	59.7	99.0	1.0	20.5	15.5	0.75	43.5	38.5	0.89	52.3
CA0890B0435C	62.0	100.0	1.0	36.8	22.3	0.61	51.0	45.5	0.90	56.6
CA0890B0531C	58.3	99.0	1.0	22.0	18.5	0.85	39.5	37.8	0.96	52.9
CA0890B0551C	60.3	99.0	1.0	23.3	18.5	0.81	39.3	36.0	0.92	54.0
CA11900014C	63.0	107.0	1.0	26.5	18.8	0.71	43.0	38.0	0.89	59.4
CA11900028C	63.0	110.0	1.0	28.3	22.5	0.82	45.0	41.0	0.92	60.6
CA11900031W	63.0	110.0	1.0	24.8	21.0	0.87	44.3	40.3	0.91	58.8
CA12900046W	59.0	97.0	1.0	22.5	19.8	0.89	40.5	36.8	0.92	58.1
CA12900287C	60.0	93.0	1.0	25.5	22.0	0.89	44.3	38.5	0.88	52.0
Grand Mean	60.5	100.5	1.0	25.2	19.4	0.78	43.6	38.8	0.89	52.3
CV	3.0	4.1	1.0	12.5	16.2	12.3	6.4	5.1	4.6	5.8
LSD (0.05)	3.0	8.7	1.0	6.6	6.6	0.20	5.9	4.2	0.08	6.4

Pod height was measured at the green pod stage and at harvest maturity. Pod Height Index = Pod height at harvest maturity divided by the pod height at the green pod stage.

Plant Height was measured at the green pod stage and at harvest maturity. Plant Height Index = plant height at harvest maturity divided by the plant height at the green pod stage

Agronomic data are means of three replications at Pullman, WA.

Agronomic and Yield Data for the 2015 Large Kabuli Chickpea Preliminary Yield Trial (1583)

Entry	Days to Flower	Days to Mat	Pods/Peduncle	Pod Height (cm)	Pod Ht Maturity (cm)	Pod Ht Index	Vine Length (cm)	Canopy Height (cm)	Plant Ht Index	100 Sd Weight (g)	Yield (kg/ha)	% of Sierra
CA13900151C	59.7	100.0	1.0	23.8	20.8	0.88	45.0	40.3	0.90	46.2	1296	141
CA13900119C	57.7	102.0	1.0	24.0	20.8	0.87	43.0	38.8	0.91	51.3	1285	140
CA13900061C	58.3	101.0	1.0	25.3	20.3	0.82	45.2	38.3	0.85	50.0	1260	137
CA13900162C	57.7	104.0	1.0	21.8	19.8	0.91	42.5	36.3	0.86	46.5	1257	136
CA13900049C	59.0	93.0	1.0	25.0	19.7	0.80	44.3	40.2	0.91	34.7	1196	130
CA13900004C	59.0	98.0	1.0	25.0	19.0	0.76	48.0	40.2	0.85	41.2	1180	128
CA13900129C	60.3	105.0	1.0	25.0	19.7	0.80	45.2	37.3	0.83	50.4	1159	126
CA13900168C	60.3	102.0	1.0	26.3	20.7	0.79	46.3	40.7	0.88	35.9	1154	125
CA13900115C	58.3	97.0	1.0	26.5	23.3	0.88	45.0	37.2	0.83	50.1	1133	123
CA13900023C	59.7	96.0	1.0	27.3	23.8	0.88	47.5	43.2	0.92	50.8	1131	123
CA13900002C	58.3	96.0	1.0	26.5	18.3	0.71	47.2	38.7	0.83	44.9	1129	122
CA13900139C	59.0	100.0	1.0	23.7	20.8	0.88	41.5	37.7	0.91	48.5	1098	119
CA13900051C	63.0	96.0	1.0	25.8	21.8	0.85	45.8	40.0	0.88	36.0	1044	113
CA13900166C	58.3	99.0	1.0	22.2	15.3	0.71	42.8	35.3	0.83	43.5	1024	111
Sawyer	59.7	93.0	1.0	27.0	22.3	0.83	44.8	41.3	0.93	41.3	999	108
CA13900008C	59.0	101.0	1.0	28.3	22.3	0.79	49.2	40.5	0.83	44.6	996	108
CA13900147C	59.0	102.0	1.0	24.8	19.0	0.78	46.3	42.2	0.92	54.1	972	105
Sierra	62.0	98.0	1.0	27.8	21.8	0.80	44.8	40.8	0.92	47.0	918	100
CA13900065C	60.0	100.0	1.0	21.3	17.5	0.84	41.3	35.2	0.86	44.3	906	98
CA13900150C	59.0	105.0	1.0	24.5	19.5	0.81	43.2	38.2	0.89	56.0	853	92
CA13900149C	59.7	103.0	1.0	24.8	19.2	0.78	46.7	39.8	0.86	57.7	840	91
CA13900125C	59.0	107.0	1.0	24.0	21.2	0.87	47.0	43.5	0.93	50.9	833	90
CA13900031C	60.3	111.0	1.0	28.2	23.5	0.84	47.0	39.8	0.85	55.2	713	77
CA13900090C	60.7	99.0	1.0	21.3	15.5	0.73	42.7	38.2	0.90	52.7	713	77
Grand Mean	59.4	100.2	1.0	25.0	20.2	0.81	45.0	39.3	0.87	47.2	1045	
CV	2.2	4.5	1.0	9.7	11.6	12.5	5.7	5.6	7.1	3.8	12.0	
LSD (0.05)	2.2	7.5	1.0	4.0	3.8	0.16	4.2	3.6	0.10	2.9	221	

Pod height was measured at the green pod stage and at harvest maturity. Pod Height Index = Pod height at harvest maturity divided by the pod height at the green pod stage. Plant Height was measured at the green pod stage and at harvest maturity. Plant Height Index = plant height at harvest maturity divided by the plant height at the green pod stage. Data are means of three replications at Pullman, WA.