4-27-2017

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Urrea, Carlos A.; Muehlbauer, Fred J.; and Harveson, Robert M., "Registration of 'New Hope' Chickpea Cultivar with Enhanced Resistance to Ascochyta Blight" (2017). *Panhandle Research and Extension Center*. 122.
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Registration of 'New Hope' Chickpea Cultivar with Enhanced Resistance to Ascochyta Blight

Carlos A. Urrea,* Fred J. Muehlbauer, and Robert M. Harveson

Abstract

Chickpea (*Cicer arietinum* L.) cultivar New Hope (Reg. No. CV-315, PI 679590), a large, cream-colored, kabuli type, is a F_{8:13} line obtained from the cross CA9990B1895C/CA9890233W. CA9990B1895C is a F₄ line derived from the cross of FLIP91-021/ 'Sanford'. CA9890233W was an F₆ selection from the cross of 'Blanco Lechoso'/*2/CA188620. New Hope was selected specifically for adaptation to Nebraska growing conditions and for enhanced resistance to Ascochyta blight, a major disease of chickpea caused by *Ascochyta rabiei* (Pass.) Labr. Under nonfungicide conditions (natural infection), New Hope had significantly lower ($P < 0.05$) incidence and severity of Ascochyta blight compared with the commercial kabuli cultivars 'CDC Orion', 'Sierra', and 'HB-14' in 2012, and compared with CDC Orion, 'CDC Frontier', Sierra, and HB-14 in 2015. In both 2012 and 2015, incidence of Ascochyta blight in New Hope was similar to that of resistant germplasm line PHREC-Ca-Comp. #1, released in 2011. Across years (2012–2015) and environments (fungicide protected, nonprotected), yield of New Hope did not differ significantly ($P > 0.05$) from the other cultivars. New Hope exhibits an upright indeterminate growth habit. Plants average 43 cm tall and have excellent lodging resistance. New Hope has a compound leaf structure and white blossoms and flowers 44 d after planting. It is a midseason chickpea maturing 105 d after planting. Seed size meets commercial standards.

CHICKPEA (*Cicer arietinum* L.), often referred as garbanzo beans, is the third most important food legume in the world. It is grown in 57 countries, with the continents of Asia, Africa, Oceania, the Americas, and Europe contributing 88.8, 4.2, 4.0, 2.1, and 0.9%, respectively, of the total worldwide planted area (14.8 million ha) (FAOSTAT, 2014). India, Pakistan, Turkey, and Myanmar are the top-producing countries, with 72.63, 6.70, 2.63, and 2.27% of the total planted area, respectively (FAOSTAT, 2014). Chickpea is used extensively for human consumption. Chickpea is more frequently cooked and blended with rice dishes in South Asia, while in the Middle East and North America, it is commonly used for making hummus, a spread that is often consumed with flat bread. Chickpea has been widely used in the United States in salad bars (Margheim et al., 2004); however, within the past 20 yr, hummus has also become very popular in the United States and now represents the country's most important use for chickpea.

Ascochyta blight [caused by *Ascochyta rabiei* (Pass.) Labr.], a fungal disease that can affect all aboveground plant parts (Ahmed et al., 2006; Harveson, 2013), is the most limiting factor affecting chickpea production, causing reduced yields and crop quality (Miller et al., 2002; Harveson, 2013). The pathogen can be seed transmitted and can also be spread by infected chickpea crop debris (Kaiser, 1992; Akem, 1999). Cool, moist, and windy conditions favor the development and spread of the disease (Kaiser, 1992; Akem, 1999).

Damage caused by Ascochyta blight in chickpea can be minimized by use of moderately resistant cultivars integrated with strategic agronomic management practices such as disease-free seed, seed treatment, crop rotation, tillage, and foliar applications of fungicides (Gan et al., 2006; Harveson, 2013). The development of resistant cultivars is one of the most cost effective practices to control Ascochyta blight; however, it has not always been effective under high disease pressure (Akem, 1999; Jayakumar et al., 2005). Compound-leaved chickpea varieties had more resistance to Ascochyta blight than unifoliate-leaved varieties (Ahmed et al., 2006).

Numerous patterns of inheritance of Ascochyta blight resistance have been identified. Resistance to Ascochyta blight

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Journal of Plant Registrations 11:107–111 (2017).

doi:10.3198/jpr2016.07.0034crc

Received 1 July 2016.

Accepted 15 Nov. 2016.

Registration by CSSA.

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Abbreviations: PREC, Panhandle Research and Extension Center; PVP, Plant Variety Protection; UNL, University of Nebraska-Lincoln.

is reported to be controlled by a single dominant gene pair (Vir et al., 1975), a single dominant and a recessive gene (Singh and Reddy, 1983), and two dominant complementary genes or by one dominant and one recessive independent gene (Dey and Singh, 1993). Others consider *Ascochyta* blight resistance to be a quantitative trait involving several genes (Tekeoglu et al., 2000; Udupa and Baum, 2003; Danehlouipour et al., 2007). Recent efforts have focused on identifying genomic locations associated with resistance so that genetic markers can be used to facilitate breeding for resistance (Santra et al., 2000; Collard et al., 2003; Millan et al., 2006).

Chickpea has potential as an alternative crop in western Nebraska because it fits well with growers' existing equipment, dry bean processors, and regional infrastructure. Irrigated production of chickpea is viable for western Nebraska (Urrea et al., 2010). Initially, chickpea production grew rapidly (from 607 ha in 2000 to almost 4046 ha in 2006). However, planted acreage declined to fewer than 40 ha in 2007 (Urrea et al., 2010) and none in 2015, largely because of damage from *Ascochyta* blight. Harveson (2002) first reported the presence of *Ascochyta* blight in Nebraska and its threat to chickpea production. In 2011, the dry bean breeding program released PHREC-*Ca*-Comp. #1 (Urrea et al., 2011) with enhanced resistance to *Ascochyta* blight. We evaluated the Western Regional Chickpea Trial obtained from USDA-ARS, Pullman, WA, and other segregating populations to identify sources of *Ascochyta* blight resistance with good agronomic performance that could revive the chickpea industry in Nebraska. As part of the ongoing breeding efforts at the University of Nebraska, we developed and are releasing the kabuli chickpea cultivar New Hope (Reg. No. CV-315, PI 679590), which has enhanced resistance to *Ascochyta* blight.

Methods

New Hope is a large, cream-colored kabuli chickpea. Initially coded as NE21-11-22, 'New Hope' is an $F_{8:13}$ line obtained from the cross CA9990B1895C/CA9890233W. The initial cross was made at the USDA-ARS at Washington State University, Pullman, WA, by Dr. Fred Muehlbauer. CA9990B1895C was selected in the F_4 in 1999 from the cross of FLIP91-021/'Sanford', the single-plant-row nursery designated as Experiment 9990. That nursery was simultaneously screened for resistance to *Ascochyta* blight, with the better rows selected for further testing and crossing. FLIP91-021 is an *Ascochyta* blight-resistant germplasm line obtained from the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, and Sanford (Muehlbauer et al., 1998) is a unifoliate cultivar with partial resistance to *Ascochyta* blight that was developed and released by the USDA-ARS program at Washington State University. CA9890233W was selected in the F_6 in 1998 from the cross of 'Blanco Lechoso'/*2/CA188620. The purpose of that cross was to develop a large white-seeded cultivar with resistance to *Ascochyta* blight. Blanco Lechoso is a large white-seeded cultivar that is popular in Spain, while CA188620 is a selection from the USDA-ARS program with partial resistance to *Ascochyta* blight.

In 2006, a chickpea nursery (0594 Pullman) from the USDA-ARS at Washington State University was provided to the University of Nebraska dry bean breeding program and planted at

Scottsbluff, NE (41°53.6' N, 103°40.7' W, 1200 m elevation). NE21-11-22 was originally coded as NE4-04-19 in 2006. Individual plant selections based on *Ascochyta* blight resistance began in 2006, when nine plants were selected, and continued through 2010. In 2010, NE4-04-19 was bulked, and in 2011, it was coded as NE21-11-22. In 2012, it was named New Hope.

New Hope was tested in replicated yield trials at Mitchell, NE (41°56.6' N, 103°41.9' W, 1240 m elevation) from 2012 to 2015. In these chickpea trials, we compared New Hope's agronomic performance and *Ascochyta* blight reaction to that of commercial checks 'CDC Orion' (Taran et al., 2011), 'CDC Frontier' (Warkentin et al., 2005), 'Sierra' (Muehlbauer et al., 2004), 'HB-14', and the PHREC-*Ca*-Comp. #1 germplasm under six environments (fungicide protected, nonprotected).

Locations

New Hope was evaluated at the University of Nebraska Panhandle Research and Extension Center at Mitchell, NE (PREC-Mitchell) (41°56.6' N, 103°41.9' W, 1240 m elevation). Soil at this site is a silt loam (Typic Ustorthents).

Experimental Design

We evaluated the adaptation of chickpea germplasm at PREC-Mitchell, NE, from 2012 to 2015 using a split-plot design with three replications from 2012 to 2014 and two replications in 2015. Each year, *Ascochyta* blight treatments (protected with fungicide at flowering stage and nonprotected [natural *Ascochyta* blight infection]) were randomly assigned to the main plots and genotypes were randomly assigned to the subplots. All subplots were 2.2 m wide and consisted of four 3.7-m-long rows. Seed was planted at a density of 44.7 seeds m^{-2} . Prior to planting, seed was inoculated with N-Dure (Microbials, LLC) at a rate of 2.2 kg inoculum 682 kg seed $^{-1}$. Trials were planted in early May, when soil temperature at a depth of 5 cm was 7.2°C and rising, as recommended by Margheim et al. (2004) in fields where corn (*Zea mays* L.) had been grown the preceding year.

Phosphorus was applied at a rate of 4.8 kg ha^{-1} by broadcasting an 11-15-0 (N-P-K) starter fertilizer. Plots were treated with 85 g ha^{-1} of sulfentrazone (Spartan, FMC Corp.) and 170 g ha^{-1} of pendimethalin (Prowl H₂O, BASF Corp.) to control both broadleaf and grass weeds. In the fungicide-protected main plots, *Ascochyta* blight was controlled at the flowering stage by applying 421.5 mL ha^{-1} of prothioconazole (Proline 480 SC, Bayer Crop Science). The fungicide was applied using a four-wheeler with a spray boom with four nozzles 50.8 cm apart. Thirty-seven liters of water was used at a speed of 4.8 km h^{-1} and 137.9 kPa. After emergence and throughout the growing season, irrigated plots were watered approximately once weekly with 1.3 cm of water using sprinkler irrigation systems. Plots were harvested with a plot combine (Wintersteiger Classic).

Response Variables

Response variables were measured for each plot. We evaluated agronomic performance by determining yield (kg ha^{-1}), 100-seed weight (g), and the number of days to harvest (when plants were dry enough to be harvested with a combine). We evaluated *Ascochyta* blight reaction in mid-July of each year by determining percentage *Ascochyta* blight incidence (% of plants infected in the

whole plot) and Ascochyta blight incidence using a 1 to 9 scale, where 1 = immune and 9 = very susceptible (van Schoonhoven and Pastor-Corrales, 1987). Reactions from 1 to 3 were considered resistant, 4 to 6 intermediate, and 7 to 9 susceptible.

Statistical Analysis

Data were analyzed using PROC MIXED (SAS Institute, 2004). Each environment was analyzed separately. Replication was treated as a random effect and genotype was treated as a fixed effect. Homogeneity of the variances was evaluated using Barlett's χ^2 test (Steel and Torrie, 1980) and appropriate data were pooled. In the pooled analyses, year $\times$ location and replication were random effects and genotypes were fixed effects. Means were separated using an *F*-protected LSD. All tests were considered significant at $P \leq 0.05$.

Characteristics

Ascochyta Blight

Natural infection was the primary source of Ascochyta blight. In 2013 and 2014, Ascochyta blight incidence and severity were low due to hot summers, precluding comparison of reactions. In both 2012 and 2015, incidence and severity of Ascochyta blight in New Hope were low under both fungicide-protected and nonprotected conditions and were similar to the reaction of resistant germplasm PHREC-*Ca*-Comp. #1 released in 2011 (Table 1), providing evidence of Ascochyta blight resistance in New Hope. Under fungicide-protected conditions, incidence and severity of Ascochyta blight in New Hope were lower than in commercial cultivars Sierra and HB-14 equal to commercial cultivars CDC Orion, Sierra, and HB-14 in both 2012 and 2015, and equal to (2012) or similar to lower than (2015) in commercial cultivars CDC Orion and CDC Frontier (Table 1). Under nonprotected conditions, New Hope had significantly lower ($P < 0.05$) severity of Ascochyta blight compared with the commercial cultivars Sierra, CDC Frontier, and HB-14 in 2012 and compared with CDC Orion, CDC Frontier, Sierra, and HB-14 in 2015 (Table 1).

Yield

Across years (2012–2015) and environments (fungicide protected, nonprotected), yield of New Hope did not differ significantly from the other cultivars ($P > 0.05$), although some differences were observed in individual years (Table 2). In 2012, CDC Frontier had significantly greater yield than New Hope ($P < 0.05$), whereas in 2015, New Hope had significantly greater yield than Sierra and HB-14 ($P < 0.05$) (Table 2).

Seed Size

New Hope, a large kabuli-type chickpea, generally had higher average 100-seed weight (indicating larger seed size) than CDC Orion and CDC Frontier across and within fungicide-protected and nonprotected environments (ranges 50.5–45.4 and 41.3–38.6 g, respectively) in 2012 and 2015 (Table 3). Seed size (average 100-seed) was significantly greater ($P < 0.05$) for New Hope than for CDC Frontier (both environments) in 2012, than for CDC Frontier and Sierra in 2013, and than for CDC Orion (both environments) and CDC Frontier and HB-14 (fungicide-protected environment) in 2015 (Table 3). Average 100-seed weight of New Hope was 8.2% lower under nonprotected than under fungicide-protected conditions.

Seed of New Hope varies somewhat in size. In 2015, 61.3% of the chickpeas in a commercially graded 500-g sample were 9 mm, 34.2% were 8 mm, 2.2% were 7 mm, and 2.3% were <7 mm in size.

Days to Harvest

New Hope is a midseason chickpea maturing 105 d after planting, although days to harvest varied among years and environments (range 90–114 d) (Table 4). New Hope matured 3 d earlier under fungicide-protected than under nonprotected conditions in 2012 but matured 4 d later under fungicide-protected conditions than under nonprotected conditions in 2015 (Table 4). Greatest variation in days to harvest occurred in 2015, with New Hope and CDC Orion maturing latest under fungicide-protected conditions and Sierra and HB-14 maturing earliest under both fungicide-protected and nonprotected environments (Table 4).

Table 1. Mean Ascochyta blight incidence (%) and severity (1–9) of the chickpea cultivar New Hope, four check cultivars, and one germplasm line evaluated at four irrigated environments in western Nebraska during 2012 and 2015.

Genotype	2012				2015			
	Protected†		Nonprotected‡		Protected		Nonprotected	
	Incidence	Severity§	Incidence	Severity	Incidence	Severity	Incidence	Severity
	%	1–9	%	1–9	%	1–9	%	1–9
CDC Orion	1.0	1.5	13.3	2.6	25.0	3.0	35.0	4.5
CDC Frontier	1.0	1.5	1.7	3.8	7.5	2.3	45.0	4.5
PHREC- <i>Ca</i> -Comp. #1	1.0	1.5	1.0	1.5	5.0	1.8	10.0	2.0
Sierra	5.0	2.0	16.7	3.0	60.0	6.0	70.0	7.0
HB-14	40.0	6.0	40.0	5.3	70.0	7.0	70.0	7.0
New Hope	1.0	1.5	1.2	1.5	7.5	2.8	10.0	2.5
LSD (0.05)¶	9.2	1.0	9.2	1.0	21.6	1.7	21.6	1.7

† Protected against Ascochyta blight at the flowering stage by applying 421.5 mL ha⁻¹ of prothioconazole (Proline 480 SC, Bayer Crop Science).

‡ Natural Ascochyta blight infection.

§ Ascochyta blight severity: 1= immune and 9= very susceptible. Reactions from 1 to 4 were considered resistant and from 5 to 9 susceptible (van Schoonhoven and Pastor-Corrales, 1987).

¶ To compare means among genotypes.

Other Characteristics

New Hope exhibits an upright indeterminate growth habit. Plants averaged 43 cm in height during 2015 and had excellent lodging resistance. New Hope has white flowers and a compound leaf structure composed of several pairs of small oblong leaflets.

Summary

New Hope showed evidence of *Ascochyta* blight resistance with consistently low incidence of *Ascochyta* blight across environments (fungicide protected, nonprotected) and at levels similar to that of resistant germplasm PHREC-*Ca*-Comp. #1. In addition, New Hope showed acceptable agronomic characteristics. It matured in a suitable timeframe for this region, yield

Table 2. Mean yield (kg ha⁻¹) of the chickpea cultivar New Hope, four cultivars, and one germplasm line evaluated at six irrigated environments in western Nebraska during 2012–2015.

Genotype	Mean yield					
	2012		2013	2014	2015	
	Protected†	Nonprotected‡			Protected	Nonprotected
	kg ha ⁻¹					
CDC Orion	2949	2391	2078	2477	3450	3166
CDC Frontier	4743	3065	2317	3108	3051	2788
PHREC- <i>Ca</i> -Comp. #1	3872	1905	1702	2082	2311	2781
Sierra	2337	1942	1149	2155	999	942
HB-14	2713	2122	864	3145	355	749
New Hope	3277	1810	1931	2232	2750	2434
LSD (0.05)§		1071	942	1432		900

† Protected against *Ascochyta* blight at the flowering stage by applying 421.5 mL ha⁻¹ of prothioconazole (Proline 480 SC, Bayer Crop Science).

‡ Natural *Ascochyta* blight infection.

§ To compare means among genotypes.

Table 3. Mean 100-seed weight (g) of the chickpea cultivar New Hope, four cultivars, and one germplasm line evaluated at six irrigated environments in western Nebraska during 2012–2015.

Genotype	100-seed weight					
	2012		2013	2014	2015	
	Protected†	Nonprotected‡			Protected	Nonprotected
	g					
CDC Orion	49.3	46.0	34.7	39.5	33.7	31.3
CDC Frontier	40.2	38.2	31.7	36.1	31.1	32.9
PHREC- <i>Ca</i> -Comp. #1	33.8	33.5	30.1	27.3	26.6	28.9
Sierra	54.4	53.1	39.3	49.5	36.6	35.5
HB-14	53.1	51.8	39.0	49.6	31.3	35.2
New Hope	50.5	45.4	40.5	43.3	41.3	38.6
LSD (0.05)\$	4.0		5.4	8.1	5.7	

† Protected against *Ascochyta* blight at the flowering stage by applying 421.5 mL ha⁻¹ of prothioconazole (Proline 480 SC, Bayer Crop Science).

‡ Natural *Ascochyta* blight infection.

§ To compare means among genotypes.

Table 4. Mean number of days to maturity (d) of the chickpea cultivar New Hope, four cultivars, and one germplasm line evaluated at four irrigated environments in western Nebraska during 2012 and 2015.

Genotype	Mean days to maturity			
	2012		2015	
	Protected†	Nonprotected‡	Protected	Nonprotected
	d			
CDC Orion	113	114	100	96
CDC Frontier	113	114	96	96
PHREC- <i>Ca</i> -Comp. #1	113	114	96	96
Sierra	114	114	90	90
HB-14	113	114	90	90
New Hope	111	114	100	96
LSD (0.05)§	6		3	

† Protected against *Ascochyta* blight at flowering stage by applying 421.5 mL ha⁻¹ of prothioconazole (Proline 480 SC, Bayer Crop Science).

‡ Natural *Ascochyta* blight infection.

§ To compare means among genotypes.

did not differ significantly from that of the commercial cultivars under either fungicide-protected or nonprotected conditions, and seed size met commercial kabuli-type standards. It was also less affected by *Ascochyta* blight incidence than the commercial cultivars standards in terms of severity of infection and impacts of yield. New Hope has the potential to revive the chickpea industry in western Nebraska or at least serve as a parent for another hybrid combination. It is assumed to be adaptable for other areas of chickpea production in North Dakota, South Dakota, and Montana.

Availability

Husker Genetics Foundation Seed Program, University of Nebraska-Lincoln, will maintain a small quantity of breeder seed of New Hope. An application will be filed for cultivar protection under Title V of the US Plant Variety Protection (PVP) Act. A small quantity of seed of New Hope is available for research purposes from the corresponding author for the first 5 yr. Seed of New Hope has been deposited with the USDA-ARS National Laboratory for Genetic Resources Preservation, where it will be available on expiration of PVP 20 yr after the date of publication. Approval by the University of Nebraska-Lincoln will be required to market a new cultivar that is 25% or more New Hope. This will include a negotiated license agreement and fee structure. We ask that appropriate recognition of source be given when this cultivar contributes to the development of a new cultivar.

Acknowledgments

We are grateful for financial support from the Nebraska Dry Bean Commission (project WBS# 266243, -0204, -0254, -0274, and -0279) from 2006 to 2010, the Nebraska Department of Agriculture through the Specialty Crop Block Grant Initiative (project WBS# 266243, 001) from 2011 to 2013, and the Hatch Project (NEB43-117). We thank Kathy Nielsen, Gene Kizzire, and Eduardo Valentin Cruzado for technical help and Ann Koehler for editing assistance.

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