Genotype and Environment Effects on Lablab Seed Yield and Composition

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Abstract. Lablab [*Lablab purpureus* (L.) Sweet], which is one of the most ancient crops among cultivated plants, is a relatively unknown crop in the United States. Lablab is a major source of protein in the human diet in many parts of the world. Even though lablab is a potential alternative food and feed crop in other areas of the United States, it is expected to produce seed in southern United States (Florida, Georgia, and Texas). However, there is a lack of information about production potential of lablab in Virginia and adjoining states. We report the results of a replicated field study that was conducted for 2 years with 17 lablab lines in Virginia. The seed yield varied from 559 to 1678, with a mean yield of 1012 kg·ha⁻¹. The seed protein concentration varied from 20.6 to 28.8, with a mean concentration of 25.4%. Lablab seed contained small amounts of oil (0.54% to 1.13%). Total sugars in lablab seed meal varied from 4.2% to 10.1%. Based on seed yields from other parts of the world and concentrations of protein, oil, and total sugars reported in literature regarding other food legumes, we concluded that lablab is a potential alternative summer crop in Virginia and other mid-Atlantic states.

Lablab [*Lablab purpureus* (L.) Sweet] is a relatively unknown crop in the United States. From a historical perspective, lablab seeds were planted in 1819 in the Botanical Garden of Sydney, Australia, which eventually led to the release of the first improved cultivar Rongai in Australia in 1962. ‘Rongai’ seed was imported to the United States in the late 1960s and marketed as supplemental forage for white-tailed deer. Lablab cultivar Rio Verde was developed by Texas A&M Agri-Life Research and Extension Center in 2006. This was the first lablab cultivar developed in the United States for tolerance to defoliation, forage, and seed production (Houck, 2013). Lablab has been a novelty garden plant in the United States for generations. This vigorous twining vine is characterized by large alternating purple and green leaves and purple petioles. The vines produce hundreds of spikes of lavender flowers during late summer, followed by long-lasting deep lavender–purple pods. It is primarily an ornamental annual vine in the United States (Anderson et al., 1996). During the 1970s, lablab was

labeled as “neglected” but worthy of more intensive studies and further developments (NAS, 1979). Maass et al. (2010) indicated that more than 3000 accessions of lablab have been collected worldwide. Sheahan (2012) observed that lablab will produce seed in the southern United States (Florida, Georgia, and Texas), and they reported three lablab cultivars for use in the United States: ‘Rongai’ and ‘Highworth’ from Australia and ‘Rio Verde’ from the United States.

Pengelly and Maass (2001) indicated that lablab is a native of Asia and Africa. However, Maass et al. (2010) indicated that despite its large agro-morphological diversity in South Asia, its origin appears to be African, which is the only continent where wild plants of the species occur naturally. According to the information available at the University of Agricultural Sciences (Bangalore, India), a well-known source of information for this crop, lablab is usually known as Dolichos bean, Hyacinth bean, Bonavist bean, Seim bean, Lablab bean, Egyptian kidney bean, Indian bean, Common bean, Field bean, Pandal bean, Pole bean, and Waby bean (www.lablablab.org). It is one of the most ancient crops among cultivated plants found in archaeo-botanical fields in India before 1500 BC (Fuller, 2003) and in Egyptian Nubia from the fourth century AD (Clapham and Rowley-Conwy, 2007). Lablab is a bushy, semi-erect, and perennial herb. Most lablab cultivars are strong climbers; only a few cultivars from India are bush-type. It is a major source of protein in the human diet in southern states of India. The consumer preference varies with pod size, shape, color and aroma (pod fragrance).

Lablab has been noted for decades as being one of the most agro-morphologically diverse (Islam 2008; Pengelly and Maass

2001; Piper and Morse 1915) and versatile tropical legume species through its roles as pulse (also used as ‘dhal’), vegetable (green bean, pod, leaf), forage/green manure, herbal medicine, and even as an ornamental (NRC, 2006). Biofunctional properties of lablab for use as a pharmaceutical or nutraceutical have also been reviewed (Morris, 2009). In Indonesia, seeds serve as raw materials for tempeh, a traditional fermented food typically made from soybeans (Subagio and Morita, 2008).

The New Crops Program of Virginia State University (Petersburg, VA), established in 1991, has been evaluating a wide array of food, feed, and industrial use crops for diversification of cropping system (Bhardwaj et al., 1996). We became interested in lablab as a potential alternative food, feed, and forage crop based on its reported adaptability over a wide range of agro-climatic conditions (www.lablablab.org).

The overall goal of lablab research was to expand the menu of alternative crops for tobacco farmers in a nontraditional area. Specifically, the objective of the current research of lablab was to characterize lablab seed yield and the composition of its seed produced in Virginia to address its potential use as food and feed. The desirability of lablab as a forage crop in Virginia has been previously reported (Bhardwaj and Hamama, 2019).

Materials and Methods

The 17 lablab entries were grown during 2011 and 2012 in the field (Abel sandy loam–fine loamy mixed thermic Aquatic Hapridult soil) at Randolph Farm of Virginia State University in Ettrick, VA. The environmental conditions during the growing season (May–November) for each year are presented in Table 1. Sixteen lablab accessions (received from the Plant Genetic Conservation Unit, Agricultural Research Service, United States Department of Agriculture, Griffin, GA) and the cultivar Rio Verde (received from Texas A&M University, Overton, TX) comprised the plant materials for this study (Table 2).

Planting dates in 2011 and 2012 were 23 May and 15 May, respectively. Each plot consisted of four rows with ≈50 seeds planted in 2.5-m row length. The rows were 1.2 m apart. Two rows were harvested for forage characterization of forage yield and quality (Bhardwaj and Hamama, 2019), whereas two rows were harvested to record the seed yield. The experimental design was a randomized controlled block design with two replications. These plots did not receive any herbicide, insecticide, or fertilizer treatments. The plots were kept weed-free manually during the early growth period. After ≈30 d, the lablab canopy spread enough to crowd the weeds.

Two rows (each was 2.5 m long) from each plot were harvested manually and threshed after plants were effectively killed by a killing frost during late November

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Use of any trade names or vendors does not imply approval of the exclusion of other products or vendors that may also be suitable.

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Table 1. Environmental conditions of the lablab growing season during 2011 and 2012 in Ettrick, VA.

	2011				2012			
	Avg high temp (°F)	Avg low temp (°F)	Avg temp (°F)	Total precipitation (inches)	Avg high temp (°F)	Avg low temp (°F)	Avg temp (°F)	Total precipitation (inches)
May	75.5	54.0	64.7	3.61	79.3	58.7	69.0	4.44
June	87.7	65.8	76.7	5.02	85.1	61.0	73.0	1.78
July	88.7	68.1	78.4	7.38	92.6	72.4	82.5	8.10
August	85.1	65.6	75.3	8.92	86.1	68.2	77.1	2.62
September	80.6	63.7	72.1	9.12	80.9	59.0	69.9	6.35
October	69.9	47.6	58.7	3.43	68.1	47.5	57.8	3.99
November	65.3	40.5	52.9	4.57	51.8	30.4	41.1	0.35
Annual averages	70.2	47.1	58.6	43.9	70.2	47.1	58.6	43.9

Table 2. Seed yield and composition of 17 lablab accessions when grown in Ettrick, VA, during 2011 and 2012.

Genotype	Source	Seed yield (kg·ha ⁻¹)	Protein (%)	Oil (%)	Total sugars (%)
PI 164772 60	India	962 bc ^z	25.0 a-d ^z	1.01 a-d ^z	4.9 bc
PI 183451 61	India	1445 ab	20.6 d	1.13 a	7.6 abc
PI 284802 64	China	912 bc	25.8 abc	0.84 a-f	4.4 c
PI 288466 65	India	963 bc	21.1 cd	1.05 abc	8.6 ab
PI 288467 66	India	1678 a	26.8 a	0.85 a-f	5.2 bc
PI 388003 70	Australia	1001 bc	21.4 bcd	1.01 a-d	10.1 a
PI 388012 71	Australia	862 bc	26.1 ab	1.03 a-d	5.4 bc
PI 388013 72	Australia	944 bc	27.0 a	1.08 ab	6.2 abc
PI 388017 73	Australia	996 bc	28.3 a	0.82 a-f	8.6 ab
PI 388018 74	Australia	727 c	26.6 a	0.64 ef	4.8 bc
PI 542609 80	India	686 c	28.2 a	0.54 f	6.0 bc
PI 593055 82	United States	559 c	25.0 a-d	0.71 def	4.2 c
PI 639277 85	China	881 bc	24.7 a-d	0.66 ef	4.4 c
PI 639279 87	China	1664 a	26.7 a	0.94 a-e	6.7 abc
PI 639280 88	China	1009 bc	28.8 a	0.74 c-f	5.5 bc
PI 653615 89	United States	891 bc	26.0 ab	0.87 a-e	6.2 abc
Rio Verde	United States	969 bc	23.9 a-d	0.77 b-f	6.2 abc
Mean		1012	25.4	0.87	6.2

^zMeans followed by similar letters are not different according to Duncan's multiple range test at a 5% level of significance.

Means were determined over 2 years with two replications per year.

during each year. A seed sample from each of the 68 plots (17 lines, 2 replications, 2 years) was used to determine nitrogen (N) according to the Association of Official Agricultural Chemists methods (Association of Official Agricultural Chemists, 2016) at the Waypoint Analytical Laboratory in Richmond, VA. The total protein concentration was calculated by multiplying the N content by protein factor 6.25. The oil concentration was determined at the Common Laboratory of Agricultural Research Station of Virginia State University. The oil was extracted from ground lablab seeds (5 g) three times at room temperature by homogenization for 2 min in 20 mL of hexane/isopropanol (3:2, v/v) with a Biospec Model 985-370 Tissue Homogenizer (Biospec Products, Inc., Racine, WI) and centrifuged at 4000 g for 5 min, as described by Hamama et al. (2003). The three extractions were combined, and the hexane-lipid layer was separated from the combined extract after shaking with 10 mL of 1% solution of equal amounts of CaCl₂ and NaCl in 50% methanol. The hexane lipid layer was removed by aspiration and dried over anhydrous Na₂SO₄. The oil percentage (g/100 g dry basis) was determined gravimetrically after drying under a vacuum at 40 °C and stored under nitrogen at -10 °C until analysis.

Sugars were extracted from the ground sample (1 g) and analyzed by high-performance liquid chromatography following the methods optimized by Johansen et al. (1996). Sugars in

the extracts were identified by comparing their retention times with standard sugars. For quantification, trehalose was used as the internal standard and the sugar concentration was expressed as a percentage of lablab seed meal (Bhardwaj and Hamama, 2016). All data were analyzed using version 9.1 of SAS (SAS Institute, Inc., 2014) using an analysis of variance with a 5% level of significance.

Results and Discussion

Significant differences existed among 17 lablab accessions for seed yield and concentrations of oil, protein, and total sugars (Table 2). Effects of year of production and interactions between accessions and years were not significant, implying that main effects (i.e., the effects of accessions) could be directly compared.

The seed yields varied from 559 (PI 593055) to 1678 (PI 288467) kg·ha⁻¹. Lablab seed yield information from the United States is not available. However, seed yields of 1200–2350 kg·ha⁻¹ were reported in Eastern Kenya by Sennhenn et al. (2017). Cook et al. (2005) reported seed yields of 1038–2306 kg·ha⁻¹ in Australia, but seed yields in South America were 519–1038 kg·ha⁻¹. Sheahan (2012) indicated that flowering and seedpod production of lablab are sporadic. To our knowledge, the current report from Virginia is the first to indicate seed production by lablab outside the southern United States.

The average seed yield in Virginia of 1012 kg·ha⁻¹ compared well with seed yield reported in other locations.

The average protein concentration in lablab seed produced in Virginia was 25.4%, with a range from 20.6 to 28.8%, on a dry weight basis. This protein concentration compares well with lablab produced at other locations: 22.4 to 31.3 in India (Deka and Sarkar, 1990); 25% in India (Ramakrishna et al., 2008); 30.2% in Florida (United States) (Venkatachalam and Sathe, 2007); and 25.3% in Nigeria (Ewansiha et al., 2007). Based on the average protein concentrations in navy, pinto, and kidney beans (22.3%, 20.9%, and 22.5%, respectively) (Bhardwaj and Hamama, 2004), lablab dry seed are wholesome (Stephens, 2018).

The lablab seeds contained small quantities of oil. It varied from 0.54% to 0.84% on a dry weight basis, with an average of 0.87%. Deka and Sarkar (1990) also reported that lablab seeds contain small quantities of oil (1.6% to 2.0%, dry weight basis). The sugar concentration in lablab seeds varied from 4.2% to 10.1% on a dry weight basis, with a mean concentration of 6.2%. This sugar concentration compared favorably with 5.67% in pea seeds (USDA ARS, 2018). We concluded that, generally, lablab produced in Virginia as a summer crop has potential as an alternate food and feed crop. Therefore, further studies might be worthwhile.

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