Scientia Horticulturae 237 (2018) 112–119

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Progress in genetic analysis and breeding of tepary bean (*Phaseolus acutifolius* A. Gray): A review

Zinhle Babongile Mhlaba[a,b], Jacob Mashilo[a,b,*], Hussein Shimelis[a,b], Amelework Beyene Assefa[b], Albert Thembinkosi Modi[a]

[a] University of KwaZulu-Natal, Crop Science Discipline, Private Bag X01, Scottsville 3209, Pietermaritzburg, South Africa
[b] University of KwaZulu-Natal, African Centre for Crop Improvement (ACCI), Private Bag X01, Scottsville 3209, Pietermaritzburg, South Africa

ARTICLE INFO

Keywords:
Abiotic stress
Biotic stress
Breeding
Genetic diversity
Population structure
Phaseolus acutifolius

ABSTRACT

Tepary bean (*Phaseolus acutifolius* L. Gray) is one of the five domesticated species of the genus *Phaseolus*. It possesses novel genes for abiotic and biotic stress tolerance. It is being widely used in the breeding of common bean or cross-compatible *Phaseolus* species. Tepary bean is regarded as an underutilized crop and has received limited research focus with regards to genetic improvement and cultivar development. Recently, there has been a renewed interest in using tepary bean genetic resources for breeding and for interspecific hybridization to transfer biotic and abiotic stress tolerance. The objective of this review is to highlight progress made in tepary bean breeding and genetic analysis. This review discusses the potential of available genetic and genomic resources for accelerated breeding and genetic improvement of tepary bean for enhanced resistance to biotic and abiotic stress tolerance. Finally, the paper discusses potential research focus areas that should be integrated for effective utilization of tepary bean genetic resources for accelerated breeding and sustainable production.

1. Introduction

Tepary bean (*Phaseolus acutifolius* A. Gray) belonging to the genus *Phaseolus* is a diploid (2n = 2x = 22) and predominantly self-fertilizing crop (Schinkel and Gepts, 1988). Tepary bean is estimated to have a slightly larger genome (647 Mbp) compared to Lima bean (622 Mbp) and common bean (637 Mbp) (Arumuganathan and Earle, 1991). The crop possesses unique genetic attributes such as tolerance to drought (Markhart, 1985), heat and salt stress making it an ideal crop for cultivation in arid and semi-arid environments (Blair et al., 2002; Rao et al., 2013; Porch et al., 2013). Tepary bean fixes atmospheric N via symbiotic N fixation with bradyrhizobial bacteria (Shisanya, 2002; Mohrmann et al., 2017).

Tepary bean is grown mostly for its dry grains which contains high protein content of ~ 24%, essential mineral elements (e.g. Ca, Mg, Cu, Fe, K, Mn, S, Zn, Na), oil and 33% saturated fatty acids, 67% unsaturated fatty acids, 24% monounsaturated fatty acids and 42% polyunsaturated fatty acids (Amarteifio and Moholo, 1998; Bhardwaj and Hamama, 2004; 2005; Porch et al., 2017). Furthermore, the concentration of essential amino acids in tepary bean is relatively high and similar to that of common bean (Porch et al., 2017). The crop is grown as leafy vegetable in certain instances and the haulms are used for animal feed (Molosiwa et al., 2014).

Tepary bean has high level of resistance to bean weevil caused by *Acanthoscelides obtectus* (Kusolwa and Myers, 2011; Jiménez et al., 2017), common bacterial blight [*Xanthomonas campestris* (axonopodis) pv. *Phaseoli*] (Singh and Muñoz, 1999; Miklas et al., 2006a), bean rust (*Uromyces phaseoli*), anthracnose (*Colletotrichum lindemuthianum*), *Fusarium* wilt (*Fusarium oxysporum*), angular leaf spot (*Isariopsis griseola)* (Santiago et al., 1994; Pratt and Nabhan, 1988; Thomas et al., 1983), bean golden mosaic virus (Salgado et al., 1994; Miklas and Santiago, 1996) and ashy stem blight [*Macrophomina phaseolina* (Tassi) Goid] (Miklas et al., 1998). These diseases are the most important in common bean. Yield losses due to common bacterial blight, bean rust, anthracnose, angular leaf spot and bean golden mosaic virus in common bean are estimated to be 45, 50, 100, 80 and 100%, respectively (Singh and Howard, 2010). Owing to its disease resistance and various desirable attributes (e.g. drought and heat tolerance), tepary bean genetic resources are recommended as sources of useful genes for breeding in common bean or cross-compatible *Phaseolus* species (Tar'an et al., 1998; Rainey and Griffiths, 2005; Liu et al., 2008; Beebe et al., 2011).

Tepary bean has been successfully used to develop interspecific common bean breeding lines with enhanced level of biotic and abiotic resistance through genomic introgression (Thomas and Waines, 1984; Mejía-Jiménez et al., 1994; Michaels et al., 2006; Park et al., 2007; Rainey and Griffiths, 2005; Souter et al., 2017). So far, 25% of the

* Corresponding author.
E-mail address: jacobmashilo@yahoo.com (J. Mashilo).

https://doi.org/10.1016/j.scienta.2018.04.012
Received 28 November 2017; Received in revised form 28 January 2018; Accepted 5 April 2018
0304-4238/ © 2018 Elsevier B.V. All rights reserved.

Table 1
Marker systems and genetic diversity analyses studies reported in tepary bean.

Marker type	No of accessions evaluated	Species	References
Gel electrophoresis	63	*P. acutifolius var. tenuifolius* (wild) *P. acutifolius var. acutifolius* (domesticated)	Schinkel and Gepts (1988)
Allozyme	63	*P. acutifolius var. tenuifolius* (wild) *P. acutifolius var. acutifolius* (domesticated)	Schinkel and Gepts (1989)
AFLP	147	*Phaseolus glabelus L.* *P. acutifolius var. acutifolius* (domesticated) *P. acutifolius var. acutifolius* (wild) *Phaseolus lunatus L* *Phaseolus angustissimus L.* *Phaseolus carteri L.* *Phaseolus filiformis L.* *Phaseolus vulgaris L.* *P. lunatus L.* *Phaseolus parvifolius L.* *Phaseolus phaseoli L.* *Phaseolus coccinei L.*	Muñoz et al. (2006)
SSR	140	*P. parvifolius* *P. acutifolius var. acutifolius* (wild) *P. acutifolius var. tenuifolius* *P. acutifolius var. acutifolius* (domesticated)	Blair et al. (2012)
SNPs	116	*P. acutifolius var. acutifolius* (domesticated) *P. acutifolius var. acutifolius* (wild) *P.acutifolius var. tenuifolius* *P.acutifolius var. latifolius* *P. parvifolius*	Gujaria-Verma et al. (2016)
Morphological	9	*P. acutifolius var. acutifolius* (domesticated)	Molosiwa et al. (2014)

AFLP = Amplified Fragment Length Polymorphism, SSR = Simple sequence repeats, SNPs = Single nucleotide polymorphism.

tepary genome has been introgressed into common bean (Muñoz et al., 2004). Tepary bean is part of the tertiary genepool of common bean and the two species can be crossed using the congruity backcross method which results in efficient introgression of genes (Mejía-Jiménez et al., 1994; Muñoz et al., 2004; Souter et al., 2017). As a result, there is a renewed interest in using tepary bean genetic resources for breeding and for interspecific hybridization to transfer biotic and abiotic stress tolerance to common bean (Souter et al., 2017). The objective of this review is to highlight progress made on tepary bean breeding and genetic analysis. The review discussed the potential of available genetic and genomic resources for accelerated breeding and genetic improvement of tepary bean for enhanced resistance to biotic and abiotic stress tolerance. Finally, the paper discusses potential research focus areas that should be integrated for effective utilization of tepary bean genetic resources for accelerated breeding and sustainable production.

2. Tepary bean origin, domestication and genetic diversity

Tepary bean is thought to have originated from the Mexican states of Jalisco and the Sonoran desert region of Sinaloa where wild tepary accessions with similar features to the domesticated types were found (Garvin and Weeden, 1994; Freytag and Debouck, 2002; Blair et al., 2012). Domestication of tepary bean is thought to have occurred about 5000 years ago in arid and semi-arid regions of north-western Mexico and south-western United States (Blair et al., 2002; Garvin and Weeden, 1994). Archeological evidences suggested that early domestication took place in Hohokam, New Mexico and Tehuacan in Central Mexico (Kaplan, 1967; Kaplan and Lynch, 1999). Historically, tepary bean cultivation stretched from the southwestern United States (Arizona, Colorado and New Mexico) to Mexico, Guatemala and Nicaragua (Pratt and Nabhan, 1988).

Four botanical varieties (var.) of tepary bean are recognized including var. acutifolius (wild and domesticated), var. latifolius and var. tenuifolius (Buhrow, 1983; Blair et al., 2012; Gujaria-Verma et al., 2016). The domesticated tepary bean is under-utilized and under-researched crop and is mostly cultivated using unimproved landraces or wild accessions (Debouck, 1991; Schinkel and Gepts, 1988). Tepary bean has potential to be a future food security crop and may play a prominent role in increasing food availability, especially protein uptake (Taggart et al., 1983; Thomas et al., 1983; Amarteifio and Moholo, 1998). Tepary bean has a similar nutritional profile (e.g. mineral elements, amino acids and soluble sugars) and flavour compared to common bean (Pratt and Nabhan, 1988; Porch et al., 2017) making it suitable for human consumption (Benitez et al., 1994; Miklas et al., 1994). Due to its high protein content, and resistance to biotic and abiotic stress factors, tepary bean is also regarded as a suitable legume crop for cultivation by resource-poor farmers (Taggart et al., 1983; Nabhan and Felger, 1978; Bhardwaj et al., 2002).

Despite its potential significance, tepary bean has received limited research priority towards genetic improvement and, as a result, a very limited number of improved varieties have been released so far for cultivation. This can perhaps be attributed to the low consumption worldwide (Bhardwaj et al., 2002; Shi et al., 2011; 2012; Porch et al., 2013). Tepary been production can be enhanced through development of superior and high-yielding genotypes with enhanced resistance to abiotic and biotic stresses and improved nutritional quality. Genetic diversity within this crop and its closely related species needs to be explored to unravel novel genetic variation which may be exploited for breeding (Porch et al., 2013).

3. Genetic and genomic resources for tepary bean breeding

Tepary bean genetic resources are held at various institutions globally. The United States of America Department of Agriculture (USDA) (The Western Regional Plant Introduction Station, Pullman, WA) currently holds 204 *P. acutifolius* accessions of which 58 and 148 belong to var. *tenuifolius* and *acutifolius*, respectively (https://npgsweb.ars-grin.gov/gringlobal/search.aspx; Dr. Khisha Theodore, personal communication). The Genetic Resources Unit of the International Center for Tropical Agriculture (CIAT) holds about 326 domesticated tepary bean (*P. acutifolius* var. *acutifolius*) accessions and 20 accessions of *P. acutifolius* var. *parvifolius* (http://genebank.ciat.cgiar.org/genebank). The Virginia State University in the USA currently maintains 35 accessions of tepary which were selected to be drought-tolerant from

Download English Version:

https://daneshyari.com/en/article/8892559

Download Persian Version:

https://daneshyari.com/article/8892559

Daneshyari.com