Chapter 4

Morpho-Agronomic Variation among *Phaseolus vulgaris* Landraces: A Review

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Additional information is available at the end of the chapter

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Abstract

Phaseolus vulgaris L. of the family Fabaceae is widely grown for essential nutrients in its edible leaves, immature pods, and mature seeds. Landraces are local crops with wide morphological and genetic diversity. Morpho-agronomically, *P. vulgaris* landraces vary exceptionally in their vegetative and reproductive traits. These landraces vary in their germination rate and final percentage. Their growth form varies from bushy to vining type. Flowers range in their time to flowering, color, and size. Pods also vary widely in their time to pod formation; pod size, color, and shape; number of pods per plant; and time to pod maturity. Seeds also vary in their size, shape, color, and mass, as well as their number per pod and per plant. These landraces also vary in their resistance to pests and diseases from seed germination, plant growth and yield, and seed storage duration. A review on variation among *P. vulgaris* landraces forms basis for their future breeding as they are a good source of genetic diversity. This enables a possible selection for leaf, pod, and seed consumption, as well as resistance toward pests and diseases during the entire growth.

Keywords: *Phaseolus vulgaris*, traits, variability, landraces, morpho-agronomic

1. Introduction

Phaseolus vulgaris L. known as common bean is a member of the family Fabaceae [1]. It is an annual leguminous crop grown for its nutritional leaves, tender pods, and dry seeds [2]. It is a warm season legume crop and is self-pollinating with low frequency of crossing [3]. *P. vulgaris* provides protein and calories [4] as well as micronutrients such as zinc (Zn) and iron (Fe), essential vitamins, dietary fiber, and fat [5]. It is also an important legume which contains antioxidants [6, 7] and other chemically diverse components which fight against many diseases [8].

A landrace is defined as a crop with wide genetic diversity, which is usually identifiable, is known locally, has a local name, and has not undergone the proper crop improvement [4].

Landraces of *P. vulgaris* show a wide range of variation in their vegetative and reproductive traits [5]. The germination percentage among common bean cultivars ranges from 89 to 94% [9]. *P. vulgaris* landraces either show bushy, determinate, or indeterminate climbing growth form [10]. The number of branches among *P. vulgaris* landraces ranges from 17 to 57, and the number of leaves ranges from 19 to 37 [1]. Furthermore, days to flowering ranges from 26 to 40 days after sowing in *P. vulgaris* cultivars [9]. Some *P. vulgaris* landraces show white flower color, while others lilac [10]. *P. vulgaris* landraces have green and yellow mottling color of immature and matured pods, respectively [11]. Seed colors vary from black, brown, cream, green, mix red and white around the hilum, purple, and white to white/mottled [10, 12]. Pod color varies from pure green to green with purple or carmine stripes [11]. Pod length varies from 67.4 to 163.4 mm [13]. The number of pods per plant among *P. vulgaris* cultivars ranges from 5.4 to 9.9, while the number of seeds per pod ranges from 2.9 to 4.4 [9]. Seed length also ranges from 10.0 to 16.7 mm, width from 6.1 cm to 9.8 mm, and height from 4.2 to 8.2 mm [14]. Studies on the variation among *P. vulgaris* landraces are essential to select the desired traits for future breeding.

2. Taxonomy, uses, and variation among *Phaseolus vulgaris* landraces

2.1. Taxonomy, origin, and distribution of *Phaseolus vulgaris*

P. vulgaris L. belongs to subclass Rosidae, order Fabales, family Fabaceae, and subfamily Papilionoidea [5]. It is commonly known as the common bean [1], French bean, garden bean, kidney bean, snap bean, or string bean [15]. The genus *Phaseolus* contains more than 150 species [1], where the major domesticated species are *Phaseolus acutifolius* A. Gray, *P. coccineus* L., *P. lunatus* L., *P. polyanthus* Greenman, as well as *P. vulgaris* L [16]. *P. vulgaris* is the third important legume crop grown worldwide, after soya beans (*Glycine max* L.) and peanut (*Arachis hypogea* L.) [17].

Common beans are mostly annual, while others are short-lived perennial. They are cultivated in the warm climatic regions especially in tropical, semitropical, and temperate regions [18]. *P. vulgaris* is predominantly self-pollinating species with low average of cross-pollinating rate (3%) [3]. *P. vulgaris* is cultivated under various conditions in all continents and countries [19]. It is grown in a variety of soil types rich in organic matter, light loamy, sandy loam, well-drained soils with range pH of 5.7 and 7.0 neutral [20]. Fall, summer, and spring are seasons suitable for good crop production of *P. vulgaris* with optimum growth temperature ranges from 16 to 30°C [1].

P. vulgaris is native to Central and Southern America, where the world biodiversity hotspots of *P. vulgaris* are South-Central Mexico [19]. It was introduced to Africa and worldwide by Spaniards and Portuguese [2]. The African countries that are major producers of *P. vulgaris* are Burundi, Democratic Republic of Congo, Ethiopia, Kenya, Malawi, Rwanda, South Africa, Tanzania, and Uganda [20].

2.2. Uses of *P. vulgaris*

P. vulgaris is considered as a basic crop in many developing countries due to its high content of protein, micronutrients, vitamins, minerals, fiber, and carbohydrates [21]. It also serves as a

source of iron and thus is consumed as a meat substitute [7]. In some varieties, green immature pods are cooked as vegetable, while mature seeds are cooked and consumed for their high nutrient content [21]. The consumption of *P. vulgaris* is higher among both rural and urban societies with low income [20].

The consumption of common bean has health benefits by decreasing and preventing the glucose and cholesterol level [21, 22]. It also prevents stress and cancer and decreases heart diseases and obesity [8, 21]. It consists of enzyme inhibitors as well as compounds such as phenolic, phytates, and lectins, which help in metabolic functions in animal and human body systems [6].

However, *P. vulgaris* also has some problems due to the presence of certain anti-nutritional compounds such as saponins, flatulence factors, lectins, and phytic acid, and it also needs prolonged cooking [21, 22]. *P. vulgaris* fixes nitrogen to the soil through rhizobia by nitrogen-fixing bacteria [23].

2.3. Landraces and their uses

Landraces are crops with wide genetic diversity, which are usually identifiable, are known locally, and have not undergone the proper crop improvement [4]. Landraces are categorized into primary and secondary landraces [24]. Primary landraces contain their original and uncontaminated traits, whereas secondary (improved) landraces consist of foreign material that was incorporated into them through partial breeding [24]. Secondary landrace may change back to primary landrace after sometime [24]. An autochthonous landrace is a variety which is native and grown for a long period of time in a certain environment within a particular agricultural system [25]. It has specialized traits that allow biotic and abiotic stress conditions to increase and stabilize their yield [25]. Allochthonous landraces are varieties which are taken from other regions and introduced (grown) in another region and then allowed to adapt to that new region [24]. Landraces are naturally selected and are also characterized by the lack of formal genetic improvement [26].

Landraces play a significant role in agricultural production ensuring quality and well-managed crops [26]. They are varieties that have genotypes with wide specific traits [27]. These traits are adaptive to a specific environment and produces well-improved genotype, reduces the vulnerability, resistance to pests and diseases [27]. Landraces serve as a source of genetic diversity, and plant breeders often use specific traits to create new variation and maximize genetic diversity [12]. It also plays important role in ensuring food security [26]. Landraces result in high to intermediated yield, which is also stable under a low-input agricultural system in small-scale farmers [24, 27, 28]. They are a unique source of special traits which have marginal environment tolerance and nutritional quality [26]. The basis of diversity in landraces is genetic heterogeneity [29].

Common bean landraces have advantages of adaptation to cultural practices and local climatic conditions, resistance or tolerance to diseases, and early or late seed maturation, resulting high to intermediate yields under low inputs [10]. In eastern and southern Africa, farmers grow *P. vulgaris* landraces as genetic resources to be used for breeding programs [11]. *P. vulgaris*

landraces result to higher variation within the population [10]. Landraces are also much appreciated for their taste, high nutritional value, and short cooking time [28].

2.4. Germination percentage

The higher germination percentage of seed depends on the availability of environmental factors, like adequate temperature, light, salinity, moisture, and water [30]. The germination stage is the most important stage in the crop survival, which is to determine the amount of water and nutrient resources that need to be applied [31]. In Mexico the germination percentage ranges from 58.27 to 73.51% among the *P. vulgaris* landraces [31]. *P. vulgaris* landraces from Uganda show uniformity in seed germination, where after 5 days of planting all genotypes emerge from the soil [11].

2.5. Growth form, plant height, and number of branches and leaves

P. vulgaris differed in their growth habits which may be climbing or semiclimbing, erect or even bush type [1]. Their growth habit can either be determinate or indeterminate [17]. These growth habits are classified into four major classes, namely, Type 1 has determinate, upright, and bushy habit; Type 2 has indeterminate, upright, and bushy habit; Type 3 has indeterminate, prostrate with no climbing or semiclimbing, habit; and Type 4 has indeterminate and strong climbing habit [17].

The plant height of Brazilian *P. vulgaris* landraces ranges from 338 to 988 mm [27]. According to Stoilova et al. [32], plant height of landraces from Portugal and Bulgaria ranges from 195 to 1234 mm with the average of 447 mm. However, Sozen et al. [33] record plant height among Turkey landraces ranging from 200 and 3100 mm. The plant height shows wide variability among the landraces in Madeira where climbing landraces have a variation from 1086 to 1441 mm and bushy from 138 to 382 mm [5].

P. vulgaris landraces from Portugal and Bulgaria with climbing growth form have the numerous branches than bushy type [10]. The number of shoots in the main stem shows variation, with a range either from 4 to 14 among the landraces in Uganda [11] or from 17 to 57 in Nigeria [1]. The number of leaves per plant varies with a range from 45 to 96 leaves among *P. acutifolius* landraces in Botswana [34].

2.6. Days to first flower formation and flower color

Days to flowering also vary among *P. vulgaris* landraces, which generally commences from 26 to 51 days after planting in Portugal and Bulgaria landraces [10], Honduras [35], and Uganda [11]. However, a variation in days to flowering from 35 to 75 days after sowing is evident among landraces from Mexico [32]. The color of the flowers among *P. vulgaris* landraces can be white, carmine, red, purple, pink, white with lilac edges, or white with red stripes [11, 32].

2.7. Color, shape, number, and size of pods

The color of immature pods in Uganda *P. vulgaris* landraces is pure green; green with purple, carmine, or red stripes; dark purple; carmine, red, or pink, whereas physiologically matured

pods are yellow, yellow mottling, red, pink, or dark purple in color [11]. Pod shape varies from straight to slightly curved to fully curved [35]. In Portugal and Bulgaria, Stoilova et al. [10] reported a number of pods per plant as ranging from 6.4 to 20.8 among landraces. In Greece, the number of pod per plant shows wide variation between the local landraces and commercial cultivars. The numbers of pod per plant ranges from 21.5 to 51.3, among local landraces, and from 20.4 to 28.4 among cultivars [36]. The number of pods per plant ranges from 6.3 to 18.1 among *P. vulgaris* landraces from Brazil [27]. Turkey landraces have a number of pods per plant ranging from 1 and 163 [33]. The number of pods among landraces from Chrisoupoli and Nakolets in Greece ranges from 51.8 to 101.1, respectively [37]. Pod length shows wide variation among *P. vulgaris* landraces, with a range from 89 to 129 mm in Portugal and Bulgaria [10], from 123 to 309 mm in Island of Madeira [5], and from 40 to 120 mm in Uganda [11]. *P. vulgaris* landraces also show variation in yield parameters, where the number of pods per plant varies from 20.5 to 51.3 [36]. Pod length varies from 67.4 to 163.4 mm [13].

2.8. Color, shape, number, and size of seeds as well as seed maturity

Genetic variability in *P. vulgaris* landraces is sometimes indicated by seed color, size, and shape (**Figure 1**) [28, 38]. Shininess of seeds can either be shiny, intermediate, or opaque [39]. There is a wide variation in both seed coat main and secondary colors. Seed coat main color can be brown, cream, red, white, or yellow, while the secondary color can be black, red, or violet on the entire grain [28, 40]. White grain seed is commonly used by commercial farmers [41]. Seed shape can be round (circular), oval, kidney, hook, truncate, as well as cuboid (rectangular) shape [12, 40].

The number of seeds per pod among the *P. vulgaris* landraces has comparable ranges from 4.96 to 5.01 in Greece [37], from 2.8 to 6.6 in Italy [13], and from 3.60 to 5.53 in Zimbabwe [42]. Landraces from Italy that are categorized into traditional and nontraditional agro-food products vary from 3.2 to 6.3 and from 3.0 to 4.9 seeds per pod, respectively [43].

Seed size varies widely among *P. vulgaris* landraces. In Kosovo, seed length has a range of 12.8–18.3 mm, width 7.4–10.1 mm, and thickness 4.6–6.9 mm [44]. In Turkey, seed length has a variation of 11.8–23.1 mm, width 5.8–15.4 mm, and thickness 0.7–10.0 mm [38]. Seed length also ranges from 10.0 to 16.7 mm, from width 6.1 cm to 9.8 mm, and thickness from 4.2 to 8.2 mm, in Iran [14]. Consumers normally favor medium-sized to large-sized seeds probably because of their mass, taste, and easiness in hydration when cooked [45]. Seeds have certain properties such as early or late maturity, as some physiological maturity ranges from 65 to 120 days [10, 46].

2.9. Plant resistance to diseases and pests

In Tanzania, the screening of different *P. vulgaris* landraces and released varieties against *Phaeoisariopsis griseola* (Sacc) [Ferr], which causes angular leaf spot disease, shows that landraces were resistant, while varieties were either intermediate resistant or susceptible to this disease [20]. This suggests the presence of resistant genes on these landraces toward the *P. griseola*. The response of *P. vulgaris* parental lines to infestation by bean fly (*Ophiomyia phaseoli*) ranges from susceptible to resistant in Kenya [47].

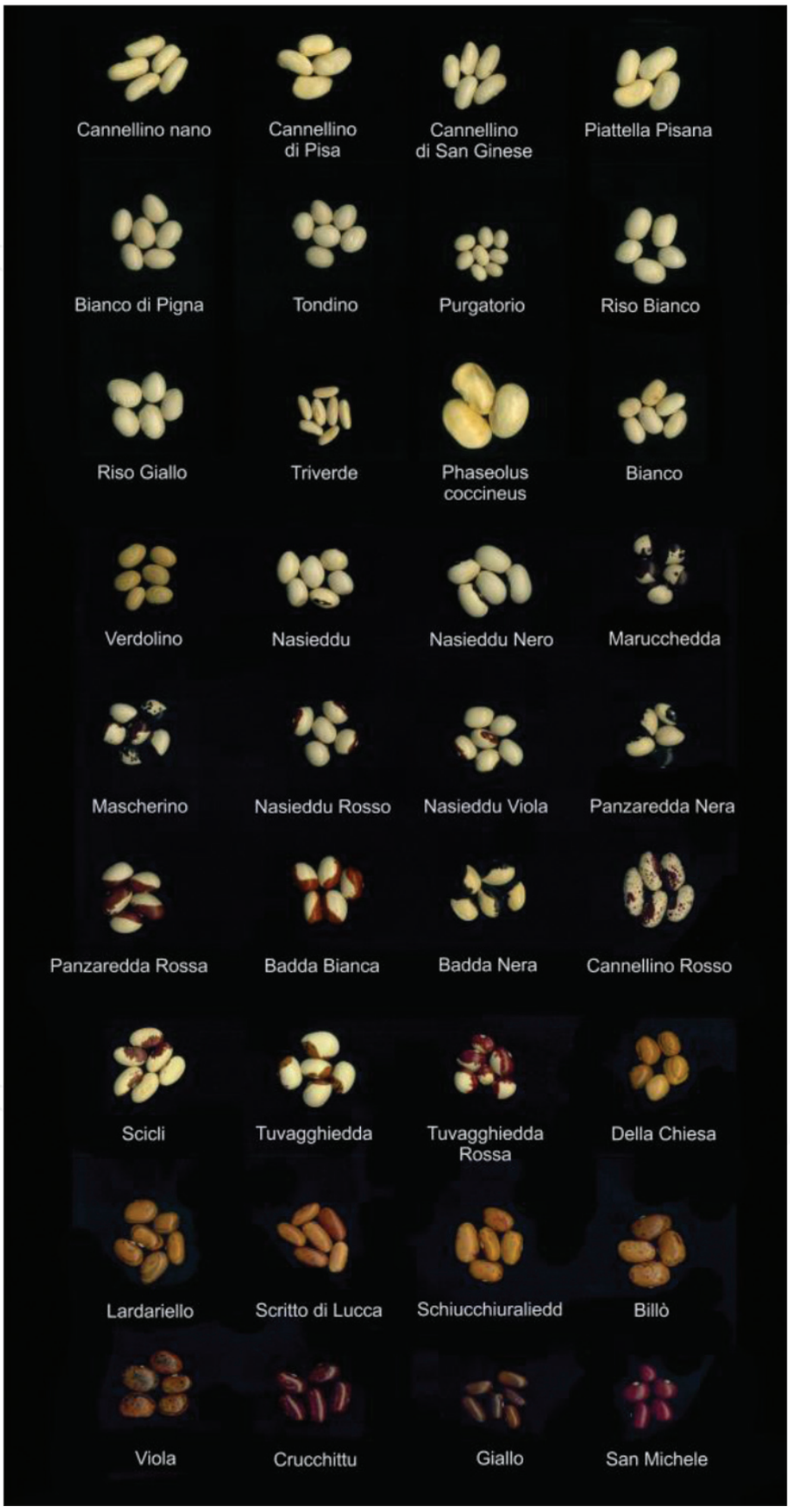

Figure 1. Variation in shape, size, and color of some Italian *P. vulgaris* landraces [28].

3. Conclusion

A wide variation in growth and yield of *P. vulgaris* landraces discussed in this review will enable a possible breeding selection for leaf consumption based on bigger and soft-textured leaves. A selection for green beans can be on pod size, texture, and yield. Further, selection for dry beans can be based on seed yield, size, taste, and cooking time, to name a few. Breeding for resistance toward pests and diseases can be enhanced on landraces with resistant genes.

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