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Cultivation and Breeding Activities of Cowpea: A Turkish Perspective

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Abstract

Cowpea syn long bean and Turkish vernacular name Börülce (*Vigna unguiculata* L) is an economically valuable crop plant in the dry and drought-hit resource-poor agricultural system of West Africa, where it is used as a vegetable, dry edible legume, salad, and soup. Green leaves can be used as feed. With the passage of time, the cowpea was introduced and naturalized in other parts of the World. It is grown in Turkey in the Aegean and Marmara regions. It can grow in drought-hit sandy areas, where most significant crops fail to emerge and grow. It is highly efficient to fix atmospheric nitrogen and improve soil fertility levels. However, very limited breeding, research, and development work are done on cowpea at the Aegean Research Institute Izmir and some Universities selectively. Therefore, yields are low to intermediate compared to yields in other parts of the world. Thus, promoting and breeding cowpea to address the crop's food, feed, and nutritional requirements will ensure food security.

Keywords: Long bean, improvement, nutrition values, physical characteristics, nutritional makeup

1. Introduction

Cowpea (*Vigna unguiculata* L.), an annual legume of the Fabaceae family, is highly tolerant to water scarcity, drought stress, high temperature, and biotic stresses (Kır et al., 2017; Carvalho et al., 2017; Carvalho et al., 2019). It is grown throughout tropical, subtropical, and temperate regions (Timko et al., 2007; Omomowo and Babalola, 2021). Cowpea grows at 15 -30°C on well-drained loamy, sandy loam, or slightly heavy soils. In addition, cowpea can fix atmospheric N and improve soil fertility (Makinde and Abolarin, 2020).

Its origin is in Central Africa and was introduced from where it was introduced in West Africa about 2000 to 3500 years ago (Allen, 1983; Gómez, 2003; Rerkasem et al., 2009; Crowther et al., 2016; Santos et al., 2019). First, it was naturalized in Europe and North Africa in the 17th century ACE. Next, the Spanish took the crop to the West Indies. Finally, the slave trade introduced the crop to Southern USA in the 18th century. According to the Food and Agriculture Organization Corporate Statistical Database, African countries provide 96.7% of cowpea production worldwide, and Nigeria comes first with 3.6 million tons in production (Osipitan et al., 2021). It is cultivated on 871 thousand hectares in Turkiye, with total dry legume production of 1.3 million tons, and the share of cowpea is 0.2% (Osipitan et al, 2021).

General characteristics of cowpea

Cowpea is a highly nutritious nutraceutical grain legume crop that is commonly called a long bean, southern pea, black-eyed pea (English), چھوٹا لوبیا *chota lobia* (Pakistan), fagiolo dall'occhio (Italian), caupí (Spanish), niebe (French), börülce (Turkish), لوبیا چشم بلبلی or *lobia chasmi bulbul* (Iran). Old varieties of cowpea have a climbing annual growth habit. However, the newly developed cultivars are erect with alternately arranged trifoliate leaves on ribbed stems (Praneetha et al., 2022). The plant produces 2 - 3 flowers and about 35 cm long cylindrical, curved, or smooth seed pods on each peduncle (Praneetha et al., 2022). The seed pods are the mature pods that are tan to brown containing cream, black-eyed white, or mottled colors. Cowpea grows to about 80 cm in height as an annual plant (Jain et al., 2019). They are grown as winter or spring season crops (Garrett, 2004). The moisture content ranges from 6 to 13.4%, which depends on the time of harvest, conditions during storage, and relative humidity (Odjo et al., 2022). The seed coat color (white, cream, brown, black, etc.) and kernel weight influence their cooking quality (Summerfield et al., 1974; Omueti and Singh, 1987) and also influence the quality of composite cowpea flour (Dankwa et al., 2021). Henshaw (2008) has classified cowpea varieties based on 100-kernel weight as small (10-15 g), medium (15.1-20 g), large (20.1-25 g), and giant (>25 g) seeds. Seed size also affects their cooking capability (Mannur et al., 2018), based on varietal characteristics (Yeung et al., 2009). The varieties with more than 100 g seed weight of >17 g mature earlier than medium-sized cultivars (Devi, 2012; Viera et al., 1989). These may be attributed to variances in genetic traits (Chinma et al., 2008; Devi, 2012). Grain hardness is genotypic and is affected by moisture contents, climate, soil type, depot conditions, temperature, time of harvest and maturity, harvesting, and seed size. (Sefa-Dedeh *et al.* 1978).

Nutritional composition of cowpea

Cowpea is rich in protein, carbohydrates, mineral elements, and vitamins that make them an essential nutritional crop plant in the human diet (Jayathilake et al., 2018; Mekonnen et al., 2022). Kır et al. (2017) noted rich protein, dietary fiber, zinc, potassium, and iron on dry grains of cowpea landraces taken from local markets of Aydın and Muğla, in Turkiye.

Cowpea seeds have a protein range of 19.96-33 g percent depending on the growing season, geographical location, environmental factors (Sathe et al., 1984), day length, and genotypes (Ddamulira et al., 2015), starch contents of the mature seeds (Omueti and Singh, 1987). Protein digestibility could vary depending on genotype in the range of 73-77.9% (Carvalho et al., 2012; Phillips and Adams, 1983; Marconi et al., 1990), depending on extruded and raw flour as 79.9% and 74.1% (Tuan and Phillips, 1999; Affrifah et al., 2022). Protein is an essential ingredient of cowpea that can play a significant role in the nutritional security of underprivileged people to alleviate the problems of protein-calorie-based malnutrition.

Khalid and Elharadallou (2013) noted that one of the main components of the whole (WCF) and dehulled defatted (DDCF) cowpea seed flour is composed of 59-60% carbohydrates. The high carbohydrate was noted in some varieties of cowpea growing in Swaziland with a range of 45.64-57.12% (Gondwe et al., 2019).

Variable concentrations of minerals have been reported in cowpeas seeds by various authors. These concentrations are affected by the genotypes, culture methods, extraction techniques, environmental conditions, etc. Total ash or total mineral contents vary (2.0-4.59 g) depending on the genotype (Mamiro et al., 2011) or 3.47-6.84% depending on varieties (Gondwe et al., 2019). Cowpea's essential minerals include phosphorus (4250 mg kg^{-1}), zinc (34 mg kg^{-1}), iron (83 mg kg^{-1}), potassium (11100 mg kg^{-1}), sodium (162 mg kg^{-1}), magnesium (1840 mg kg^{-1}), copper (8 mg kg^{-1}), and calcium (1100 mg kg^{-1}) (Farinu and Ingrao, 1991). Kır et al. (2017) noted that dried grain cowpea's mineral contents are higher than fresh pods.

Cowpea seeds also contain vitamin A, niacin, riboflavin, folic acid, thiamin, and carotene and contribute to B-vitamin intake (Garreana et al., 1996; Sarkar et al., 2022). Kır et al. (2017) detected vitamin C and alpha-tocopherol in fresh pods.

Anti-nutrient factors in cowpea induce low digestibility due to the presence of tannin to 13.5 mg per100 g in the wild, 0.5 g per 100 g in cultivated genotypes (Marconi et al., 1990), and 0.42 to 0.66 per 100 g dry matter causing abdominal upsets (Ologhobo and Fetuga, 1983). In addition, it has been observed that extrusion cooking ends up in gelatinizing starch and denaturing protein, along with the inactivation of food enzymes causing rapid food deterioration with a reduced shelf life of the cooked material during storage, destroying trypsin inhibitors by reducing microbial counts in the end product (Harper, 1981).

Its seeds are fibers with a crude fiber range of 1.7-19.46 g per 100 g (Kay, 1979; Enyiukwu et al., 2018). Fresh fast-growing twigs and leaves with minimum fiber contents cellulose are often plucked to make a stew-like spinach and salad (Bressani, 1985), improving the nutritional quality of starchy diets (Singh et al., 1997).

Cowpea seeds are low in fat, about 1% fat (Jayathilake et al., 2018). Kır et al. (2017) noted a high dried grain of cowpea compared to fresh pods.

Dietary effects on health

Dry cowpea grains or leaves are used in human consumption. The leaves can be consumed fresh or dried (Ahenkora et al., 1998). It is mainly used as a vegetable in stews, salads, and grains, making stews and soups from its flour making salty snacks or boiling by rural and urban households in varieties of forms all over the World (Ünlü and Padem, 2004; Yıldız, 2017; Kır et al., 2017). Its green foliage can be an essential feed source for cattle and livestock. Therefore, there is a need to develop novel methods to use this plant in human diet. Some researchers suggest its use as a functional food and making of *akara, helva*, and thin crispy spiced paper bread called paparh (Bhagirathi et al., 1992), dosa bread, and Pakorhas (dumplings) of South India and Pakistan, or Brazilian Tutic.

Many researchers have mentioned that cowpea consumption has various protective effects against the development of obesity, hypercholesterolemia, cardiovascular diseases (Frota et al., 2008), diabetes gastrointestinal disorders (Trehan et al., 2015), and some types of cancer (Chon, 2013). At the same time, the literature also describes components with unsaturated fatty acids, phytochemicals, resistant starch, dietary fiber, and low-fat content in cowpea, which contribute to weight loss, improve digestion and strengthen blood circulation (Oboh and Agu, 2010; Trehan et al., 2015; Perera et al., 2016).

Cowpea in Türkiye

Cowpeas are widely grown in the Aegean and Mediterranean Regions (80%) (Gündüz et al., 2015). It is cultivated in Isparta, Manisa, Muğla, Denizli, İzmir, Çanakkale, and Balıkesir. The cowpea is also grown in the Mediterranean region, especially in Antalya and Hatay (Aasim, 2010). *Vigna unguiculata* (L.) Walp., *Vigna unguiculata* subsp. *sesquipedalian* (L.) Verdcourt, *Vigna unguiculata* subsp. *unguiculata* (L.) Walp. are commonly found in Turkey (Tubives, 2022; Vural, 2013).

Cowpeas as edible legumes

Turkey's two groups of certified and registered cowpea varieties are dry and fresh edible legumes. (Table 1).

Table 1. Registered varieties of cowpea *Vigna unguiculata* (TTSM, 2022)

Variety	Maintainer Universities or organisations	Registration date	Registration extention date
Sırma (dry)	Ondokuz Mayıs University, Agriculture Faculty	13.04.2010	31.12.2020
Amazon (dry)	Ondokuz Mayıs University, Agriculture Faculty	13.04.2010	31.12.2020
Akkız 86 (dry)	Çoker Tohumculuk Tarım Gıda Bahçe Kültürleri İnş. İth. İhr. San. Ve Tic. Ltd. Şti	16.04.1986	11.03.2022
Karagöz (dry)	Çoker Tohumculuk Tarım Gıda Bahçe Kültürleri İnş. İth. İhr. San. Ve Tic. Ltd. Şti	16.04.1986	11.03.2022
Poyraz (fresh)	Biotek Toh. Tarım Ürünleri San.Vetic.Ltd.Şti.	15.02.2006	-
Sarıgelin (fresh)	İstanbul Tohumculuk Tar. San. Ve Tic. Ltd. Şti.	21.02.2007	-
Şimal (fresh)	Paşa Tohumculuk San. Ve Tic. Ltd. Şti.	2.11.2017	-
Karnıkara (fresh)	Paşa Tohumculuk San. Ve Tic. Ltd. Şti.	2.11.2017	-
Endaze (fresh)	Çoker Tohumculuk Tarım Gıda Bahçe Kültürleri İnş. İth. İhr. San. Ve Tic. Ltd. Şti	26.02.2020	-

TTSM (Tohumluk Tescil ve Sertifikasyon Merkez - Variety Registration and Seed Certification Center)

Pekşen (2013) reported Pekşen and Reyhan cowpea cultivars that could be cultivated as vegetables. Pekşen and Reyhan varieties were registered as the first vegetable cowpea cultivars in Turkey on April 15, 2011, by VRSCC (Variety Registration and Seed Certification Center, Turkey).

It is informed that the high amount and frequency of cowpea consumption in the Aegean Region is 6.3 kg year^{-1} with the cooking frequency of 1-2 times per week (Kır et al. 2017). It is consumed as green pods, fresh and dried cowpea grains, or as salads and mixed soups like Tarhana soup.

Cowpeas as a forage crops

Some research has been conducted on the potential of cowpea as a forage crop using registered cowpea varieties in Turkiye. Ayan et al. (2012) studied two released varieties (Akkiz, Karagoz) and seven cowpea genotypes for their forage potential at Samsun and Kavak. They have mentioned its use as forage based on yield and quality. Beycioğlu and İdikut (2017) emphasized the potential of Karnıkara cowpea as feed due to forage yield and its nutritive value under Kahramanmaraş condition to find variance due to inter and intrarow effects.

Research study in Türkiye

A review of literature from the National Thesis Centre (Ulusal Tez Merkezi) during 2023 suggests the award of 69 MSc and 8 Ph.D. degrees to students in different universities of Turkey. The main topics undertaken for the studies (Anonymous 2022).

The main topics of the study are as follows:

Soil science, agronomy, and breeding

The thesis studied genetic, morphologic characterization, e.g., Zn deficiency, Phenotypic characterization, feed, ecologic adaptation, boron and iron, intercropping, Magnesium deficiency, storage, fertilizer treatments, and molecular characterization.

Plant protection

The insects of cowpea are undertaken in the studies with a primary focus on bruchus, e.g., weevil, Callosobruchus maculates, to hum böceği (*Callosobruchus maculatus* F.)

Food technology

Topics related to phenolic compounds, protein digestibility, cowpea flour, and different quality parameters are undertaken.

Some cowpea agronomic and breeding studies in Türkiye

Some researchers at Ondokuz Mayıs University, Samsun, studied cowpea breeding. These theses have reported cultivation of var. Kavak in Samsun province (Basaran et al. 2011), Akkız, Karagöz, and 14 lines (Bozoğlu et al., 2016),–BC-38 (cv. Karnıkara – Balıkesir), and two exotic cultivars BC-23 (Northern Cyprus), BC-31 (Kirkuk, Iraq) (Bozokalfa et al., 2017), based on quantitative and qualitative traits.

Agronomy and breeding studies are critical to solve food issues. Conventional breeding is also linked to agronomic properties. Therefore, conventional and biotechnology approaches are needed to improve the agronomic characteristics of cowpea for use as food or feed crops.

These studies have reported both agronomic and breeding studies. Pekşen et al. (2000) conducted the integrated studies on the seed coat ratio of 18 Turkish and three exotic cowpeas with the conclusion of inverse correlation of germination percentage to the first and final count day.

Pekşen and Artık (2004) investigated the growth parameters of 6 genotypes of cowpeas with two registered cowpea Akkız and Karagöz. It is recommended genotype of the Doğanca location for potential cowpea genotypes to its high seed yield compared to others. Another study by Pekşen (2004) using identical genotypes with two addition genotypes (G10 and G18) showed that G10 has the highest value in phenological and morphological characteristics. It is also noted in a previous study that G10 recommend as a potential genotype due to its green pod yield under controlled conditions (Peksen et al., 2000). The leaf characteristics were also observed in the mentioned genotypes (Peksen et al., 2005). Peksen (2007) and Pekşen et al. (2014) tested the endurance of Karagöz and Akkız cowpeas to water under irrigated and rainfed conditions and both of Karagöz and Akkız growth parameters affected by water deficit as a rainfed condition. However, Karagöz was more adaptable to water deficit compared to Akkız. Pekşen and Pekşen (2012) encouraged the Pekşen and Reyhan cowpea cultivars could be cultivated as a vegetable due to their edible pod features.

Basaran et al. (2011) observed growth parameters of two registered varieties of cowpea (Akkız and Karagöz) and seven cowpea landraces in Samsun and Kavak with the highest yielding of Karagoz and followed by all landraces and Akkız.

Kır et al. (2015) noted high variation in 102 landrace accessions from Turkey's Aegean and Mediterranean regions due to 48 qualitative and quantitative agro-morphological characteristics.

Bozoğlu et al. (2016) conducted a study on two registered varieties of cowpea, Karagöz, an adaptable species which had black hilum, and Akkız, a resistant species which had white hilum, and 14 lines of local cowpea with a recommended lines Genotype 4 which had black hilum and Genotype 13 which had brown hilum due to their seed yield, plant height, and biological yield values.

Bozokalfa et al. (2017) evaluated the genetic diversity of 29 genotypes of the southwest, the Aegean, and Marmara regions with a cultivar BC-38 (cv.

Karnıkara - Balıkesir), and two foreign cultivars BC-23 (Northern Cyprus), BC-31 (Kirkuk, Iraq) based on quantitative and qualitative traits of geomorphological characteristics. The previous study by Peksen and Peksen (2013) also investigated the argomorphological of Peksen and Reyhan cultivars.

Karaman (2022) studied two released varieties (Amazon and Sırma) and five local varieties from a different region (Adana, İzmir, Mersin, Mersin/ Mut, and İsparta), and it had been recommended that local varieties of Adana and İzmir for breeding purposes due to high yield under İsparta conditions.

***In vitro* micropropagation, tissue culture, and genetic transformation**

Very little literature about genetic transformation is available on this subject, described briefly in the following lines. Some *in vitro* studies under tissue culture were conducted by Aasim et al. (2008).

Aasim et al. (2008) induced multiple shoots from shoot meristems of three - five-day-old *in vitro* grown seedlings taken from Turkish local cowpea cv. Akkiz using MS medium having 0.50 mg^{-1}BAP. A maximum of 2.60 shoot counts per explant was obtained on MS culture medium without NAA. Rooting was achieved on MS medium containing 0.50 mg L^{-1} IBA. Seven adventitious secondary shoots also arose from the base of mother shoots during rooting.

Aasim et al. (2009a), the authors have also compared the efficiency of agar and gelrite on micro shoot regeneration in cowpea. Both cultivars showed maximum shoot regeneration on gelrite with 4.72 and 2.86 shoot counts per explant on MS culture medium having 0.25 mg L^{-1} thidiazuron using in cv. Akkiz and cv. Karagoz respectively. Agar gelled medium had greater shoot length than gelrite medium in both cultivars. They compared the effects of agar and gelrite on micropropagation from the shoot tip explant of two Turkish cowpea cultivars, Akkiz and Karagoz, using TDZ. The authors have compared different combinations of BAP-NAA and Thidiazuron for shoot regeneration. They have rooted their regenerated shoots on IBA or NAA containing half or full-strength MS medium.

Aasim et al. (2009b) induced multiple shoot induction on plumular a piece of mature embryos of cv. Akkiz, after treatment of 10 mg L^{-1} BAP for five days, was ensured by culturing on MS culture medium having different concentrations of BAP with and without NAA. They noted callus and shoot induction in all cultures. They induced multiple extended shoot counts on each explant using MS cultural medium having 1 mg L^{-1} BAP + 0.1 mg L^{-1} NAA. Rooting was noted on MS medium having 0.50 mg L^{-1} IBA.

Aasim et al. (2010a), the five days preconditioned embryonic axes of the Akkız cowpea cultivar using MS culture medium with 10 mg L^{-1} BA were grown on MS culture medium having 0.25 - 1.00 mg L^{-1} BA together or separately using 0.10 mg L^{-1} NAA. The negative correlation between single BA concentration and percentage number of shoot counts per explant and their length, and adding 0.10 mg L^{-1} NAA can increase all observed parameters. It was noted that flowering and setting seed on regenerated shoots by MS culture medium with 0.5 mg L^{-1} IBA after 3 months.

Aasim et al. (2010b) noted callus induction followed by somatic embryogenesis from cultured plumule explant on MS culture medium having 0.25, 0.50, and 1.0 mg L^{-1} BAP with 1.0, 2.0, and 4.0 mg L^{-1} NAA that previously was taken from the 1 and 3 weeks old culture of the mature embryo of Akkız and Karagöz with 20 mg L^{-1} NAA. Shoot regeneration was noted on the same explants cultured on MS medium containing 0.25, 0.5, 0.75, and 1.00 mg L^{-1} BAP. The using 0.5 mg L^{-1} IBA promoted the rooting of regenerated shoots. Aasim et al. (2013) studied shoot regeneration of the immature cotyledons explant on (MS) culture medium containing 0.25 - 0.75 mg L^{-1} BAP with or without 0.25 mg L^{-1} NAA. The shoot regeneration percentage changed between 44.4 - 83.3% with 2.1 - 5.0 shoot counts per explant. It was noted that the genome of cowpea cultivar Akkız introduced an herbicide tolerance gene (bar) previously transferred to LBA4404 strain of *Agrobacterium tumefaciens* bearing the vector pRGGbar to immature cotyledon explant of cowpea. As a result, they recorded resistance against Basta® nonselective herbicide up to 10 ml.

2. Conclusion

Cowpea is a significantly important vegetable food and feed crop of West African countries, grown variably in arid and scarcely in semi-arid and temperate regions. In addition, it is a highly drought-tolerant crop, which suggests its scope as a multipurpose future alternative crop. Therefore, the promotion of this crop to address food, feed, and nutritional security would be desired.

Some studies have been conducted to evaluate genetic diversity using the geomorphological characteristic of cowpea landraces. However, there is a need to carry out more studies on biotechnological or molecular approaches. More molecular studies are needed to assess and manage the genetic diversity of cowpea landraces found in Turkey to support the breeding programs. In addition, more studies are needed to determine the phylogenic status of cowpea landraces in Turkey.

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

Declaration of Conflicts of Interest

All authors declare that there is no conflict of interest related to this article.

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