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REVIEW ARTICLE

ORIGIN, DOMESTICATION, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS AND CYTOGENETICS, GENETC DIVERSITY AND BREEDING OF URAD BEAN (*Vigna mungo* (L.) Hepper)

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ABSTRACT

Urad bean belongs to the Family Fabaceae, Subfamily Faboideae, Gnus *Vigna*, Species *Vigna mungo*. The chromosome number 2n=22. Urad bean (Vigna mungo) is a different species from mung bean/green gram (Vigna radiata). Both species are similar and are sometimes called by the same vernacular names. Urad bean has been reclassified from the *Phaseolus* to the *Vigna* genus. However, at present they are considered as 2 separate species with as major differences: flower colour (bright yellow in *Vigna mungo*, pale yellow in *Vigna radiata*), pocket on the keel (longer in *Vigna mungo* than in *Vigna radiata*), fruit shape (pods of *Vigna mungo* are shorter and erect on the peduncle, in *Vigna radiata* the pods are longer and spreading or pendulous). Three taxa are distinguished within *Vigna mungo*: 1) var. *mungo*, with large, black-seeded and early-maturing cultivars; 2) var. *viridis* Bose, with greenish dull or glossy seeds and late-maturing cultivars; and 3) var. *silvestris* Lukoki, Maréchal & Otoul, the wild type; compared to cultivated types it is smaller, more climbing, more hairy, with denser inflorescences and small seeds with prominent raised aril; it is considered the ancestor of the cultivated black gram. Common names are Black gram, urd bean, urad bean, Haricot urd. In Gujarati: *aḷad*, *aḍad;* Hindi: *uṛad dāl*, *urad dāl;* Kannada: *uddu*, *uddina bēḷe;* Marathi/Konkani: *uḍid;* Malayalam: *uẓhunnu;* Punjabi: "mānha di dāl"; Tamil: *uḷuntu*, *ulundu*, *ulutham paruppu;* Telugu: *minumulu* and *uddhi pappu* in Rayalaseema; Tulu: *urdu bele; Urdu: urad dāl* . Other Names are Adad, Arad, Karu-minimulu, Maga, Mas, Mash kalai, Masha, Matimah, Minumulu, Nallaminumulu, Tikari kalai, Uddu, Udid, Ulundu, Urad, Urd dhal, Urdi, Uzhunnu, ambérique, black gram, fagiolo urd, feijão-da-china, frijol mungo, haricot mungo, mash, mash kalai, masha, moong, mung bean, urd, urd bean, urd-bean, urdbohne, urdböna, urd|ulundu / urd. These are available in various avatars as whole, dehulled and in the form of split bean. Vigna mungo is a hairy and bushy, annual plant which has an elaborate taproot. The stem is highly branched from the base. The plant is cultivated for its edible seeds in tropical countries, especially in Asia. In addition, being an important source of human food and animal feed**,** it also plays an important role in sustaining soil fertility by improving soil physical properties and fixing atmospheric nitrogen. Being a drought resistant crop, it is suitable for dry land farming and predominantly used as an intercrop with other crops. This crop is itself a mini-fertilizer factory, as it has unique characteristics of maintaining and restoring soil fertility through fixing atmospheric nitrogen in symbiotic association with *Rhizobium* bacteria, present in the root nodules. Crop is suitable for inter cropping with different crops such as cotton, sorghum, pearl millet, green gram, maize, soybean, groundnut, for increasing production and maintaining soil fertility. In India the black gram is one of the important pulses grown in both Kharif and Rabi seasons. This crop is extensively grown in southern part of India, northern part of Bangladesh and Nepal. In Bangladesh and Nepal it is known as mash daal. It is a popular *daal* (legume) side dish in South Asia, that goes with curry and rice as a platter. Black gram has also been introduced to other tropical areas such as the Caribbean, Fiji, Mauritius, Myanmar and Africa. Black gram (urad bean) will be black in colour usually. But black gram in green colour has been invented by C.S.Azad University of Agriculture and Technology, Kanpur (variety Shekhar 1). In this review article on Origin, Domestication, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding, Uses, Nutritional Value and Health Benefits of Urad bean or Black gram are discussed.

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INTRODUCTION

Urad bean belongs to the Family Fabaceae, Subfamily Faboideae, Gnus *Vigna*, Species *Vigna mungo* (Singh, 2021; Wikipedia, 2023). The chromosome number is 2n = 22. Black gram (*Vigna mungo*) is a different species from mung bean/green gram (*Vigna radiata*). Both species are similar and are sometimes called by the same vernacular names (Heuzé *et al*., 2016). It is popularly known as urd. *Vigna mungo* is divided in to two sub species. *V. mungo* var. *niger:* It includes varieties which mature early and have bold and black seeds. *V. mungo* var. *viridis:* It includes varieties having longer maturity period. Seeds are small and green (Agropedias, 2023). However, at present they are considered as 2 separate species with as major differences: flower colour (bright yellow in *Vigna mungo*, pale yellow in *Vigna radiata*), pocket on the keel (longer in *Vigna mungo* than in *Vigna radiata*), fruit shape (pods of *Vigna mungo* are shorter and erect on the peduncle, in *Vigna radiata* the pods are longer and spreading or pendulous). Three taxa are distinguished within *Vigna mungo*: 1) var. *mungo*, with large, black-seeded and early-maturing cultivars; 2) var. *viridis* Bose, with greenish dull or glossy seeds and late-maturing cultivars; and 3) var. *silvestris* Lukoki, Maréchal & Otoul, the wild type; compared to cultivated types it is smaller, more climbing, more hairy, with denser inflorescences and small seeds with prominent raised aril; it is considered the ancestor of the cultivated black gram (Jansen, 2006). Black gram is an annual food legume. It shows both erect and crawling growth habit. There are several distinct characters between black gram and mun gbean. Flower color of black gram is bright yellow, while that of mung bean is pale yellow. Pocket on the keel, which is a characteristics of the subgenus *Ceratotropis*, of black gram is longer than that of mung bean. Pod of black gram is shorter than that of mung bean. Pod of black gram attaches upright to the peduncle, while mung bean pod attaches sideward or downward to the peduncle. In most cases, seed color is dull black. However, shiny black and shiny green seeded black gram is also cultivated in Nepal (PGRD, 2023). *Vigna mungo* resembles green gram (*Vigna radiata* (L.) R. Wilczek) with two main differences: the corolla of *Vigna mungo* is bright yellow while that of *Vigna radiata* is pale yellow; black gram pods are erect whereas they are pendulous for green gram. Black gram is somewhat more hairy than green gram; the white hilum also protrudes from the seed. Black gram is sown on heavier soils and green gram is sown on lighter soils (Heuzé *et al.,* 2016). Black gram is an annual food legume. It shows both erect and crawling growth habit. There are several distinct characters between black gram and mung bean. Flower color of black gram is bright yellow, while that of mung bean is pale yellow. Pocket on the keel, which is a characteristics of the subgenus *Ceratotropis*, of black gram is longer than that of mung bean. Pod of black gram is shorter than that of mung bean. Pod of black gram attaches upright to the peduncle, while mung bean pod attaches sideward or downward to the peduncle. In most cases, seed color is dull black. However, shiny black and shiny green seeded black gram is also cultivated in Nepal (PGRD, 2023)

Common names are Black gram, urd bean, urad bean, Haricot urd. In Gujarati: *aḷad*, *aḍad;* Hindi: *uṛad dāl*, *urad dāl;* Kannada: *uddu*, *uddina bēḷe;* Marathi/Konkani: *uḍid;* Malayalam: *uẓhunnu;* Punjabi: "mānha di dāl"; Tamil: *uḷuntu*, *ulundu*, *ulutham paruppu;* Telugu: *minumulu* and *uddhi pappu* in Rayalaseema; Tulu: *urdu bele; Urdu: urad dāl* (Wikipedia, 2023). Other Names are adad, arad, karu-minimulu, maga, mas, mash kalai, masha, matimah, minumulu, nallaminumulu, tikari kalai, uddu, udid, ulundu, urad, urd dhal, urdi, uzhunnu, ambérique, black gram, fagiolo urd, feijão-da-china, frijol mungo, haricot mungo, mash, mash kalai, masha, moong, mung bean, urd, urd bean, urd-bean, urdbohne, urdböna, urd|ulundu / urd (PFF, 2023). Ihese are available in various avatars as whole, dehulled and in the form of split bean (Binu, 2019). English- Black gram; Hindi - Uṛad; Bengali- Mash-kalai; Gujarati - Aḍad, Arad; Sanskrit- Masa; Kannada- Uddu; Marathi - Uḍid, Maga; Tamil- Ulundu, Ulunthu; Malyalam- Uẓhunnu, Ulnnu; Urdu- Urad; Telgu- Minumulu, karuminimulu, nallaminimulu, Uddulu (Khan *et al*., 2021). Vigna mungo, also known as black gram, urad bean, urid bean, mash kalai, uzhunnu parippu, ulundu paruppu, minapa pappu, uddu, or black matpe, is a bean grown in South Asia (Chandel et al., 2008). It is also called urd bean, urad bean, black lentil, black matpe bean and mungo bean in English, and urad dal in Hindi (Bodhare, 2023). It is also known as black gram, urad dal, urd bean, urad bean, minapa pappu, black matpe bean, mungo bean or Haricot urd, urd (French). Feijão urida (Portuguese). Mchooko mweusi (Swahili) (Liz, 2018). Urad dal or *black gram* are the *black seeds* of the leguminous plant called *Vigna mungo*. It's mainly grown in *India* and used to make the Indian soup commonly known as *'Dal'* (Liz, 2018).

Vigna mungo is a hairy and bushy, annual plant which has an elaborate taproot. The stem is highly branched from the base. The plant is cultivated for its edible seeds in tropical countries, especially in Asia (Bodhare, 2023). Urad dal, scientifically called *Vigna mungo*, is a lentil most commonly used in South Indian households. *Vigna mungo* seeds are mainly a staple food, and the dehulled and split seeds (*dhal* in Hindi) are a typical dish in South Asia. It can be found in Asia, Madagascar, and Africa too (Bodhare, 2023). Its young seed pods and seeds can be cooked. Even the leaves are tasty. The seeds are used as a poultice on abscesses in traditional Chinese medicine. The soap-like properties of seed flour come from the presence of saponins. Since the plant can absorb and use nitrogen from the air, it is sometimes used as a green manure crop (HND, 2023). Commonly called black gram, *Vigna mungo* is an old South Asian crop that is counted amongst the most coveted pulses in India. It is widely used in Indian cooking (HND, 2023). In addition, being an important source of human food and animal feed, it also plays an important role in sustaining soil fertility by improving soil physical properties and fixingatmospheric nitrogen (Kanade, 2006). Being a drought resistant crop, it is suitable for dryland farming and predominantly used as an intercrop with other crops. This crop is itself a mini-fertilizer factory, as it has unique characteristics of maintaining and restoring soil fertility through fixing atmospheric nitrogen in symbiotic association with *Rhizobium* bacteria, present in the root nodules. Crop is suitable for inter cropping with different crops such as cotton, sorghum, pearl millet, green gram, maize, soybean, groundnut, for increasing production and maintaining soil fertility (Kanade, 2006). Black gram is also used as fodder. Black gram straw, black gram haulms, urd bhoosa, black gram seeds, black gram chuni, black gram bran, urd chuni, mashkalai bran, moong chuni are used as fodder (Heuzé et al., 2016). Black gram (*Phaseolus mungo*), also known as urd, mush and mung in India, is an important pulse crop of India next to green gram. It is used more or less in the same way as green gram. As forage, it is inferior to green gram due to hairiness. It is a highly priced pulse, very rich in phosphoric acid (Pallavi, 2023).

Countries where the plant has been found are Afghanistan, Africa, Asia, Australia, Bangladesh, Central Africa, Congo, East Africa, Egypt, Fiji, Gabon, Himalayas, India, Indochina, Iran, Japan, Kenya, Madagascar, Malawi, Marianas, Mauritius, Mozambique, Nepal, North Africa, Pacific, Pakistan, Papua New Guinea, PNG, Pakistan, Philippines, SE Asia, Solomon Islands, South Africa, Southern Africa, Sri Lanka, Sudan, Tajikistan, Tanzania, Uganda, Vietnam (PFF, 2023). It is cultivated as a rain fed crop in drier parts of India. India contributes to 80% of the global production of black gram. Important states growing black gram in India are Uttar Pradesh, Chattisgarh and Karnataka (Brainkart, 2023).
In India, the major producer and consumer, average annual production of black gram seed is about 1.3 million t from 3 million ha. Thailand produces annually about 90,000 t which is mainly exported to Japan, where seed sprouts from black gram are preferred to those from green gram (*Vigna radiata* (L.) R.Wilczek) because of their longer shelf life. Annual production in Pakistan is about 28,000 t from 57,000 ha, and in Sri Lanka 6000 t from 8000 ha. Sri Lanka additionally imports 6000 t/year (Jansen, 2006). India is the largest producer and consumer of Black gram in the world (Kanade, 2006). The main producer of black gram is India, which produces about 1.5 million t of seeds annually. India consumes its entire production. The other main producers (Myanmar and Thailand) are the major exporters. Globally black gram accounts for more than 40%

of total legume seeds traded (Heuzé *et al*., 2016). Black gram is mainly grown in *India*, and to some extent throughout tropical Asia. It's also grown in some countries in *Africa*. In the *US* and *Australia* it's mainly grown as a fodder crop. India is the major *producer* and *consumer* of black gram (Liz, 2018). This fast-growing plant has in fact made India the largest producer of black gram in the world with 1.5 million tonnes of seeds annually, followed by Fiji, Mauritius, Africa and Caribbean countries (Binu, 2019). It is grown throughout India as a pulse crop and cultivated as a component of various cropping systems that cover over four million hectares, principally in India, Myanmar, Pakistan, Bangladesh and Thailand. Most Black gram cultivars produce black-coloured seeds which are rich in proteins in addition to lysine and phosphoric acid (Khan *et al*., 2021). Currently, India is its largest producer and is also considered to be the primary center for black gram genetic diversity. However, the crop is also grown across South and Southeast Asian countries, including Thailand, Afghanistan, Philippines, Myanmar, Bangladesh, Pakistan, and Nepal (Verma *et al*., 2022).

Madhya Pradesh, Uttar Pradesh and Andhra Pradesh are major blackgram growing states area-wise. The highest yield was recorded by the state of Bihar (898 kg/ha) followed by Sikkim (895 kg/ha) and Jharkhand (890 kg/ha). The National yield average is 585 kg/ha. The lowest yield was recorded in the state of Chattisgarh (309 kg/ha) followed by Odisha (326 kg/ha) and J&K (385 kg/ha) (Vikaspedia, 2023). Urd should be harvested when 70-80 % pods matured and most of the pods turn black. Over maturity may result in shattering. Harvested crop should be dried on threshing floor for few days and then threshed. Threshing can be done either manually or by trampling under the feet of bullocks. The clean seeds should be sun dried for 3 - 4 days to bring their moisture content at 8-10% to safely store in appropriate bins (Vikaspedia, 2023). A well managed crop of Urd may produce 12 - 15 quintals grains/ha. About 70 per cent of the world's black gram production comes from India. India is the world's largest producer as well as consumer of blackgram. It produces about 24.5 lakh tonnes of Urad annually from about 4.6 million hectares of area, with an average productivity of 533 Kg per hectare in 2020-21 (Vikaspedia, 2023). Black gram (*Vigna Mungo* L.), is one of the important pulses crop, grown throughout the country. The crop is resistant to adverse climatic conditions and improve the soil fertility by fixing atmospheric nitrogen in the soil. It has been reported that the crop produces equivalent to 22.10 kg of N/ha., which has been estimated to be supplement of 59 thousand tonnes of urea annually (Vikaspedia, 2023). The product sold as black lentil is usually the whole urad bean, whereas the split bean (the interior being white) is called white lentil. It should not be confused with the much smaller true black lentil (*Lens culinaris*) (Wikipedia, 2023). In India the black gram is one of the important pulses grown in both Kharif and Rabi seasons. This crop is extensively grown in southern part of India, northern part of Bangladesh and Nepal. In Bangladesh and Nepal it is known as mash daal. It is a popular *daal* (legume) side dish in South Asia, that goes with curry and rice as a platter. Black gram has also been introduced to other tropical areas such as the Caribbean, Fiji, Mauritius, Myanmar and Africa (Wikipedia, 2023). Black gram (urd bean) will be black in colour usually. But black gram in green colour has been invented by C.S.Azad University of Agriculture and Technology of Kanpur. The new variety Shekhar 1 (KU 301) from C.S.Azad University of Agriculture and Technology is green in colour which resembles green gram. Weight of 1000 grains is 44 grams (The Hindu, 2010). In this review article on Origin, Domestication, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding, Uses, Nutritional Value and Health Benefits of Urad bean or Black gram are discussed.

ORIGIN AND DOMESTICATION

Black gram (*Vigna mungo* L) reported to be originated in India**.** Its references have also been found in Vedic texts such as Kautilya's 'Arthasasthra' and in 'Charak Samhita' lends support to the presumption of its origin in India (Kanade, 2006). Black gram was most probably domesticated in India from its wild ancestral type, which is also found in Bangladesh, Pakistan and Myanmar. At present black gram cultivation is of major importance in India only, but it is also grown to some extent throughout tropical Asia. In Africa it is grown in Gabon, DR Congo, Kenya, Uganda, Tanzania, Malawi, Mozambique, South Africa, Madagascar and Mauritius. It is grown in the United States and Australia mainly as a fodder crop (Jansen, 2006). It is believed to have been domesticated in India from its wild progenitor, *Vigna mungo* var. *silvestris* Lukoki, Maréchal, and Otoul. Based on archeological evidence found in India, domestication of black gram may have occurred about 4,500 years ago (Chandel *et al.,* 2008). It is believed to have been domesticated in India from its wild progenitor, *Vigna mungo* var. *silvestris* Lukoki, Maréchal, and Otoul (Chandel *et al.* 1984). Based on archeological evidence found in India(Fuller and Harvey 2006), domestication of black gram may have occurred about 4,500 years ago. Early finds of black gram were from Gujarat and the Northern Peninsula in India, where wild black gram populations persist (Kaewwongwal *et al*., 2015). *Vigna mungo* originated from central Asia and India from where it was domesticated. It is now found in many tropical areas of Asia, Africa and Madagascar. It is cultivated in the USA and Australia as a fodder crop (Heuzé *et al.,* 2016). Native to the Indian subcontinent and mostly grown in the coastal Andhra Pradesh in our country, these smooth, cylindrical oval shaped black gram beans go with the botanical name *Vigna mungo* (Binu, 2019). Black gram is grown mainly in Central and Southeast Asia. It is widely distributed in tropical West Africa and extensively cultivated all over India. The Guntur District ranks first in Andhra Pradesh for the production of black gram in India (Khan *et al*., 2021).

Black gram is believed to be domesticated from its wild progenitor *V. mungo* var. *silvestris* in India (Verma *et al.*, 2022). Based on archeological evidences, black gram is said to be domesticated in India around 4,500 years ago in the regions of Gujarat and in the Northern Peninsula. *V. mungo* var. *silvestris* is considered as the wild progenitor of *V. mungo* (L.) Hepper var. *mungo* from which it would have domesticated in India. It further spread from India to regions of Myanmar and Thailand (Verma *et al*., 2022). The primary centre of origin of black gram is India and its secondary origin is central Asia. It is an important pulse crop in India, Pakistan, Myanmar and parts of southern Asia, Africa and America. In India, it is primarily grown in Madhya Pradesh, Maharashtra, Orissa, Andhra Pradesh, Uttar Pradesh, and Tamil Nadu (Pallavi, 2023). This very important black bean in the diet of vegetarian Indians was originally found growing in India. It is now widely cultivated in the tropics (Echocommunity, 2023). Black gram originated in South Asia, where it has been in cultivation from ancient times and is one of the most highly prized pulses of India. It is very widely used in Indian cuisine (Wikipedia, 2023). Black gram is considered to bave been domesticated in India from its wild ancestral form (*V.mungo* var.*silvestris* Lukoki, Marechal & Otoul). Center of genetic diversity is found in India (Zeven and de Wet. 1982). Natural distribution of *V.mungo* var.*silvestris* ranges from India to Myanmar (PGRD, 2023). Black gram is native to India. Earliest archeobotanical evidences record the presence of black gram about 3,500 years ago (Brainkart, 2023).

TAXONOMY

Urad bean belongs to the Family Fabaceae, Subfamily Faboideae, Genus Vigna and Species *Vigna mungo* (L.) Hepper (Mia, 2016; Heuzé et al., 2016; Wikipedia, 2023). Phylogenetic tree of the species in the genus *Vigna* is given in Fig. 1

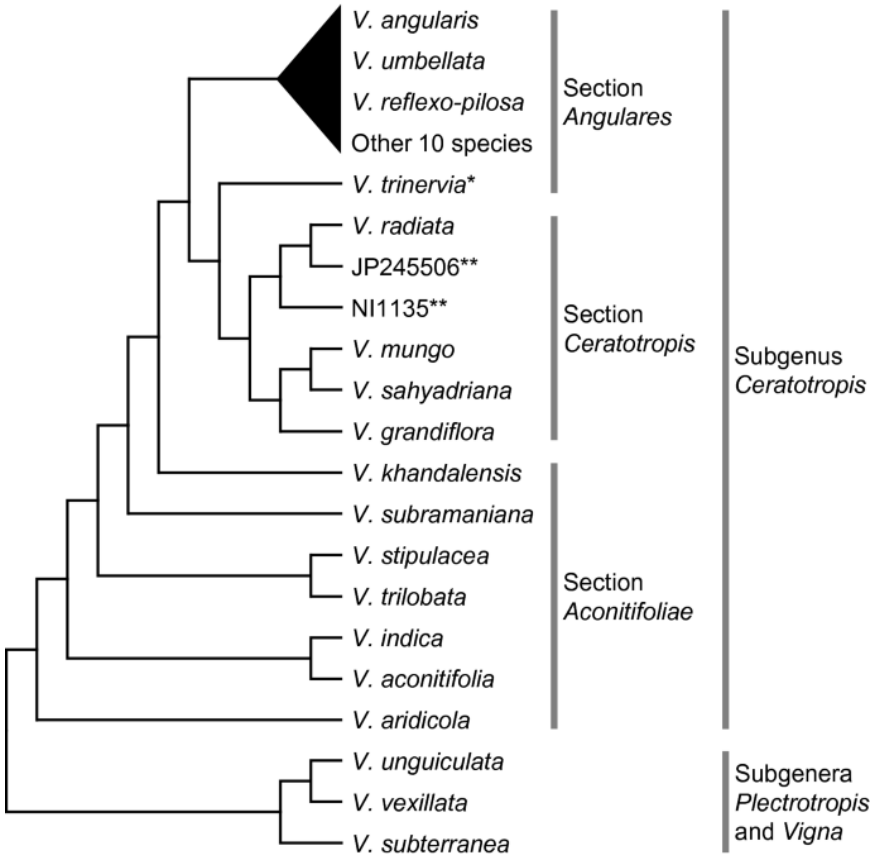


Fig. 1: Phylogenetic tree of the species in the genus *Vigna*

This self-pollinated and diploid legume crop belongs to the family Leguminosae or Fabaceae. This plant family is widely spread all over the world and resides for the third position for the biggest family of flowering plants. It has approximately 650 genus and 20,000 species (Doyle, 1994). Mungbean belongs to the Asian *Vigna*, subgenus *Ceratotropis*. Taxonomically, subgenus *Ceratotropis* has been divided into the following three sections: *Ceratotropis*, *Angulares* and *Aconitifoliae*. Section *Ceratotropis* also includes the South Asian cultigen black gram [*V. mungo* (L.) Hepper] (Sangiri *et al.,* 2007). Urad bean is morphologically very similar to mung bean and they are sometimes considered variants of the same species. Chemotaxonomy and cytogenetics, however, support the distinction, but the debate still continues. Both species are sometimes considered to be domesticates from the same wild forms (*Vigna sublobata*, based on *Phaseolus sublobatus* Roxb.). The genus *Vigna* is a large leguminous taxon comprising 104 described species distributed in tropical and sub- tropical regions of Africa, Asia, America, and Australia. It is an important and interesting taxon because up to nine species in this taxon are domesticated as food crops in Asia, Africa, and America. These species include *V. subterranea* (L.) Verdc. (Bambara groundnut), *V. unguiculata* (L.) Walp. (cowpea), *V. vexillata* (L.) (zombi pea), *V. radiata* (L.) Wilczek (mungbean), *V. angularis* (Ohwi) Ohwi & Ohashi (azuki bean), *V. mungo* (L.) Hepper (black gram), *V. aconitifolia* Jacq. (moth bean), *V. umbellata* (Thunb.) Ohwi & Ohashi (rice bean), and *V. reflexo-pilosa* Hayata (créole bean) (Kaewwongwal *et al*., 2015).

Vigna comprises about 80 species and occurs throughout the tropics. *Vigna mungo* belongs to subgenus *Ceratotropis*, which also includes *Vigna radiata* (L.) R.Wilczek (mung bean), *Vigna umbellata* (Thunb.) Ohwi & H.Ohashi (rice bean), *Vigna angularis* (Willd.) Ohwi & H.Ohashi (adzuki bean) and *Vigna aconitifolia* (Jacq.) Maréchal (moth bean). There has been confusion on the taxonomic status of *Vigna mungo* and *Vigna radiata*; because they are closely related it was proposed that they be grouped into a single species. However, at present they are considered as 2 separate species with as major differences: flower colour (bright yellow in *Vigna mungo*, pale yellow in *Vigna radiata*), pocket on the keel (longer in *Vigna mungo* than in *Vigna radiata*), fruit shape (pods of *Vigna mungo* are shorter and erect on the peduncle, in *Vigna radiata* the pods are longer and spreading or pendulous). Three taxa are distinguished within *Vigna mungo*: 1) var. *mungo*, with large, black-seeded and early-maturing cultivars; 2) var. *viridis* Bose, with greenish dull or glossy seeds and late-maturing cultivars; and 3) var. *silvestris* Lukoki, Maréchal & Otoul, the wild type; compared to cultivated types it is smaller, more climbing, more hairy, with denser inflorescences and small seeds with prominent raised aril; it is considered the ancestor of the cultivated black gram (Jansen, 2006). The crop plants *Vigna mungo* (urid, urd or black gram) and *V. radiata* (mung bean or green gram: and related taxa have been studied by seed protein electrophoresis, leaf phenolics chromatography, vegetative morphology, and seed testa patterns. The results disprove the theory that these species are very closely related and have evolved from a single wild taxon. The present evidence shows that *V. mungo* var. *mungo* and *V. radiata* var. *radiata* have independent lineages and were domesticated from two very distinct taxa. namely *V. mungo* var. *silvestris* and *V. radoata* var. *sublobata* respectively (Chandel *et al.,* 2008).

Black gram **(***Vigna mungo)* is popularly known as urd. *Vigna mungo* is divided in to two sub species. 1) *V. mungo* var. niger: It includes varieties which mature early and have bold andblack seeds. And 2) *V. mungo* var. viridis**:** It includes varieties having longer maturity period. Seeds are small and green (Kanade, 2006; Agropedias, 2023). Black gram belongs to the subgenus *Ceratotropis* in the genus *Vigna*. The genus

Vigna, together with the closely related genus *Phaseolus*, forms a coplex taxonomic group, called *Phaseolus-Vigna* complex. Verdcourt (1970) proposed a very restricted concept of *Phaseolus*, limiting it exclusively to those American species with a tightly coiled style and pollen grains lacking course reticulation, hence, promoting significantly the concept of *Vigna*. According to his proposal, black gram and its relatives (which is now recognized as the subgenus *Ceratotropis*) were transferred to the genus *Vigna* from the genus *Phaseolus*. Marechal *et al.* (1978) followed Verdcourt and presented a monograph on the *Phaseolus-Vigna* complex. Their taxonomic system is generally accepted now. Taxonomic treatment of black gram and mungbean (*V.radiata*) has been confused. Verdcourt (1970) proposed that these two species should be treated as a single species. However, Marechal *et al*. (1978) considered these two as distinct species and his proposal was supported by many taxonomists. Two botanical varieties were recognized in *V.mungo*. *V.mungo* var *mungo* is the cultivated form (black gram), var.*silvestris* is the wild ancestral form of black gram (Lukoki *et al*., 1980). 2n=22. (PGRD, 2023). *Māsh* bean (*Vigna mungo* (L.) is one of the important legume crops extensively cultivated in India and other parts of the world from ancient times. The name of the *Vigna* genus is derived from an Italian botanist of the 17th century *Dominico vigna*. It comprises around 150 species . Its name in most languages of India derives from Proto-Dravidian *uṛ-untu-*, borrowed into Sanskrit as *uḍida*. India is the largest producer and consumer of pulses (Khan *et al*., 2021). *Vigna mungo* var.*silvestris* belongs to the subgenus *Ceratotropis* in the genus *Vigna* . This species was formerly treated by many authors as *Phaseolus sublobatus* Roxb., which was considered as the common ancestor of both *V.radiata* and *V.mungo.* After further studies using newly collected living materials, it was revealed that the taxon contained two different forms, one related to *V.radiata* and the other to *V.mungo*. Lukoki *et al*.(1980) accepted the specific distinction between the two forms and their relations as wild ancestors to the cultivated species. They treated two forms as *V.radiata* var.*sublobata*(Roxb.) Verdcourt and *V.mungo* var.*silvestris* Lukoki, Marechal et Otoul (NARO, 2023).

Synonyms (Heuzé *et al.*, 2016).

1.*Azukia mungo* (L.) Masam.,
2.*Phaseolus hernandezii* Savi,
3.*Phaseolus* max sensu auct.,
4.*Phaseolus mungo* L.,
5.*Phaseolus mungo* L. var. *radiatus* sensu Baker,
6.*Phaseolus radiatus* Roxb. non L.,
7.*Phaseolus roxburghii* Wight & Arn.

Synonyms: (Khan *et al*., 2021).

1.Phaseolus radiates Roxb.
2.Phaseolus mungo Linn.
3.Azukia mungo (L.) *Masam*.
4.Phaseolus hernandezii Savi
5.*Phaseolus mungo* L.
6.*Phaseolus roxburghii* Wight & Arn.

Synonyms (PFF, 2023).

1.Azukia mungo (L.) Masam.
2.Phaseolus hernandezii Savi
3.Phaseolus mungo L.
4.Phaseolus radiatus Roxb. Phas

Synonyms (Wikipedia, 2023)

1.*Azukia mungo* (L.) Masam.
2.*Phaseolus hernandezii* Savi
3.*Phaseolus mungo* L.
4.*Phaseolus roxburghii* Wight & Arn.

BOTANICAL DESCRIPTION

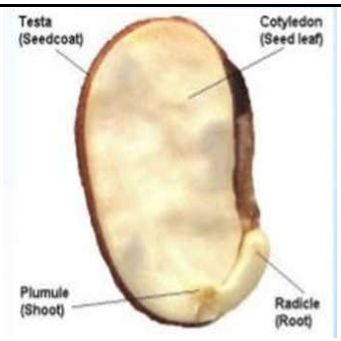
The plant attains a height of 30 to 100 centimeters, with stem lightly ridged, covered with brown hairs and much branches from the base. The leaves are large, trifoliate and are also hairy, generally with a purplish tinge. Theleaflets are 5-10 cm long and ovate. Inflorescence consists of a cluster of 5-6 flowers at the top.The pods are long and cylindrical and about 4 to 6 centimeters in length.There are four to ten seeds in a pod. The seeds are generally black or very dark brown. Black gram has a tap root system (Kanade, 2006). Erect, hairy annual herb up to 100 cm tall, sometimes twining, with a well-developed taproot; stem diffusely branched from the base, furrowed. Leaves alternate, 3-foliolate; stipules peltate, ovate; petiole 6–20 cm long; stipels falcate; leaflets ovate or rhombic-ovate, 4–10 cm × 2–7 cm, entire, acuminate. Inflorescence an axillary false raceme; peduncle up to 18 cm long. Flowers bisexual, papilionaceous, small; bracteoles linear to lanceolate, exceeding the calyx; calyx campanulate; corolla yellow, standard 12–16 mm wide, wings about as long as standard, keel spirally coiled with a terminal horn-like appendage; stamens 10, 9 united and 1 free; ovary superior, style spirally curved. Fruit a cylindrical pod 4–7 cm × 0.5 cm, erect or almost so, with long hairs and short hooked beak, 4–10-seeded. Seed ellipsoid, up to 5 mm long, with square ends, and raised and concave hilum, usually black or mottled, sometimes green. Seedling with epigeal germination. Germination of black gram normally takes 7–10 days. Flowering starts 30–60 days after sowing. Flowers are normally self-pollinating, with the pollen shedding before the flower opens. Maturity is reached in 60–140 days after sowing. Black gram effectively nodulates with *Bradyrhizobium* bacteria (Jansen, 2006). Black gram (*Vigna mungo* (L.) Hepper) is an erect, fast-growing annual, herbaceous legume reaching 30-100 cm in height. It has a well-developed taproot and its stems are diffusely branched from the base. Occasionally it has a twining habit and it is generally pubescent. The leaves are trifoliate with ovate leaflets, 4-10 cm long and 2-7 cm wide. The inflorescence is borne at the extremity of a long (up to 18 cm) peduncle and bears yellow, small, papilionaceous flowers. The fruit is a cylindrical, erect pod, 4-7 cm long x 0.5 cm broad. The pod is hairy and has a short hooked beak. It contains 4-10 ellipsoid black or mottled seeds (Heuzé et al., 2016). Black Gram is a cultivated annual herb. It has a deep rooted tap root system. Stem is erect to sub-erect, highly branching and hairy. Leaf is alternate, compound, trifoliate, dark green, leaflets ovate. Inflorescence is an axillary raceme. Flower is

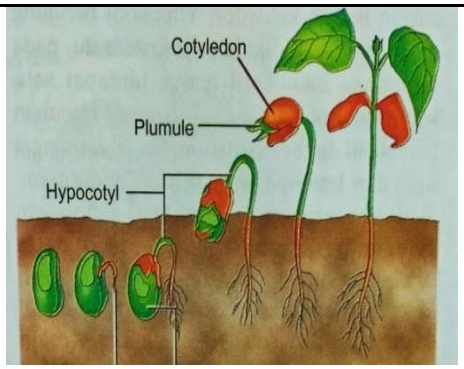
zygomorphic, complete, papilionaceous. Calyx consists of 5 sepal, gamosepalous. Corolla consists of 5 petals, divided into standard, wing and keel; aestivation vexilary. Androecium consists of stamen 10 (9+1) diadelphous. Gynoecium consists of one carpel, style spirally twisted, ovary superior, placentation marginal. Fruit is a pod with densely trichomed. Seed is non-endospermic, globur usually green (Mia, 2016). Black gram grows on an erect, hairy bush with stems diffusing from the base reaching up to 30 to 100 cm in height with trifoliate leaves, sporting tiny, yellow flowers. The fruit looks cylindrical while its hairy pods contain up to 4 to 10 black seeds (Binu, 2019).

An erect, hairy annual plant, height varying from 30-90 cm with long twinning branches, leaves trifoliate, leaflets ovate 5-10 cm long, small flowers with elongating peduncles, cylindrical fruit pods, hairy with a short-hooked beak, seeds usually 4 but maybe 1 in a pod, generally black with white hilum protruding from the seeds. It has a taproot that branches to form branched roots. It is sweet to taste and hot in potency. The ellipsoid, usually black seed is up to 5mm long with square ends and raised and concave hilum, usually black or mottled. Sometimes the plant adopts a twining habit. Flowers are bisexual, papilionaceous, small; bracteoles linear to lanceolate, exceeding the calyx. Flowers are yellow and in dense clusters (Khan et al., 2021). It is an annual, semi-erect to spreading herb growing to a height of 25-90 cm. Stem is slightly ridged and covered with brown hairs. Stems are diffuse, branching sometimes procumbent, covered with long dense brown or black hairs. Leaves are pinnately trifoliate, hairy with large ovate to lanceolate and entire leaflets. The leaves are large and trifoliate. It possesses strong tap root system with many laterals. Inflorescence is a raceme,which may be branched with clusters of 5-6 flowerson a short but later elongating peduncle. Flowers are bracteate , bracteolate , pedicellate, bisexual,hypogynous , zygomorphic, complete flowers. Flowers are pale yellow, small with a yellow spirally coiled keel. They are borne in clusters of 5-6 on a short hairy peduncle in axillary racemes. Calyx consistsof 5 , gamosepalous , valvate . Corolla is papilionaceous, polypetalous, desendingly imbricate, keel petals spirally coiled. Androecium consists of stamens 10 (9+1) , diadelphous, filaments alternately long and short ,anthers uniform introse , dorsifixed . Gynoecium consists of ovary superior, monocarpellary, ovule unilocular with afew ovules on marginal placentation. Style terminal and hairy, stigma filiform. They are Self-fertilize and self-pollinated. Flowering is indeterminate. Fruits/Pods are short, erect to stuberect, brown to black in color, hairy and with stout hooked beak, containing 6-10 seeds. Pods do not shatter readily. Seeds are small, oblong slightly truncated at ends. Seeds have varying color from black, dark brown to green. The testa is smooth and hilum white and concave (Singh, 2021)

Black gram can reach a height of 100 centimetres and is characterised by an erect, hairy, bushy form with a well-developed tap root. The pods have a narrow, cylindrical shape; inside each pod are 4–10 tiny, black seeds. Three individual leaflets are oval on each leaf. There are clusters of bright yellow flowers (HND, 2023). Black gram is a twining herb, annual plant, densely hairy, stem slightly ridged, leaves alternate, stipulate, petiolate, Pinnately trifolate. Inflorescence axillary raceme with flowers congested at the top of the peduncle. Flowers 5-6. Shortly pedicelled bisexual, hypogynous, Zygomorphic, Complete. Sepals 5 gamosepalous, imbricate corolla papilionaceous, petals five, polypetalous keel in the form of spiral beak. Androecium diadelphous (9+1) filament alternately long and short. Gynoecium superior ovary, monocarpellary unilocular marginal placentation. Fruit – Legume densely hairy seeds, generally black (E-Agri, 2023a). It has all the morphological key characters of black gram (*V.mungo*), but stem is lunk and all the plant parts are smaller. Hilum ovate, aril very thick. Seeds coverd with seed coat covering. Flowers golden yellow. Germination epigeal, primary leaf lanceolate without petiole (NARO, 2023). Vigna mungo or also known in various common names such as Black Gram, Urd Bean, Black Matpe, and Black Mung Bean, is an erect, hairy, and bushy annual plant with a well-developed tap root and grows up to 100 cm in height. It is often grown in the Indian subcontinent. The pods are narrow and cylindrical with each pod containing about 4-10 small, black seeds. The leaves are composed of three oval leaflets each. Flowers are yellow and in dense clusters. Young seedpods and seeds are cooked and consumed as a vegetables. Dried seeds are boiled or ground into flour. The leaves are also edible. In traditional medicine, the seeds are used as a poultice on abscesses. Seed flour is rich in saponins and can be used as a substitute to soap. The plant has the ability to fix atmospheric nitrogen hence it is grown in some areas as green manure (PFF, 2023).

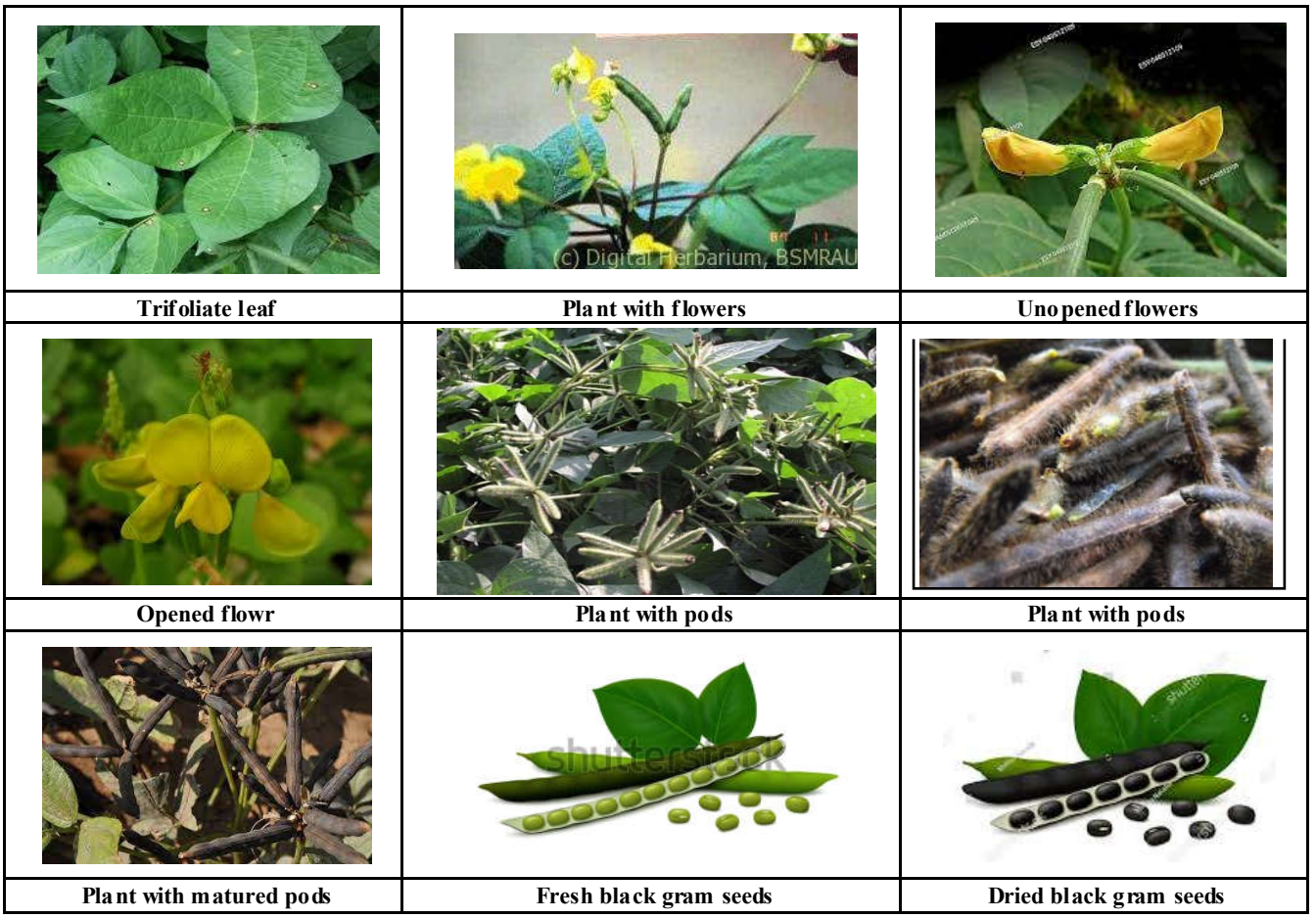
Annual, herbaceous, 30-100 cm in height, erect, semi erect to trailing or spreading types, plant densely hairy. Stem is slightly ridged, covered with brown hairs, hairs pointed downwards. Stem colour dust brown much branched from the base. Leaves are trifoliate, alternate, stipulate, stipules narrow and falcate, petiolate, pulvinate, stipellate, stipel small and flat, leaflets ovate, entire, acute, sparsely hairy on both surfaces, palmately reticulate. Inflorescence is axillary raceme with the flowers congested at the top of the peduncle, flowers five to six, bracteate, bracteolate, bracteoles 2, pedicillate, bisexual hypogynous, zygomorphic, complete, pentamerous. Mature pod is puff to brown colour, 6-8 mm long (shorter than mug bean) round, erect with long and dense hairs and short hooked beak. Seed is oblong with square ends, black. Hilum white and concave, seed coat surface is smooth. Cotyledons white in colour (IKisan, 2023). Black gram (*Vigna mungo* L.) belongs to the Fabaceae or Leguminosae family. It has a tap root system. Stem is slightly ridged, covered with brown hairs and much branched from the base. Leaves are large, trifoliate and hairy with purplish tinge. The leaflets are 5-10 cm long and ovate. Inflorescence consists of a cluster of 5-6 flowers at the top. Pods are long and cylindrical and 4-6 cm long. Each pod contains 4-10 seeds which are black or dark brown (Agropedias, 2023). It is an erect, suberect or trailing, densely hairy, annual bush. The tap root produces a branched root system with smooth, rounded nodules. The pods are narrow, cylindrical and up to six cm long. The plant grows 30–100 cm with large hairy leaves and 4–6 cm seed pods. While the urad dal was, along with the mung bean, originally placed in Phaseolus, it has since been transferred to Vigna (Wikipedia, 2023) **(Fig 2, 3).**





Parts of seed	Epigeal germination	Field view

Continue ….



Trifoliate leaf	Plant with flowers	Unopened flowers
Opened flowr	Plant with pods	Plant with pods
Plant with matured pods	Fresh black gram seeds	Dried black gram seeds

Fig. 2. Botanical Description of black gram/Urd bean

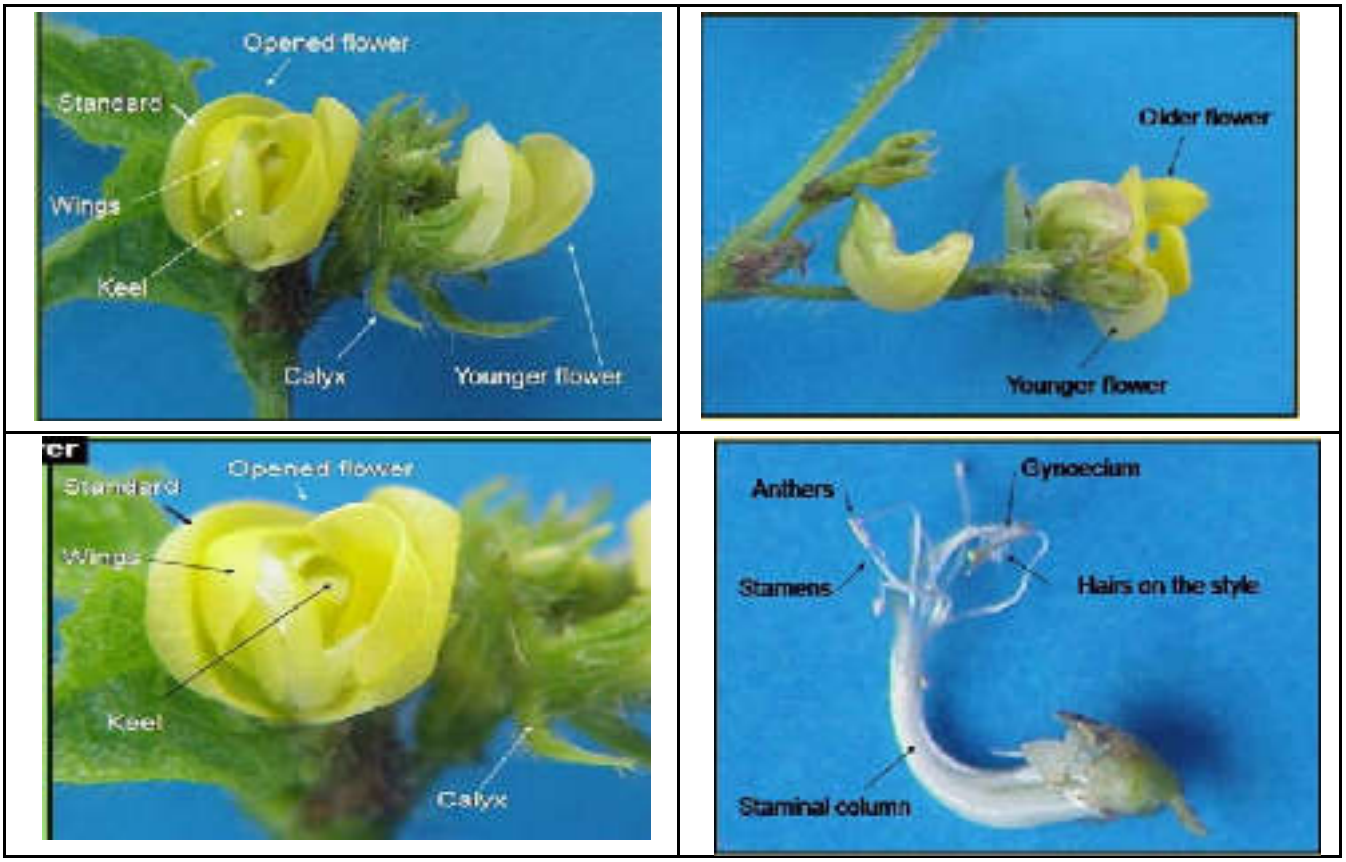


Fig. 3. Parts of black gram/Urad bean flower

GENETICS AND CYTOGENETICS

In black gram (Vigna mungo (L.) Hepper), the mode of inheritance of six pairs of characters has been analysed, *viz*.: erect versus spreading habit; hairy versus glabrous fruit; bluish black versus straw fruit colour; shiny versus dull seed surface; green versus brown seed colour. On the basis of the results, the following gene symbols are proposed: Erect habit *Sp* is incompletely dominant over spreading, *sp*.—Hairy fruit *G* is dominant over glabrous, *g*, while in *G* plants the extent of hairiness is controlled by more than one pair of genes.—Bluish black fruit colour *S* is dominant over straw, *s*.—Shiny seed surface *D* is dominant over dull, *d*.—Green seed colour *Br* is dominant over brown; *br*.—Mosaic colour pattern of the seed *Uc* is dominant over non-patterned, *uc* (Sen and Jana, 1964).

The cytogenetic studies showed that these two cultivated species are closely related with chromosome differentiation having occurred through one major reciprocal translocation. Attempts made to combine the desirable features of these two cultivated species of Asiatic *Vigna* genus have been successful (Singh *et al.,* 2021). It is a self-pollinated crop having diploid 2n = 2x = 22 chromosomes with a genome size of 579 Mbp Chromosome number 2n=22, 24 is also reported. Cytogenetics and morphological studies have been conducted to compare between the cultivated and wild relatives of the genus *Vigna* in Egypt. Eleven germplasms, representing three species of the genus *Vigna,* were obtained from National Gene Bank (NGB), as well as collected taxa from natural habitats. In general, the plant haimess, flower color, pod wall thickness, cotyledon color, seed color, eye pattern and color, seed turgidity and seed crowding are the most important morphological attributes to distinguish between two the subgenera, *Vigna* and *Ceratotropis* of the genus *Vigna*. The taxa under study are diploid, twenty-two chromosomes are observed in somatic cells of the eleven studied taxa of *Vigna* (Fig. 4) (Soliman *et al*., 2008). Black gram is a self-pollinating diploid species (2n = 2x = 22) with an estimated genome size of 574 Mb (Chandel *et al.,* 2008; Bodhare, 2023). Chromosome number is 2n= 22 (Jansen, 2006; Singh, 2021; Verma *et al*., 2022; IKisan, 2023). However, it is also reported that black gram has 2n = 2x = 24 chromosomes (E-Agri, 2023; E-Agri, 2023a).

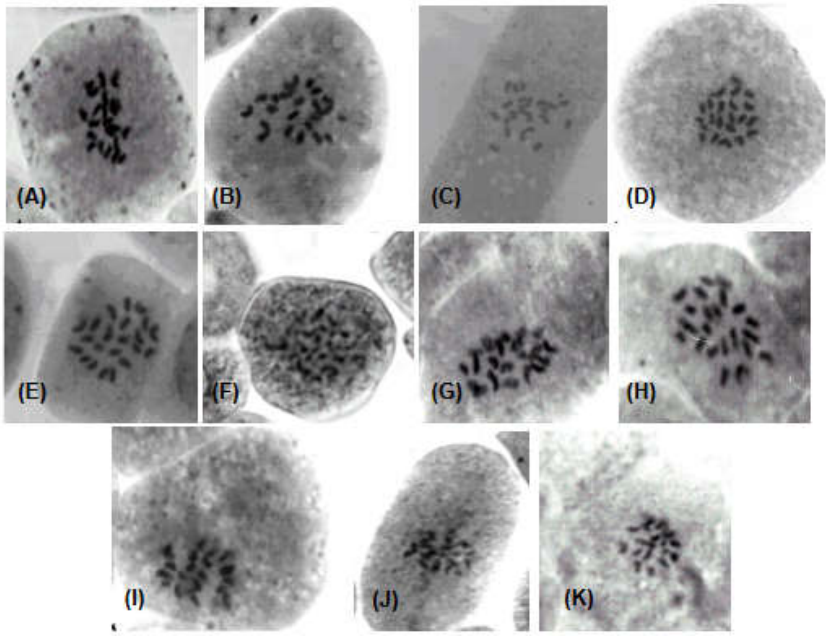


Fig.4 Somatic cell with chromosome number (2n=22).(A) (V.u.) Doki-126, (B) (V.u.) Doki-31, (C) (V.u.) Kafr EL-Sheikh, (D) (V.u.) Kahha-1, (E) (V.u.) Kream-7, (F) (V.u.) Fodder, (G) (V.l.) Rosetta, (H) (V.l.)Basendela, (I) (V.r.) Qumi-1, (J) (V.r.) VC2719 and (K) (V.r.) L303, (X=1000).

GENETIC DIVERSITY

Seeds have varying color from black, dark brown to green. The testa is smooth and hilum white and concave (Singh, 2021). Each pod contains 4-10 seeds which are black or dark brown (Agropedias, 2023). Black gram (urdbean) will be black in colour usually. But black gram in green colour has been invented by C.S.Azad University of Agriculture and Technology of Kanpur. The new variety Shekhar 1 (KU 301) from C.S.Azad University of Agriculture and Technology is green in colour which resembles green gram. Weight of 1000 grains is 44 grams (The Hindu, 2010). Fig. 5 shows the variability for seed color, shape and size. Twenty-six landraces of black gram collected from Orissa, India were analysed for genetic diversity using amplified fragment length polymorphism (AFLP) markers. Seven primer combinations were used for AFLP analysis. The percentage polymorphism across the samples varied from 74.5 to 93%. The level of rare and common alleles contributing to the diversity in the sample was analysed using the Shannon–Weiner (SW) diversity index. The SW index revealed that three samples of the entire twenty-six contributed significantly to the overall diversity of the sample set. A dendrogram was constructed based on the UPGMA clustering method, which revealed three major clusters. A principal component analysis of the same dataset revealed similar results to that of the dendrogram, with the first principle component accounting for 58% of the total variation. The analysed samples formed five significant groups. Three samples were distinct in their clustering and remained separate from the other samples. Influence of soil pattern and topography in the genetic makeup of the landraces was visible and seemed to contribute to the genetic distinctness of the landraces. This genetic diversity could well be utilized for future breeding work (Sivaprakash *et al.,* 2004). Genetic variation has led to an increase in the quantitative traits of crops. The variability on genome is induced by mutation, which enhances the productivity. We evaluated variability on quantitative characters such as, plant height, number of branches/plant, number of leaves/plant, number of fruit clusters/plant, number of pods/plant, number of seeds/pod, yield/plant and 100 seed weight of black gram in M_2 generation by the effect of mutation by gamma rays. The results were shown high genetic variability, heritability and genetic advance with significant enhancement (P 0.05 and P 0.01) in growth and yield traits. Hence selection is effective for these traits could be possible through gamma rays.

Fig. 5. Variability for seed color, size and shape

The speculation of effects of gamma rays on genome is that irradiation, induced addition, deletion in DNA pairs and also attributed large chromosomal rearrangement. The result were shown significant enhancement in yield and related traits. It indicates that improvement in quantitative traits would be possible through gamma rays. From the present investigation it is evident that the wide range of variability for different traits coupled with high heritability and high genetic advance for important yield traits hence selection is effective for these traits. Hence, gamma ray played a pivotal role in crop breeding through mutation. This stability of genetic variability should be analyzed next generation and genes for important traits should be cloned and used in transgenic technique of black gram (Arulbalachandran *et al.,* 2010). Genetic diversity and relatedness were measured in 17 mungbean (*Vigna radiata* (L.) Wilczek) and 5 blackgram (*Vigna mungo* (L.) Hepper) genotypes by means of inter-simple sequence repeat (ISSR) analysis and morphological characters. Unweighted pair-group method arithmetic average (UPGMA) analysis of 19 morpho-agronomic characters showed clear separation of the genotypes into 3 major groups; cluster I containing 15 Thai cultivated mung bean varieties and breeding lines, cluster III containing 4 Thai cultivated black gram varieties, and cluster II containing a mung bean wild relative (subspecies *sublobata*), a black gram wild relative (subspecies *silvestris*) together with an Indian mung bean landrace. Pair wise coefficients of genetic similarity between all genotypes ranged from 0.17 to 0.84 with an average of 0.52. In total, 341 ISSR fragments were amplified for the two *Vigna* species by ISSR analysis using 18 ISSR primers. The polymorphism revealed with the ISSR primers was 90.6%. The number of amplified fragments varied from 9 to 32, with a size range of 200 - 1500 bp. The average numbers of fragments per primer and polymorphic fragments per primer were 18.94 and 17.17, respectively. Polymorphism information content (PIC)

values ranged from 0.23 to 0.37 with an average of 0.31 across all the genotypes. Pair wise coefficients of ISSR-based genetic similarity between all genotypes ranged from 0.70 to 0.99 with an average of 0.86, suggesting quite narrow genetic base of mung bean and black gram in Thailand that might limit continued breeding success. UPGMA analysis based on ISSR exhibited 2 major clusters; cluster I containing all mung bean genotypes and cluster II containing all black gram genotypes. It appeared that ISSR was more effective for classification at the species level although no clear separation at the subspecies level was found. All 22 mung bean and black gram genotypes can be effectively distinguished by only 6 ISSR primers with the highest PIC values, suggesting the applicability of ISSR analysis for variety identification (Tantasawat *et al.,* 2010).

Black gram or urd bean, being a fourth important pulse crop in India has low genetic variability, low harvest index and improvement in its productivity is a challenge till date. Mutation population was developed by treating the EMS and Gamma rays. The genetic variability parameters were studied in a M_2 generation. The higher estimates of PCV were observed for all the traits, when compared with GCV. High estimates of PCV and GCV was observed for primary branches per plant, number of clusters per plant, number of pods per plan and single plant yield. High heritability per cent and high genetic advance as percentage of mean was found for number of primary branches and seed yield per plant. It indicating under the control of additive gene effects, may serve as better source for breeding programme to develop high yielding varieties. From the present investigation, it is evident that the wide range of variability for different traits coupled with high heritability and high genetic advance for important yield traits, hence selection is effective for these traits.Hence, 250Gy of Gamma ray (no. of cluster per plant and seed yield per plant) and also 20 mM of EMS (hundredseed yield) were played a pivotal role in crop breedingthrough mutation. This stability of genetic variability should be analyzed next generation for important traits (Ramya *et al.,* 2014).

520 cultivated and 14 wild accessions of black gram were assessed for diversity using 22 SSR markers. Totally, 199 alleles were detected with a mean of 9.05 alleles per locus. Wild black gram showed higher gene diversity than cultivated black gram. Gene diversity of cultivated accessions among regions was comparable, while allelic richness of South Asia was higher than that of other regions. 78.67% of the wild gene diversity presented in cultivated accessions, indicating that the domestication bottleneck effect in black gram is relatively low. Genetic distance analysis revealed that cultivated black gram was more closely related to wild black gram from South Asia than that from Southeast Asia. STRUCTURE, principal coordinate and neighbor-joining analyses consistently revealed that 534 black gram accessions were grouped into three major subpopulations. The analyses also revealed that cultivated black gram from South Asia was genetically distinct from that from West Asia. Comparison by SSR analysis with other closely related *Vigna* species, including mung bean, azuki bean, and rice bean, revealed that level of gene diversity of black gram is comparable to that of mung bean and rice bean but lower than that of azuki bean (Kaewwongwal *et al*., 2015). A set of 534 black gram accessions from various origins were assessed by SSR markers from azuki bean and cowpea, with the aims of determining the level of genetic diversity and population structure. The results will be useful for black gram breeders/geneticists to better understand diversity and domestication of the crop (Kaewwongwal *et al*., 2015).

The investigation was carried out to estimate the genetic variability parameters and genotypic correlations in thirty two advanced black gram genotypes for nine traits *viz.,* days to 50% flowering, plant height (cm), number of clusters per plant, numberof pods per plant, pod length (cm), number of seeds per pod, hundred seed weight (g), single plant yield (g) and incidence of yellow mosaic virus (YMV). Based on the mean performance, the genotypes *viz.,* KKB-14-024, KKB-14-022, KKB-14-18, KKB-14-21 and KKB-14-09, KKB-14-038, KKB-14-027 and KKB-14-007 recorded higher performance for most of the traits studied. From the YMV resistance studies, twenty five genotypes showed resistant (R) reaction. A perusal of genetic parameters revealed that GCV, PCV, heritability and Genetic Advance as per cent of Mean (GAM) were high for the traits *viz.,* number of clusters per plant, number of pods per plant, hundred seed weight and single plant yield. High heritability coupled with high GAM were observed for the traits *viz.,* plant height, number of clusters per plant, number of pods per plant and single plant yield indicating that additive gene action is present and selection would be fruitful for these traits. From the correlation co efficient studies, seed yield per plant showed positive association with the traits *viz.,* plant height, number of pods per plant and number of clusters per plant. Hence, simultaneous selection for the above traits would be more rewarding to bring improvement in black gram (Sushmitharaj *et al.,* 2018).

The investigation was conducted at Allahabad to examine 39 black gram genotypes along with 2 check (T9 and AZAD.1) to evaluate Genetic variability, correlation for yield in black gram. The experiment was laid out in an in Randomize Block Design replicate thrice. Analysis of variance showed highly significant differences among 39 genotypes of black gram for 13 characters studied. Moderate genotypic coefficientof variation and phenotypic coefficient of variation was recorded for number of clusters per plant, primary branches per plant and seed yield per plant. All characters showed High broad-sense heritability and high genetic advance as percent of mean was recorded for seed yield per plant and plant height. Biological yield, harvest index, seed yield per plant, exhibited high GCV, PCV and genetic parameters revealed that heritability (broad sense) and genetic advance as % of mean values were high for seed yield per plant indicating that selection would be fruitful for improvement of these traits. It was concluded from the present investigation that among 21 crosses of black gram on the basis of mean performance and heterosis the crosses PU-38×T4 recorded the high performance for seed yield per plant followed by PU-11-14×PU-31 and MASH-338×T4, PU-31 x LBG-648, PU-31 x MU-06, PU-31 x KPU-13-192 was found to be superior crosses these performed maximum seed yield. Biological yield, harvest index, seed yield per plant, exhibited high GCV, PCV and genetic parameters revealed that heritability (broadsense) and genetic advance as % of mean values were high for seed yield per plant indicating that selection would be fruitful for improvement of these traits (Aftab *et al.,* 2018).

The investigation was carried out to estimate the genetic variability and genotypic correlation among one hundred and twenty black-gram genotypes for nine quantitative characters. High PCV and GCV were recorded for the traits *viz.,* single plant yield, number of clusters per plant, number of pods per plant and number of primary branches per plant. High heritability coupled with high GAM was recorded for the traits *viz.,* plant height, number of primary branches per plant, number of clusters per plant, number of pods per plant and single plant yield. From the association analysis, single plantyield had negative and significant association with days to 50% flowering and it also exhibited significant and positive correlation with the traits *viz.,* number of pods per plant, number of clusters per plant, number of primary branches per plant and hundred seed weight. Hence, simultaneous selection of the above traits would be more rewarding to bring improvement in black-gram (Priya *et al.,* 2018).

Generally, exotic lines and cultivated germplasm of black gram-have been used for genetic improvement of *V. mungo*. However, lack of suitable ideotypes for variable cropping systems, low harvest index, abiotic/biotic stresses and unavailability of quality seeds of improved varieties remain major constraints to achieve the true yield potential of this crop. This presents a comprehensive worldwide overview of available biodiversity in *V. mungo*. Moreover, a detailed record is also presented for mutation breeding and recent advances in molecular marker-assisted breeding and genomic research for black gram with emphasis on genetic linkage maps, genes/QTLs mapping, genetic engineering and

hybridization for improvement of agronomically-important traits. Availability of genomic resources which can be used to accelerate molecular breeding in *V. mungo* is also discussed (Azeem *et al.*, 2019).

An experiment was carried out to estimate the genetic parameters like variability, heritability and correlation studies for eleven quantitative characters viz., days to 50% flowering, days to maturity, plant height, number of primary branches plant-1, number of pods plant-1, pod length, number of seeds pod-1, biological yield plant-1, test weight, harvest index, and grain yield plant-1 in 40 genotypes of black gram. High phenotypic coefficient of variance (PCV) and genotypic coefficient of variance (GCV) were observed for all the characters studied. The phenotypic coefficient of variance was higher in magnitude than the respective genotypic coefficient of variance for all the characters indicating the important role of environment in the expression of characters. High heritability coupled with high genetic advance was observed for plant height only indicating the heritability is due to additive gene action and simple selection for this trait. Hence, yield studies revealed that, grain yield plant-1shows significant positive correlation with biological yield per plant, number of pods per plant, number of seeds per pod, test weight, plant height, number of primary branches per plant and pod length both at phenotypic and genotypic level. Path analysis studies revealed that biological yield per plant, number of pods per plant, number of seeds per pod, test weight, plant height, number of primary branches per plant and pod length both at phenotypic and genotypic level (Partap *et al.,* 2019).

The investigation was carried out with 40 diverse genotypes of black gram at Meerut, U.P. Observations were recorded on various characters viz. days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of pods per plant, podlength, number of seeds per pod, biological yield per plant, test weight, harvest index, and grainyield per plant. Analysis of variance revealed substantial amount of variability for all eleven characters. Mahalanobis (D^2) static revealed considerable genetic diversity among the genotypes. Genotypes were grouped into 5 clusters. Cluster I was the largest including 14 genotypes. The intra cluster distance among various clusters exhibited maximum intra cluster distance for cluster III and lowest intra cluster distance was reported for cluster II. The maximum intra cluster distance was because of wide genetic diversity among its genotypes. The highest inter cluster distance was revealed between cluster IV and V. The clearly indicates that the genotypes includedin this cluster are having broad spectrum of genetic diversity and could very well be used in hybridization programme of black gram for improving grain yield. The minimum inter cluster distance was revealed between clusters I and VII. It is suggested that, crosses among the parents belonging to most divergent clusters would be expected to manifest maximum heterosis and also wide variability of genetic architecture (Partap *et al.,* 2020).

Study was carried out to assess the diversity of thirty-eight black gram genotypes by using D^2 statistics for thirteen quantitative characters. All studied genotypes formed six clusters by using D^2 statistics, among these cluster I formed the largest and containing twenty three genotypes in it, followed bycluster III contains five genotypes, cluster IV contains four genotypes, cluster V contains three genotypes, cluster II contains two genotypes and cluster VI contains only one genotype. The highest inter-cluster distance is found between cluster V and cluster VI followed by cluster II and VI, cluster I and VI, cluster III and IV, cluster V and VI, showing that the effective breeding program can be started to increase productivity and other yield-related traits by exploiting heterosis breeding. Cluster V has the maximum mean values for seed yield for the plant, harvest index, number of pods per plant and plant height. Cluster II has the highest mean values for seed yield, seed index, pod length and number of seeds per pod, number of clusters per plant. The hybridization program has been suggested based on inter-cluster divergence andcluster means for the characters studied. For developing breeding program, it is suggested to choose the clusters which have more intra cluster distance because diverse parents within heterotic group may give desirable segregants. Diversity had important implications on establishment of heterotic patterns among varieties and lines. In the present study, it revealed that the maximum cluster distance was found between cluster V and VI. It is expected that maximum heterosis will be demonstrated in cross combinations involving the parents belonging to most divergent clusters (Rajasekhar *et al.,* 2020).

The experiment was conducted at Kumhrawand, Jagdalpur, Bastar (C.G.). Crop was grown proper spacing 30×10cm during Kharif 2019. The study was undertaken on the 80 black gram genotypes along with two checks (Indira Urd Pratham and T.U. 94-2) to study the correlation and path analysis. Analysis of variance showed highly genetically significant differences among (80+2 check) black gram genotypes for 13 quantitative characters studies. Correlation coefficient studies revealed that Seed yield per plant has showed positive and highly significant association with number of pods per cluster, test weight of 1000 seed (g), petiole length (cm), number of pods per plant, days to maturity, days to 50% flowering, days to first mature pod and number of seeds per pod at genotypic level. Path analysis revealed that number of pods per cluster was main component for improving the single pant yield. Hence selection of these traits would improve yield in black gram breeding programs (Kumar *et al.,* 2020).

We applied the 10X Genomics linked-read technology to obtain a de novo whole genome assembly of *V. mungo* cultivated variety Chai Nat 80 (CN80). The preliminary assembly contained 12,228 contigs and had an N50 length of 5.2 Mb. Subsequent scaffolding using the long-range Chicago and HiC techniques yielded the first high-quality, chromosome-level assembly of 499 Mb comprising 11 pseudomoleculeS. Comparative genomics analyses based on sequence information from single-copy orthologous genes revealed that black gram and mungbean (*Vigna radiata*) diverged about 2.7 million years ago. The transversion rate (4DTv) analysis in *V. mungo* revealed no evidence supporting a recent genome-wide duplication event observed in the tetraploid créole bean (*Vigna reflexo-pilosa*). The proportion of repetitive elements in the black gram genome is slightly lower than the numbers reported for related *Vigna* species. The majority of long terminal repeat retrotransposons appeared to integrate into the genome within the last five million years. We also examined alternative splicing events in *V. mungo* using full-length transcript sequences. While intron retention was the most prevalent mode of alternative splicing in several plant species, alternative 3' acceptor site selection represented the majority of events in black gram. Our high-quality genome assembly along with the genomic variation information from the germplasm provides valuable resources for accelerating the development of elite varieties through marker-assisted breeding and for future comparative genomics and phylogenetic studies in legume species (Pootakham *et al.,* 2020).

Forty black gram genotypes were evaluated using principal component analysis to estimate the extent of genetic diversity for ten different yield and its component traits. The first three principal components *viz.,* PC I, PC II and PC III with eigen values more than one contributed around 80% of the variability for the genotypes studied. PC I contributed 46.834% towards variabilityand the traits responsible for its contribution are *viz*., number of clusters per plant, grain yield per plant, number of branches per plant and number of seeds per pod. The second axis (PC II) contributed 18.951% variability and variation at this axis is due to the accumulated genetic variation of traits *viz*., days to 50% flowering, days to maturity, grain yield per plant and number of clusters per plant. While PC III and PC IV accumulated 13.807% and 5.765% respectively. Therefore on a cumulative note, first four axes contributed about 85.357% of total variance among 10 characters for all the forty genotypes under study. In the current investigation, four lines (TU 94-2, PU 31, IPU 94-1 and LBG 623) are identified from the depicted 2D & 3D figures as diverse genotypes, which may yield transgressive segregants or heterotic F1s based on nature of gene action of the trait in question (Ayesha et al., 2021). The investigation was carried out with fifty blackgram genotypes tostudy the genetic diversity for 14 characters. For all thecharacters

analysis of variance presented significant differences. For all the characters the genotypic coefficient of variation (GCV) was smaller than the phenotypic coefficient of variation (PCV). Wholly the traits have shownhigh heritability but high heritability together with high genetic advancewas revealed by number of secondary branches per plant, number of seeds per plant, number of pods per plant, plant height, biological yield per plant and number of clusters per plant indicating the substantial contribution of additive gene action. For 100 seed weight, number of primary branches per plant, harvest index, seed yield per plant, days to 50% flowering, podlength, number of seeds per pod, and days to maturity, which specify equal impact of additive and non-additive genetic action in the expression, high heritability with moderate to low genetic advancement was reported (Kundagar *et al.,* 2021). We constructed a draft genome sequence of black gram, for the first time, by employing hybrid genome assembly with Illumina reads and third generation Oxford Nanopore sequencing technology. The final de novo whole genome of blackgram is ~ 475 Mb (82 % of the genome) and has maximum scaffold length of 6.3 Mb with scaffold N50 of1.42 Mb. Genome analysis identified 18655 genes with mean coding sequence length of 970bp. Around 96.7 % of predicted genes were annotated. Nearly half of the assembled sequence is composed of repetitive elements with retrotransposons as major (47.3% of genome) transposable elements, whereas, DNA transposons made up only 2.29% of the genome. A total of 166014 SSRs, including 65180 compound SSRs, were identified and primer pairs for 34816 SSRs were designed. Out of the 18665 proteins, 678 proteins showed presence of R- gene related domains. KIN class was found in majority of the proteins (372) followed by RLK (79) and N (79). The genome sequence of black gram will facilitate identification of agronomically important genes and accelerate the genetic improvement of black gram (Jegadeesan *et al*., 2021).

Black gram is an important tropical and sub-tropical short- duration legume that is rich in dietary protein and micronutrients. Producing high-yielding black gram varieties is hampered by insufficient genetic variability, absence of suitable ideotypes, low harvest index and susceptibility to biotic-abiotic stresses. Seed yield, a complex trait resulting from the expression and interaction of multiple genes, necessitates the evaluation of diverse germplasm for the identification of novel yield contributing traits. Henceforth, a panel of 100 black gram genotypes was evaluated at two locations (Ludhiana and Gurdaspur) across two seasons for 14 different yield related traits. A wide range of variability, high broad-sense heritability and a high correlation of grain yield were observed for 12 out of 14 traits studied among all environments. Investigation of population structure in the panel using a set of 4,623 filtered SNPs led to identification of four sub-populations based on ad-hoc delta K and Cross entropy value. Using Farm CPU model and Mixed Linear Model algorithms, a total of 49 significant SNP associations representing 42 QTLs were identified. Allelic effects were found to be statistically significant at 37 out of 42 QTLs and 50 known candidate genes were identified in 24 of QTLs (Singh et al., 2022).

A set of 840 diverse accessions originated from different parts of India was used to dissect its genetic diversity on the basis of 29 morphological traits. Of which, many traits were qualitative in nature and governed by few genes. Therefore they represented dominant type of phenotype in the population. Further hierarchical clustering performed using these traits showed that most of the accessions were clustered in one group despite their site of origin. This might be due to the selection of quantitative traits that is influenced by human selection as well as agro-ecological conditions. Molecular diversity has also been evaluated using markers such as inter simple sequence repeat (ISSR), RAPD. These studies showed that different maker systems were able to dissect distinct genetic variability within the accessions. Further, excluding duplicates helped in development of core collection of elite black gram. The study reported that the cultivated black gram of South Asia was genetically different from the West Asian accessions. In gene diversity study, higher gene diversity was observed in wild black gram than the cultivated counterpart. Furthermore, 78.67% of the wild gene diversity was found in cultivated accessions which indicated that the domestication bottleneck effect in this legume is relatively less. They also analyzed the gene diversity in black gram using SSRs that was found to be closely related to *Vigna* species such as azuki bean, mung bean, and rice bean. Results indicated that black gram is more similar to mung bean and rice bean than the adzuki bean (Verma *et al*., 2022).

BREEDING

Genetic resources

About 2100 accessions of black gram are maintained by the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India, at its various research stations. The USDA Southern Regional Plant Introduction Station, Griffin, Georgia, United States, holds 300 accessions, and the Asian Vegetable Research and Development Centre (AVRDC) in Taiwan maintains a collection of 200 accessions. Breeding programmes for improvement of this pulse aim for a plant type combining determinate growth habit with a plant height of 30 cm, early maturity (60–90 days), and suitability for many different agroclimatic regions. Sources of resistance against most current diseases are available and several resistant cultivars have been released. Genetic variability of black gram is great, allowing development of suitable cultivars for most tropical and subtropical climates. Genetic transformation of black gram has been achieved using *Agrobacterium* -mediated transfer (Jansen, 2006). Black gram is reported to have a vast number of *ex situ* collections comprising of 6,483 accessions. Of which, 3,153 accessions are reported to be with National Bureau of Plant Genetic Resources (NBPGR) of Indian Council of Agricultural Research (ICAR), New Delhi, India along with several other gene banks of different countries such as Thailand (1,201 accessions), Pakistan (944 accessions), Taiwan (894 accessions), Japan (449 accessions) and the United States of America (304 accessions) (Verma *et al*., 2022).

Breeding objectives (CU, 2017; CUTM, 2020; E-Agri, 2023)

- Evolving medium duration high yielding varieties for dry land cultivation.
- Evolving short duration high yielding varieties suitable for irrigated conditions. This can be used as mixed crop in cotton, turmeric.
- Evolving short duration varieties suitable for rice fallow conditions
- Breeding varieties resistant to diseases. YMV is a serious disease. Leaf crinkle virus, powdery mildew
- Pest: White fly vector for YMV and leaf crinkle, leaf eating caterpillar
- Breeding for better quality. 24% protein. There are lines having 27% protein. These can be utilized.

Quality of black gram is determined by a) Protein content, b) Methionine content 1.17%, c) cooking quality – Time, d) less hard seeds, e) Dal recovery 70-80 %

Breeding methods (CU, 2017; CUTM, 2020; E-Agri, 2023)

1. Introduction - E.g. T.9 from U.P.; Pusa baisaki
2. Pure line selection- Co1,Co3 - Alangudi local, Co5 - musiri local
3. Hybridization and selection.

Intervarietial:

KM 2 (Derivative from T9 x L.64),
TMV 1 - Derivative from Midhiulundu x KM1,
ADT 4 - 29 x AD 2 x 6114,
VBN 3 - LBG 402 x LBG 17.

Inter specific

Vigna mungo x V.mungo var.sylvestris - Pant nagar. YMV resistant lines obtained. But pod shatters. More number of Back crosses suggested.
Vigna mungo x V.radiata for increasing pod length, digestibility. Sterility is the main problem. Few plants obtained revert back to parental form.
4) Mutation breeding- Variety Co4 - derived from Co1 by EMS treatment
5) Embryo rescue - Attempted in inter specific crosses.

Ideal plant type (CUTM, 2020; E-Agri, 2023)

For irrigated and Rice fallows: Determinate type, short duration, high dry matter producing with 30 cm plant ht. Photo insensitive.

For rainfed condition: Semi determinate with pod setting from base of the main stem; higher pod length and more number of seeds / pod.

Breeding

Black gram or Urd bean is a highly self-pollinated crop with cliestogamy up to 42%. Urd bean is grown all over the South East Asia. In India it is mostly grown as a kharif crop. In the past, remarkable progress has been made towards the development of high yielding, stress resistant and input responsive varieties by utilizing the available germplasm. The impact of these varieties has been well realized in their crop productivity. The present review highlights the past, present and future importance of improving high yield in black gram through different breeding strategies *viz*., selection, hybridization, mutation and other molecular breeding approaches. But alien gene transfer for several traits such as photo and thermo sensitive, erect plant types stand still. Heterotic studies in blackgram, the important genetic mechanism operates to bring superiority in F1 hybrid than their parents. Heterosis has been of immense economic value in agriculture and has important implications regarding the fitness and fecundity of individuals in natural populations. Considering black gram, a pulse crop which is self-pollinated, little work has been done on heterosis. This genetic tool is the basic mechanism in developing black gram cultivars with high yielding potentials. The increase in black gram production volume comes mainly from the increase in black gram cultivated area. A possible breakthrough for this production limitation is to exploit hybrid vigor of the F1 for possible production of hybrid varieties. The magnitude of hybrid vigor is normally presented in terms of heterosis (superiority of the F1 hybrid over its parental mean) and heterobeltiosis (superiority of the F1 hybrid over its better parent. The results on heterosis so far in black gram were encouraging and still there is a scope to utilize this genetic phenomenon to develop new cultivars superior than existing (Muthusamy and Pandiyan, 2018). Earliness is important because early cultivars can escape drought and some insect infestations and can be grown in a diverse array of cropping systems. Agronomic interventions and cropping system manipulations will definitely help in increasing production and area under cultivation. Earliness, delayed leaf senescence, and indeterminate growth habit are characteristics which need to be combined to improve drought adaptation. Development of cultivars with multiple resistances to biotic and abiotic stresses is an important current breeding objective. Emerging threats due to viral diseases like groundnut bud necrosis virus (GnBNV) and Urd bean Leaf Crinkle Virus (ULCV) need to be tackled through resistance breeding and management strategies. In future, high levels of resistance to very important insect pests such as thrips (*Megalurothrips distalis*), maruca pod borer (*Maruca testulalis*), and pod bugs (*Clavigralla tomentosicollis* and others) need to identified. Genes from related *Vigna* species or genetic transformations would be necessary to develop cultivars with high levels of resistance to major insect pests. Seed systems are advocated to ensure quality seed to growers of major regions of urd bean production (Gupta *et al*., 2021). Table 1 gives improved varieties of black gram grown in different states of India (Kanade, 2006).

Table 1. Improved varieties of Blackgram grown in different states in India

State	Season	Name of variety
Andhra Pradesh	Kharif and Rabi	T-9, LBG-20, LBG-26, LBG-623
	Rabi	LBG-611, LBG-17, LBG-645, LBG-685,LBG-648, LBG-639
Gujarat	Kharif	T-9, TAU-1
Karnataka	Kharif and Rabi	KARGAUN, TAU-1, T-9
Madhya Pradesh	Kharif	Pant-U-19, TPU-4,P.D.U.-4, R.U.-2, Pant-30
Maharashtra	Kharif	T-9, Lal Urd, Hara Urad, Kale Urad
Orissa	Summer	Pant U-26
	Rabi	KV-301,TU-942
	Kharif and Rabi	WBU-108
	Kharif and Summer	Pant U-19, Sarala, Pant U-30
	Kharif, summer and Rabi	T-9
Punjab	Kharif	Mash-338,Mash-1
Rajasthan	Kharif	T-9, PU-19, R.B.U.-38, T-9
	Summer	T-9
Tamil Nadu	Kharif and Rabi	ADT3, ADT4, ADT5,RM2, TMV1, VBN2,VAMBAN1, VBN3
	Kharif, Rabi and Summer	VBN(BG)4
Uttar Pradesh	Kharif and summer	I.P.U. 94-1, Narendra Urd-1, T-9, T-27, P.D.U. –1,Pant U-19, Pant U-35,Pant U-30, Shekhar-2
	Kharif	T-65, Azad-1
West Bengal	Kharif and Rabi	T-122, T-27, T-9

A number of improved varieties have been developed to suit location specific requirements. Some of the popular varieties are given Table 2 (Pallavi, 2023).

Table 2. Black gram varieties recommended for different zones of India

States/UTs	Recommended varieties
Andhra Pradesh	LBG 709, LBG 685, LBG 611, Lam 685, Lam 623, WBU 108, LBG 402.
Asom	Azad Urd 3, Gautam, WBU 109.
Bihar	Azad Urd 3, .Gautam, Birsa Urd 1.
Delhi	KU 300, Uttara (IPU 94-1), IPU 02-43.
Gujarat	KU 96-3.
Haryana	KU 300, Uttara (IPU 94-1), IPU 02-43.
Karnataka	WBG 26, KU 301, WBU 108, LBG 402, IPU 02-43.
Kerala	Sumanjana, IPU 02-43.
Madhya Pradesh	KU 96-3, RBU 38, TPU 4, WBU 109.
Maharashtra	KU 96-3, RBU 38, AKU 4, TPU 4, ujala.
Orissa	WBG 26, KU 301, LBG 402, ujala.
Punjab	KU 300, Uttara (IPU 94-1), Mash 414, Muashs 338, WBU 108.
Rajasthan	Azad Urd 3, .Gautam, KU 300, Uttara (IPU 94-1), RBU 38, TPU 4.
Tamil Nadu	VBN (Bg) 4, WBG 26, KU 301, Vamban 2. WBU 108, LBG 402, ADT 5, ADT 4, Vamban 1, IPU 02-43.
Uttar Pradesh	Azad Urd 3, KU 300, Uttara (IPU 94-1), Azad Urd 1, NDU 88-1, IPU 02-43.
West Bengal	Azad Urd 3, Gautam, WBU 109.

State-wise recommended varieties ae given in **Table 3 (**DPD, 2023a**)**.

Table 3. State-wise recommended varieties

State	Varieties		
	Kharif	Rabi	Spring/Summer
Andhra Pradesh	Pant Urd-31, IPU 2-43, LBG 685, LBG 625	TU 94-2, LBG 623, LBG 709, LBG 611	TU 94-2, LBG 623, LBG 709, LBG 611
Assam	PU-30, WBU -108, IPU 94-1 (Uttara)	-	-
Bihar & Jharkhand	Pant Urd 31, WBU 108, IPU 94-1 (Uttara), Birsa Urd 1,PU-30	-	Pant Urd 31, WBU-109, KU 91-2 (AZAD Urd 1)
Gujarat	Ku 96-3, TPU-4, AKU-4 (Melghat), GU-1, KUG-479,UH 01, Mash-414	-	-
Haryana	KU-300 (Shekhar 2), IPU 94- 1 (Uttara)	-	-
H.P.	Pant Urd 31, Pant Urd 40	-	-
Karnataka	IPU 02-43, WBU-108, KU- 301, LBG 402	IPU 2-43, WBU-108, KU-301	-
M.P. & C.G.	Pant Urd-30, JU-3, KU 96-3, TPU-4, JU-2 Khargone-3	Pant Urd 31	Pant Urd 31
Maharashtra	KU 96-3, TPU 4, AKU-4 (Melghat), AKU-15	-	-
Odisha	IPU 02-43, WBU-108, KU 301	B-3-8-8, OBG-17, Mash 338	B 3-8-8, OBG 17, Mash 338
Punjab	WBU 108, IPU 94-1 (Uttara), Mash 338, Mash 414	-	KU 300 (Shekhar 2), KUG 479
Rajasthan	Pant Urd-31, WBU 108, IPU 94-1 (Uttara)	-	KU 300 (Shekhar 2), KUG 479
U.P. & Uttarakhand	Pant Urd-40, WBU-108, IPU 94-1 (Uttara)	-	KU 300, WBU 109, KU 91(Azad Urd 2) KUG-479, Narendra Urd 1
Tamil Nadu	IPU 02-43, Vamban-4, Vamban-7	Vamban-3, TU 94-2	Vamban 3, TU 94-2, Vamban 5, Vamban 2
West Bengal	Pant Urd 31, WBU 108, IPU 94-1 (Uttara)	Pant Urd-31, WBU-190, KU-92-1 (Azad Urd-1)	Pant Urd 31, WBU 109, KU 91-2 (AZAD Urd 1)

Table 4 gives the varieties recommended for Tsamil Nadu

Table 4. Black gram varieties for Tamil Nadu varieties (E-Agri, 2023)

Varieties	Parentage	Duration (Days)
Co 4	Mutant of Co 1	70
Co 5	Pure line selection from Mustri Local	70-75
KM 2	Derivative from T 9 x L. 64	60-65
VBN 1	KM 1 x H 76-1	60-65
T 9	Pure line selection	65-70
ADT 2	Derivative from Thirunelveli Local x ADT 1	70-75
ADT 3	Pure line selection from Thriunelveli Local	70-75
TMV 1	Derivative from Midhiulundu x KM 1	65-70
ADT 4	29/ ADT 2 / Plant 6114	60-65
ADT 5	Pure line selection Kanpur variety	62
VBN 2	Reselection from T 9	70
VBN 3	LBG 402 X LBG 17	70

Table 5 gives the Central released varieties of black gram in India

Table 5. Central released varieties of black gram/Urd bean in India

Variety	Year of release	Originating centre	Yield(q/ha)	Days to maturity
WBU 109 (Sulata)	2008	Berhampore (W.B)	10-12	70-75
Pant Urd 31	2008	Central	15-16	75-80
IPU02-43	2009	IIPR, Kanpur	10-1	70-72
LU 391	2011	PAU, Ludhiana	10-12	70-75
Mash 479 (KUG 479)	2011	PAU, Ludhiana	10-12	82-85
Vishwas (NUL-7)	2012	Nirmal Seeds,	11-12	69-73
VBN (Bg) 7 (VBG04-008)	2012	TNAU, Vamban	8-9	63-90
TU 40	2013	Trombay Mumbai	9-10	70-75
Pratap Urd-1(KPU 07-08)	2013	ARS Kota	10-11	74-76
LBG 787 (Tulasi)	2016	ARS, Lam,	15-16	70-75
VBN 8 (VBG 09-005)	2018	NPRC, Vamban	13-14	65-75
Mukundra Urd-2 (KPU 405)	2018	ARS, Kota	10-11	75-80
Pant Urd 10(PU 10-23)	2019	GBPUA&T, Pantnagar	12-13	80-85
PDU 1(Basant Bahar)	2019	IIPR, Kanpur	13-14	70-80
Kota Urd 4 (KPU 12-1735)	2020	AU, Kota	12-13	75-80
VBN 9 (VBG 12-111)	2020	NPRC, Vamban	12-13	70-75
VBN 10 (VBG 12-034)	2020	NPRC Vamban	11-12	74-76

USES

Black gram seeds are eaten as a pulse, direct or in various preparations (whole or split, boiled or roasted, ground into flour for cake, bread or porridge). It is with the flour of black gram that in India the flat biscuits 'papadum' are made. Seed sprouts are also consumed. Green pods are eaten as a cooked vegetable. Small quantities of the pods and foliage are used to supplement cattle feed or as forage. Sometimes black gram is sown as a cover crop and for green manure. The pod walls are fed to cattle. Flour from the seed is used as a substitute for soap; it makes the skin soft and smooth. In traditional medicine, the seed is used for its suppurative, cooling and astringent properties, e.g. pounded and applied as a poultice on abscesses (Jansen, 2006). *Vigna mungo* seeds are mainly a staple food and the dehulled and split seeds (*dhal* in Hindi) are a common dish in South Asia. They can be ground into flour and used for making *papadum*, a typical Indian flat bread. Seeds, sprouts and green pods are edible and much appreciated for their high digestibility and lack of flatulence induction. The seeds are normally too expensive to be used as a feed, even in areas of primary production. The by-product of dhal processing (*chuni* or bran) constitutes about 15-20% of the seed weight and comprises hulls, germs and broken seeds. Chuni is a potential feed resource and large quantities are available in India and other Southern Asian countries where black gram is a popular food (Heuzé *et al.,* 2016). *Vigna mungo* is also grown for forage and hay. Its crop residues are an important feed for livestock in some regions of India. Fodder is derived mainly from the leaves and stems, but seeds, pods and pod husks are also used. *Vigna mungo* is usually fed to cattle as a fodder but the plant, the seeds and the by-products are also consumed by other species. *Vigna mungo* can be used as cover crop and green manure. It is often used as dry season intercrop in rice or wheat as it has a beneficial effect on soil nutrient status (Heuzé *et al*., 2016). Black gram is popular in *Northern India* where the bean is boiled and eaten *whole*. It can also be be split and made into Dal (black gram soup). The whole gram has an unusual *mucilaginous* texture, more like cooked oatmeal. To cook the whole gram, it is best *soaked overnight* and cooked slowly over low fire until it's falling apart. With modern advancements, it is now mostly cooked using a *pressure cooker*. The whole gram is very popular in the *Punjabi cuisine* where it's used to make *Dal Makhani*. The primary ingredients are whole black gram (urad dal), red kidney beans (rajma), butter and cream. It can also be prepared with yoghurt or dairy instead of cream. Black gram can also be used as a *seasoning*. A teaspoon or two is sautéed in hot ghee at the beginning of cooking to give a nutty flavour, add texture and thicken the dish (Liz, 2018). The split black gram is also known as chilka urad dal. It does not require soaking but can be soaked for 30 minutes only, otherwise, the skin might come off. It's used to make *Dal (black gram soup)*. The split gram is first boiled with *turmeric* and *salt* and then different seasonings (*tadka*) are made using different ingredients. *Tadka* is added just before serving the soup, to flavour it. This process of making tadka (seasoning) is called *tempering* (Liz, 2018). The whole skinless black gram is used as a key ingredient in making the idli-dosa batter. The batter is made by mixing one part of skinless black gram with three or four parts of idli rice. The mixture is ground with a little water to make a thick batter that is fermented before use. Also the batter for *vada* or udid *vada* is made by soaking whole skinless urad dal and then grinding it with a little water to form a thick batter. The batter is mixed with other spices and deep fried in cooking oil. The *skinless whole gram* is a key ingredient in making *batter* for several other recipes. It's made by soaking rice and skinless gram and grinding them into a batter, then fermenting (Liz, 2018). Black gram flour (urad Atta) is made into *'papadum'* (a crispy indian cracker usually served as an appetizer or with drinks in Indian restaurants. The skinless whole urad dal can also be made into dal (back gram soup). *Black Gram Flour* is used as a substitute for *soap*. It makes the skin soft and smooth (Liz, 2018). It is a rich source of B-vitamins, minerals like calcium, iron, zinc, potassium among others. (Fig.6).

Black grams are also known as urad dal and black dal (kali dal) due to its black color. These black grams are cylindrical and vertical in shape, their outer skin is grayish black and the inner is creamy white and oval in shape. They are extensively used in India in various culinary preparations such as dosa, vada, papad and could be eaten raw when sprouted. Black urad dal when sprouted is very refreshing, healthy and nutritious and it can be used in several forms. Sprouts are fantastic addition to salads or you can make delicious chaat for snack. Growing sprouts is fun and they can be grown anytime anywhere. There are no complicated step to sprout these beans all you need a bowl, water and towel **(Fig. 7)** (Seth, 2023). In few parts of Southern India, eating crispy vadas made from urad dal is a tradition during the harvest festival Sankranti/Pongal, as it meets the protein requirements of the vegetarians, in the winter season (Binu, 2019). And when soaked in water Urad dal which exhibits mucilaginous texture is grinded along with rice to make various recipes (Binu, 2019). The tender young pods of *Vigna mungo* can be cooked and eaten like a vegetable. When making bread, pancakes, waffles, etc., they can be ground into flour to add protein. They are an important part of the Indian fermented rice and lentil cakes called idli and dosa. The saponin content of the seed flour makes it suitable for use as a soap replacement. It softens and soothes the skin. The seed has cooling and astringent properties. It's ground into a powder, moistened and applied to abscesses (HND, 2023). Black Gram is perhaps the most important pulse crop in Asia because of its versatility of use. The bean is used whole, split, husked, fermented, sprouted or ground into flour which when combined with rice flour is especially valued for baking. After the plants are picked, animals can graze it and it can be plowed under as green manure. It is a legume with a deep root system that binds soil particles together preventing erosion.

Fig. 6. Black gram - whole with skin, split with skin, split without skin, whole skinless & flour

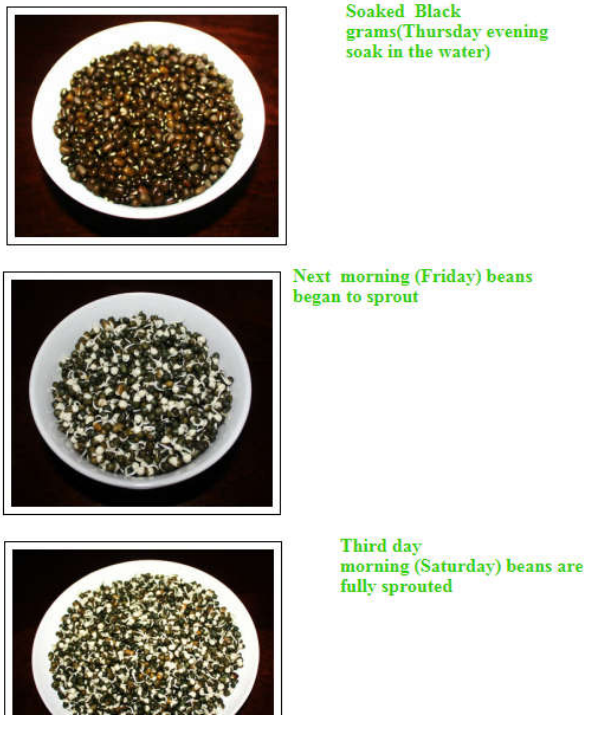


Fig. 7. Sprouting of black gram

Its foliage is lush so that when cut and left on the ground, it acts as good mulch (Echocommunity, 2023). Black gram is eaten whole or split, boiled or roasted or ground into flour. Black gram batter is a major ingredients for the preparation of popular Southern Indian breakfast dishes. Split pulse is used in seasoning Indian curries (Brainkart, 2023). There are several ways you can involve urad dal in your diet. You can boil the dried seeds of Urad and use them in various recipes. You can also ground Urad into flour and use it to add protein when making bread. Urad dal can also be used as the main ingredient of dishes like idli and dosa. These are fermented cakes made from rice and dhal (Bodhare, 2023).

Vigna mungo is popular in Northern India, largely used to make *dal* from the whole or split, dehusked seeds. The bean is boiled and eaten whole or, after splitting, made into *dal*; prepared like this it has an unusual mucilaginous texture. Its usage is quite common in Dogra Cuisine of Jammu and Lower Himachal region. The key ingredient of *Dal Maddhra* or *Maah Da Maddhra* dish served in Dogri Dhaam of Jammu is *Vigna Mungo* lentil.[3] Similarly, another dish *Teliya Maah* popular in Jammu & Kangra uses this lentil.[4] Traditionally, Vigna Mungo Lentil is used for preparing Dogra style Khichdi during Panj Bhikham and Makar Sankranti festival in Jammu and Lower Himachal. Besides, fermented Vigna Mungo paste is also used to prepare *Lakhnapuri Bhalle* or *Lakhanpuri Laddu* (a popular street food of Jammu region). In Uttarakhand Cuisine, Vigna Mungo is used for preparing traditional dish called *Chainsu* or *Chaisu* (Wikipedia, 2023). In North Indian cuisine, it is used as an ingredient of *Dal makhani,* which is a Modern restaurant style adaptation of Traditional *Sabut Urad Dal* of Northern India. In Bengal, it is used in *kalai ruti*, *biulir dal*. In Rajasthan, It is one of the ingredients of *Panchmel dal* which is usually consumed with *bati*. It is also extensively used in South Indian culinary preparations. Black gram is one of the key ingredients in making idli and dosa batter, in which one part of black gram is mixed with three or four parts of idli rice to make the batter. Vada or udid vada also contain black gram and are made from soaked batter and deep-fried in cooking oil. The dough is also used in making papadum, in which white lentils are usually used. In the telugu states, it is eaten as a sweet in the form of laddoos called Sunnundallu or Minapa Sunnundallu (Wikipedia, 2023).

NUTRITIONAL VALUE

Black gram seeds contain per 100 g edible portion: water 8.6 g, energy 1470 kJ (351 kcal), protein 25.1 g, fat 1.8 g, carbohydrate 61.0 g, crude fibre 4.4 g, Ca 196 mg, Mg 260 mg, P 575 mg, Fe 6.8 mg, Zn 3.1 mg, vitamin A 114 IU, thiamin 0.36 mg, riboflavin 0.28 mg, niacin 1.8 mg, vitamin B_6 0.28 mg, folate 628 µg and ascorbic acid 4.8 mg. The essential amino-acid composition of black gram seeds per g nitrogen is: tryptophan 65 mg, lysine 415 mg, methionine 91 mg, phenylalanine 365 mg, threonine 217 mg, valine 351 mg, leucine 518 mg and isoleucine 319 mg (Haytowitz & Matthews, 1986). Black gram seeds have shown anti-atherogenic activity in guinea pigs (Jansen, 2006; Kanade, 2006). Nutritional value of black gram seeds is given in Table 7 (Heuzé *et al*., 2016).

Table 7. Nutritional value of black gram seeds

Main analysis	Unit	Average
Dry matter	% as fed	88.4
Crude protein	% DM	23.7
Crude fibre	% DM	6.5
NDF	% DM	18.6
ADF	% DM	6.6
Lignin	% DM	0.3
Ether extract	% DM	1.5
Ash	% DM	5.1
Starch (polarimetry)	% DM	48.7
Gross energy	MJ/kg DM	18.4
Minerals	Unit	Avg
Calcium	g/kg DM	2.2
Phosphorus	g/kg DM	4.9
Magnesium	g/kg DM	3.0
Zinc	mg/kg DM	99
Copper	mg/kg DM	18
Iron	mg/kg DM	560
Amino acids	Unit	Avg
Arginine	% protein	6.7
Cystine	% protein	1.2
Glycine	% protein	3.7
Histidine	% protein	2.1
Isoleucine	% protein	4.6
Leucine	% protein	7.2
Lysine	% protein	7.0
Methionine	% protein	1.3
Phenylalanine	% protein	5.9
Threonine	% protein	3.4
Tyrosine	% protein	1.7
Valine	% protein	5.1
Secondary metabolites	Unit	Avg
Tannins (eq. tannic acid)	g/kg DM	3.8

Black gram is very rich in *protein* and *carbohydrate*. It also has a good amount of folate vitamin B9, iron, magnesium and phosphorus. It is very *nutritious*. 100g black gram has about 8.6g water, 351 calories, 25.1g protein, 1.8g fat, 61g carbohydrate and a fair amount of B-vitamins. 100g provides the following Recommended Daily Allowances (RDA): Folate (B9) 54%, Iron (58%), Magnesium (75%), Phosphorus (54%) and Zinc (35%) (Liz, 2018). Black gram or urad dal holds a high protein value than most of the legumes. It is also an excellent source of dietary fiber, isoflavones, vitamin B complex, iron, copper, calcium, magnesium, zinc, potassium, phosphorus which offers a myriad of healing health benefits (Table 8) (Binu, 2019).

Table 8. Nutritional value of raw black gram dal per 100 grams

Nutrition	Content
Energy	341 Kcal
Carbohydrates	58.99 g
Protein	25.21 g
Total Fat	1.64 g
Dietary Fiber	18.3 g
Folates	216 mg
Niacin	1.447 mg
Pantothenic acid	0.906mg
Pyridoxine	0.281 mg
Riboflavin	0.254 mg
Thiamin	0.273mg
Vitamin-A	23IU
Sodium	38 mg
Potassium	983mg
Calcium	138mg
Copper	0.981 mg
Iron	7.57 mg
Magnesium	267mg
Phosphorus	379 mg
Zinc	3.35 mg

Black gram split (urad dal) and whole urad dal have tremendous nutritional value. Urad dal is a good source of proteins, carbohydrates, lipids, iron, and calcium. In addition, whole urad has dietary fibre, whereas urad dal (split urad) does not contain fibre. Among the phytochemicals, prominent phytochemicals present in urad dal are flavonoids and phenolic compounds (Bodhare, 2023). The pulse 'Black gram' plays an important role in Indian diet, as it contains vegetable protein and supplement to cereal based diet. It contains about 26% protein, which is almost three times that of cereals and other minerals and vitamins. Besides, it is also used as nutritive fodder, specially for milch animals (Vikaspedia, 2023). Nutritive value of black gram are Protein - 24%, Fat - 1.4%, Minerals - 3.2%, Fiber - 0.9%, Carbohydrate - 59.6%, Calcium - 154 mg/100 g , Phosphorus - 385 mg/100 g , Iron - 9.1 mg/100 g , Calorific value - 347 Kcal/100 g and Moisture - 10.9% (Vikaspedia, 2023). Vitamins like tocopherols are present in black gram. In my experience, I have found that mung beans can be an excellent protein source for individuals who prefer a vegetarian diet. Mung bean protein is not only cost-effective but also highly digestible compared to a protein found in other legumes. This means that your body can efficiently break down and absorb the nutrients from mung bean protein, providing you with the necessary building blocks for muscle growth and overall health (Bodhare, 2023). Black gram's nutrition numbers when raw differ from when cooked. When raw it contains high levels of protein (25 g/100 g), potassium (983 mg/100 g), calcium (138 mg/100 g), iron (7.57 mg/100 g), niacin (1.447 mg/100 g), thiamine (0.273 mg/100 g), and riboflavin (0.254 mg/100 g).[5] Black gram complements the essential amino acids provided in most cereals and plays an important role in the diets of the people of Nepal and India.[2] Black gram is also very high in folate (628 µg/100 g raw, 216 µg/100 g cooked) (Wikipedia, 2023)

HEALTH BENEFITS

The black gram beans are referred as 'Masha' in the ayurvedic texts and is highly recommended for gaining weight and improving immunity. The ancient medicine recommends consuming de-husked urad dal as it is one of the fibre rich Indian food. In fact, ancient Ayurvedic text Charaka Samhita dedicated a chapter Mashaparni bhriteeya adhyaya to explain about the goodness of these beans. Urad dal is in fact, the only pulse that has more than 10 times of phosphorous than any other pulse and the unique type of protein present in black grams strengthen muscle fibers. This humble whole bean serves as a nutritive, bulk enhancer, diuretic, aphrodisiac and pacifies vata. Patients suffering from asthma, paralysis, constipation are recommended to include black grams in daily diet for its innumerable healing properties (Binu, 2019). Ayurveda describes black gram or Masha as a bean that is sweet to taste but hot in potency, that can calm down and regularize the imbalances caused due to Vata. It also increases Kapha and Pitta and is recommended for men suffering from erectile dysfunction, low sperm count and motility. Ayurvedic practitioners prescribe including urad dal in daily diet for the women of reproductive age to balance hormones and strengthen the reproductive organs. Our ancient medicine explains innumerable ways of consuming black gram for overall health. Try these easy-to-make home remedies with urad dal (Binu, 2019). Black gram is rich in flavonoids, isoflavonoids, phytoestrogens, phenolic acids, enzymes, fibers, starches, trypsin inhibitors, phytic acid, lectins, saponins, tocopherols, fatty acids, and proteins. Most of the reported components are from the seed part of the black gram. Various processes like cooking, soaking, and germination affect bioactive components. Studies have shown the presence of bioactive compounds in other parts of the plant like leaves, pods, roots, stems, etc. which are normally considered as a waste product. Hence there is a need to isolate and characterize novel bioactive components from other parts of the black gram plant. This review demonstrates that *Vigna mungo* is rich in bioactive components and able to cure and prevent diseases in addition to its basic nutritional value (Khan *et al*., 2021). There are many benefits of *Vigna mungo*. These include: 1) It increases the fertility of the soil. 2) It aids digestion. 3) It improves your skin's health. 4) It boosts your energy levels. 5) It increases bone mineral density. 6) It helps diabetics (HND, 2023).

Following are the health benefits of black gram (Bodhare, 2023):

***Potential Uses of Urad dal for Heart diseases*:** Regularly eating urad dal with a low-fat diet may help maintain lipid homeostasis (balance). As a result, it may help reduce the risk of heart diseases. Agents responsible for this heart-friendly property of Urad dal are fibre, low glycemic index, and minor components like saponins, phytosterols and oligosaccharides. Also, the lipids in black gram may show cholesterol-lowering effects in humans. If you are suffering from heart disease, make sure you talk to your healthcare provider before using urad dal for its properties.

***Potential Uses of Urad dal for Diabetes*:** Urad dal has a low glycemic index (increases blood glucose levels slowly). Along with a low glycemic index, it also has a high content of indigestible fibre, making it an excellent candidate for maintaining blood sugar levels in individuals with diabetes. Also, black gram may help prevent insulin resistance associated with type 2 diabetes. Hence, black grams may be consumed to avoid type 2 diabetes. However, diabetes is a severe health condition which requires you to strictly adhere to the doctor's advice. Avoid using urad dal or any herbal remedy to manage your symptoms without consulting a doctor first.

***Potential Uses of Urad dal for Obesity*:** The presence of lipids, proteins and fats lends black grams high nutritional value. In addition, black grams may help maintain healthy body weight by providing early satiety due to its high fibre content, limiting overall food consumption. However, if you are looking to reduce or manage weight, you can reach out to a dietician or nutritionist as they will be able to better guide you about the benefits and limitations of each diet.

Potential Uses of Urad dal as a Prebiotic: Prebiotics are indigestible foods beneficial in stimulating the growth of helpful intestinal bacteria and improving overall gut health. Black grams are a good source of prebiotics. Consuming black grams (whole) may provide prebiotic health benefits and might be regarded as potential functional food.

***Potential Uses of Urad dal as an Antioxidant*:** In excess, reactive oxygen species (ROS) can damage cells like proteins, lipids, and DNA, resulting in conditions like cancer, neurodegenerative diseases, and atherosclerosis. Black grams are rich in polyphenols, which possess antioxidant properties. Polyphenols may prevent cellular damage caused by the presence of excessive ROS and thus protect from diseases caused by long-term and chronic inflammation.

***Potential Uses of Urad dal in Liver and Kidney diseases*:** Urad dal may show liver protective and kidney protective properties. These properties might be due to components like phenolics, tannins, flavonoids, and phytic acid in urad. These components are potent antioxidants which may show a protective effect on the liver and kidney. However, if you are suffering from kidney or liver disease, you need to consult your healthcare provider before using urad dal or any other herbal remedy for kidney or liver problems.

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